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<td>AM</td>
<td>Advanced Materials</td>
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<tr>
<td>AMT</td>
<td>Advanced Manufacturing Technologies</td>
</tr>
<tr>
<td>BERD</td>
<td>Business expenditure on R&amp;D</td>
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<td>CBS</td>
<td>Croatian Bureau of Statistics</td>
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<td>CCC</td>
<td>Croatian Competitiveness Cluster</td>
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<tr>
<td>CEFTA</td>
<td>Central European Free Trade Agreement</td>
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<tr>
<td>CF</td>
<td>Cohesion Fund</td>
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<tr>
<td>CoC</td>
<td>Centres of competence (in Croat. CEKOM)</td>
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<tr>
<td>CoRE</td>
<td>Centres of Research Excellence</td>
</tr>
<tr>
<td>CTA</td>
<td>Commodity Trade Advisors</td>
</tr>
<tr>
<td>EBITDA</td>
<td>Earnings before interest, taxes, depreciation and amortization</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
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<tr>
<td>EMMF</td>
<td>European Maritime and Fisheries Fund</td>
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<td>ERDF</td>
<td>European Regional Development Fund</td>
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<td>EPD</td>
<td>Entrepreneurial discovery</td>
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<tr>
<td>ESF</td>
<td>European Social Fund</td>
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<tr>
<td>EST Funds</td>
<td>European Structural and Investment Funds</td>
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<td>ESFRI</td>
<td>European Strategy Forum on Research Infrastructures</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>EUROSTAT</td>
<td>EU Statistical Office</td>
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<tr>
<td>FDI</td>
<td>Foreign Direct Investment</td>
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<td>FINA</td>
<td>Financial Agency</td>
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<tr>
<td>GERD</td>
<td>Gross domestic expenditure on R&amp;D</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GVC</td>
<td>Global Value Chain</td>
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<tr>
<td>HAMAG-BICRO</td>
<td>Croatian Agency for SME, innovation and investment</td>
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<td>HEI</td>
<td>Higher Education Institute</td>
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<td>HERD</td>
<td>Higher Education Research and Development</td>
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<td>HGK</td>
<td>Croatian Chamber of Economy</td>
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<td>HNB</td>
<td>Croatian National Bank</td>
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<td>HRST</td>
<td>Human Resources in Science and Technology</td>
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<td>IB</td>
<td>Industrial Biotechnology (KET)</td>
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<td>ICT</td>
<td>Information and communications technology</td>
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<td>IPR</td>
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<td>Key Enabling Technology</td>
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<td>MoA</td>
<td>Ministry of Agriculture</td>
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<td>MoE</td>
<td>Ministry of Economy</td>
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<td>MoLPS</td>
<td>Ministry of Labour and Pension System</td>
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<td>MoEC</td>
<td>Ministry of Entrepreneurship and Craft</td>
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<tr>
<td>M&amp;E</td>
<td>Monitoring and Evaluation</td>
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<td>MFIN</td>
<td>Ministry of Finance</td>
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<tr>
<td>MIS</td>
<td>Monitoring and information system</td>
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<tr>
<td>MNE</td>
<td>Micro and Nano Electronics</td>
</tr>
<tr>
<td>MRDEUF</td>
<td>Ministry of Regional Development and EU Funds</td>
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<tr>
<td>MS</td>
<td>Member State</td>
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<td>NANO</td>
<td>Nanotechnologies</td>
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<tr>
<td>NATO</td>
<td>North Atlantic Treaty Organization</td>
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<tr>
<td>NIS</td>
<td>National Innovation System</td>
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<tr>
<td>NKD</td>
<td>National Classification of Activities</td>
</tr>
<tr>
<td>NUTS</td>
<td>Nomenclature of Units for Territorial Statistics</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<tr>
<td>OPCC</td>
<td>Operational Programme Competitiveness and Cohesion 2014-2020</td>
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<tr>
<td>OPEHR</td>
<td>Operational Programme Efficient Human Resources 2014-2020</td>
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<tr>
<td>OPMF</td>
<td>Operational Programme for Maritime and Fisheries 2014-2020</td>
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### Glossary

**Applied Research** - Applied research means theoretical or experimental work conducted primarily for the purpose of acquiring new knowledge and focused primarily on achieving a practical goal. In the context of recent terminology, the term “applied research” includes industrial research, experimental development or a combination of these two research types.

**Business Sector** - Business sector is comprised of enterprises/companies whose main activity is production of goods and services to be marketed at commercial prices.

**Centres of Competence** – Centres of competence are industry-led individual (networked) entities designed to provide support in raising capacities of business sector (mainly SME that lack in-house capacities for R&D) to enforce R&D projects (especially those focused on development and applied research and commercialization of results) in line with the thematic areas identified in Croatian S3 Strategy. Their main goal is to raise competitiveness of business sector through R&D investments and increase of business expenditures on research and development.

**Centres of Research Excellence** – Centres of Research Excellence are structures where research and technology development is performed of world standard, in terms of measurable scientific production (including training) and/or technological innovation. Some of the key features of the concept area "critical mass" of high level scientists and/or technology developers, a well-identified structure (mostly based on existing structures) having its own research agenda capable of integrating connected fields and to associate complementary skills, maintenance of a high rate of qualified human resources exchange, a dynamic role in the surrounding innovation system (adding value to knowledge), high levels of international visibility and scientific and/or industrial connectivity, a reasonable stability of funding and operating conditions over time (the basis for investing in people and building partnerships) and sources of finance which are not dependent over time on public funding. Centers of Excellence represent the network of innovative top researchers and research teams along with the business and other public subjects which are systematically conducting research in areas of most importance for both science and society at large.

**Clusters** - Clusters are legal entities, geographic concentrations of interconnected businesses, specialized suppliers, service providers and firms in related industries and associated institutions in areas in which they both compete, but also cooperate.

**Collaborative Research** - Collaborative research refers to collaboration between at least two independent parties to exchange knowledge or technology, or to achieve a common objective based on the division of labour where the parties jointly define the scope of the collaborative project, contribute to its implementation and share its risks, as well as its results.

**Competitiveness Clusters** - Competitiveness clusters are non-profit organizations operating within sectors of strategic importance for the development of the Republic of Croatia, linking private, scientific-research and public institutions (triple helix). Competitiveness clusters are used as instrument for raising sectorial competitiveness, instrument for efficient use of EU funds and programmes, instrument for internationalization and cross-sectoral networking, lobbying instrument, instrument for sector promotion and branding and instrument for targeted attracting of investments and creating new value added on the sector level.

**Context Indicators** – Context indicators provide simple and reliable information describing a variable relative to the context. It gives information about a situation and its evolution in a country/region, or an area relevant to the assistance policy.

**Contract Research** - Contract research refers to R&D activities in the form of research services provided on a contract basis (to industry, public bodies, another RO, etc.).
DIVERSIFICATION in a narrow sense is a third pattern. In such cases the discovery concerns potential synergies that are likely to materialize between an existing activity and a new one.

ECO-INNOVATIONS – Eco-innovations are any form of innovation aiming to achieve significant progress in the areas of sustainable development, through reducing impact on the environment, increasing resistance to pressures and the environment or a more efficient use of natural resources. Innovation plays a key role in moving manufacturing industries towards sustainable production, and the evolution of sustainable manufacturing initiatives has been facilitated by eco-innovation. Various Eco innovation activities can be analyzed along three dimensions: targets (the focus areas of eco-innovation: products, processes, marketing methods, organizations and institutions), mechanisms (the ways in which changes are made in the targets: modification, redesign, alternatives and creation) and impacts (effects of eco-innovation on the environment).

EMERGING INDUSTRIES – Emerging industries can be understood as either new industrial sectors or existing industrial sectors evolving or merging into new industries. The changes are most often driven by key enabling technologies, new business models, such as innovative service concepts, or by societal challenges, such as sustainability demands. Many emerging industries, like creative industries, mobile and mobility industries or eco-innovative industries, grow out of existing industries. Thus, they cut across different traditionally-defined sectors and build new industrial landscapes and value chains that integrate cross-sectoral competences and linkages.

ENTREPRENEURIAL DISCOVERY – Entrepreneurial discovery represents discovery and exploration of a new space of opportunities, which is likely to generate many innovations and the development of new activities. EVALUATION - Evaluation explains whether, why and how an intervention works (or not) and generally it tackles questions such as “Are we doing the right things?” “Are we performing them well?” “Can it be done better?” Evaluation helps understand why given effects were achieved, whether this is good or bad considering the given circumstances, how it happened, and whether it was an intervention that caused observed changes or rather whether there were other factors that influenced the outcome. Evaluation gives meaning to data, enriches it with a broader context and offers in-depth understanding of processes. By and large, evaluations can be divided according to two major lines, i.e. time in relation to intervention execution and scope. Evaluation can take place either before intervention implementation (ex ante), during (ongoing) or after (ex post) and can focus on assessing either the goals achieved by an intervention (effectiveness), or the process of how the intervention functioned (efficiency).

EXPERIMENTAL DEVELOPMENT – Experimental development means acquiring, combining, shaping and using existing scientific, technological, business and other relevant knowledge and skills with the aim of developing new or improved products, processes or services. This may also include, for example, activities aiming at the conceptual definition, planning and documentation of new products, processes or services. Experimental development may comprise prototyping, demonstrating, piloting, testing and validation of new or improved products, processes or services in environments representative of real life operating conditions where the primary objective is to make further technical improvements on products, processes or services that are not substantially set. This may include the development of a commercially usable prototype or pilot which is necessarily the final commercial product and which is too expensive to produce for it to be used only for demonstration and validation purposes. Experimental development does not include routine or periodic changes made to existing products, production lines, manufacturing processes, services and other operations in progress, even if those changes may represent improvements.

FEASIBILITY STUDY – Feasibility study means evaluation and analysis of the potential of a project, which aims at supporting the process of decision-making by objectively and rationally uncovering its strengths and weaknesses, opportunities and threats, as well as identifying the resources required to carry it through and ultimately its prospects for success.

FUNDAMENTAL RESEARCH – Fundamental research means experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any direct commercial application or use in view.

GREENFIELD INVESTMENTS - The term “greenfield investments” includes direct investments, generally of foreign capital. In other words, the terms describes capital investments by residents of one country being realized abroad. It can be an investment in the establishment of their own business (for example a new company), investment in the establishment of a joint company (for example, the establishment of a mixed society), or the establishment, i.e. opening of branch offices. This type of investment is characterized in that the investor takes control and actively carries it out and manages the company in which he invested. This marks the difference between direct investments from the so-called portfolio investments.

GROSS DOMESTIC EXPENDITURE ON R&D - Gross Domestic Expenditure on R&D (GERD) are total domestic expenditures on research and development on country territory in the observed calendar year. They are comprised of current and capital investment expenditures and expressed in gross amounts. The GERD is used as an indicator of science and technology activities as it presents a summary of R&D activities and funding.
INCUBATION - Incubation refers to aid granted to the entrepreneur in stages from establishment of a company up to its expansion. It is usually a medium-term process which takes place in the first three years of activities of the newly established company and in that period it is possible to evaluate the success of the business venture as well as good prospects for development into a fully mature company. Generally, activities in progress include access to resources, services of direct consulting and mentoring services, as well as commercial space rental services at affordable conditions, as well as specific training.

INDUSTRIAL RESEARCH - Industrial research means planned research or critical investigation aimed at the acquisition of new knowledge and skills for developing new products, processes or services or for bringing about a significant improvement in existing products, processes or services. It comprises creation of components parts of complex systems, and may include the construction of prototypes in a laboratory environment or in an environment with simulated interfaces to existing systems as well as of pilot lines, when necessary for the industrial research and notably for generic technology validation.

INNOVATION - The term “innovation” is used to describe a variety of phenomena, from scientific discovery to simply “thinking outside of the box”, which are reached by applying creative solutions. Innovation denotes implementation of a new or significantly improved product, service, process, marketing or organizational method within an existing business process, work organization or other type of contractual relationship. OECD (Oslo Manual, third edition) identifies four types of innovation in companies: innovative product, innovative process (technological innovation), and marketing or organizational innovation (non-technological innovation). It should be noted that innovations can have different degrees of novelty. It may not be new to the world; but can be new on a market, in a sector or just a new to the company/institution.

INNOVATION INCUBATOR - Innovation incubator is a centre for business development for new entrepreneurs as well as small and medium enterprises which intend to develop innovative ideas. Incubators based on innovation support innovative business projects which can be technologically or non-technologically-oriented.

INNOVATION INFRASTRUCTURE - Innovation infrastructure includes public and private institutions with a goal to support commercialization of innovations and application of technology in the economy and refers to the centres of competence, living labs, centres for new product development, centres for quality testing, design centres, and other institutions which aim to develop new products, services, technologies, improving business processes and management models.

INNOVATION NETWORK FOR THE INDUSTRY - Innovation Network for the Industry is part of the Innovation System of the Republic of Croatia and aims to support the industry in the commercialization of research results and the application of new technologies through mapping and putting into function the research infrastructure and existing research and development capacities in the public and private sector, in order to strengthen the competitiveness of priority industrial sectors in the Republic of Croatia. Setting-up of Innovation Network for the Industry is the result of cooperation between the public, business and research sectors and is comprised of thematic innovation platforms.

INNOVATION VALUE CHAIN - A term used to describe a path from research and technological development to the commercialization of innovation and application of new technologies in order to strengthen competitiveness and increase production. Among the stakeholders of the innovation chain are scientific-research institutions, institutions which enable commercialization of innovation and application of new technologies, as well as small, medium and large enterprises. It should be emphasized that the term “innovation value chain” does not only imply a linear process from idea to market performance, but the complementarity of stakeholders, partnership and cooperation with the aim of generating new knowledge which does not necessarily come only from science, but can be initiated by an another company, supplier or customer.

INNOVATION VOUCHERS - Innovation vouchers allow small and medium enterprises to purchase professional support from research institutions. They differ from consulting services as they are more focused on to help to develop new products, services and processes, rather than to solve existing business problems.

INTELLECTUAL PROPERTY - Intellectual property refers to a set of mostly exclusive rights which protect the results of innovative and creative activities, such as technological inventions, industrial design or works in the fields of literature, art, science and other related fields, as well as commercial labels which protect the source, reputation or geographical origin of products and services, such as trademarks and geographical indications of origin. Intellectual property protection is focused on ensuring a fair return on investment in research and development of new knowledge and technologies, i.e. in the promotion, quality and reputation of products and services on the market. Patents are the most common form of intellectual property that is used to establish exclusive rights to use the invention as a result of research and development of new knowledge and technologies.

KEY ENABLING TECHNOLOGIES - Key Enabling Technologies (KETs) provide the basis for innovation in a range of products across all industrial sectors. They underpin the shift to a greener economy, are instrumental in modernising Europe’s industrial base, and drive the development of entirely new industries. Their importance makes them a key element of European industrial policy. KETs refer to biotechnology, nanotechnology, micro- and nano-electronics and photonics, as well as advanced materials and technologies.
KNOWLEDGE AND INNOVATION COMMUNITIES - Knowledge and Innovation Communities (KICs) are highly integrated, creative and excellence-driven partnerships which combine together the fields of education, technology, research, business and entrepreneurship, in order to produce new innovations and new innovation models that inspire others to emulate it. KICs are legally and financially structured entities of internationally distributed but thematically convergent partners. These partners involve key actors from the three sides of the knowledge triangle: research, higher education, and innovation-entrepreneurship-business. KICs build innovative webs of excellence with the intention of addressing key societal challenges and address a long-term horizon of 7 to 15 years.

KNOWLEDGE TRANSFER - Knowledge transfer means any process which has the aim of acquiring, collecting and sharing explicit and tacit knowledge, including skills and competence in both economic and non-economic activities such as research collaborations, consultancy, licensing, spin-off creation, publication and mobility of researchers and other personnel involved in those activities. Besides scientific and technological knowledge, it includes other kinds of knowledge such as knowledge on the use of standards and regulations embedding them and on conditions of real life operating environments and methods for organisational innovation, as well as management of knowledge related to identifying, acquiring, protecting, defending and exploiting intangible assets;

MODERNIZATION is one pattern of structural changes. It is manifest when the development of specific applications of a general-purpose technology produces a significant impact on the efficiency and quality of an existing (often traditional) sector.

MONITORING - Monitoring keeps track of intervention implementation in real time – it is a continuous process taking place along the execution of intervention. Monitoring answers the question “What is happening?”. It allows regular measurement of the implementation progress of a strategy, program or instrument/action, i.e. it concentrates on obtaining information about real progress, e.g. how many milestones were achieved, is an intervention on track according to a plan, how much money has already been disbursed, is an intervention engaging the planned number of stakeholders, etc. Monitoring produces simple but instant managerial information (without judgment) that has to be interpreted and explained, the latter usually via evaluation. For instance, if the implementation of an intervention is going off plan, monitoring waves a red flag, thus providing a manager with an early warning and a signal that a corrective action may be needed. However, monitoring will not give an answer as to what has to be done to address the issue.

NATIONAL INNOVATION SYSTEM – National Innovation System is a set of institutions, individuals, knowledge, practices and resources which through their interaction ensure recognition, promotion, implementation and purposeful use of innovations.

OPEN INNOVATIONS - Open innovations mean achieving greater innovativeness through combining internal ideas fostered within the framework of the activities of certain entities and external ideas regarding the development of similar products or services. It is also necessary to combine internal and external value chains as well as research of market trends towards the development of new technologies. In a narrow sense, subjects are encouraged not to think of innovations within existing business models, but rather to seek to increase the effectiveness and efficiency through a variety of other innovative processes and ideas.

ORGANISATIONAL INNOVATION – Organizational innovation means implementation of a new organizational method in an undertaking’s business practices, workplace organization or external relations, excluding changes that are based on organizational methods already in use in the undertaking, changes in management strategy, mergers and acquisitions, ceasing to use a process, simple capital replacement or extension, changes resulting purely from changes in factor prices, customization, localization, regular, seasonal and other cyclical changes and trading of new or significantly improved products.

OUTPUT INDICATORS - Output indicators represent the “physical” product of spending resources through policy interventions.

POST-INCUBATION - Post-incubation is associated with activities to be performed when a company enters a phase of maturity and is ready to work independently. This includes the moment when the company leaves the incubator if it was physically in the process of incubation. Small and medium enterprises can still request a variety of services as support to their operations, for example to increase sales or improve production processes, such as internationalization services or introducing innovation through activities of testing and disclosure. Incubators positioned as "post-incubators" sometimes change their name to "accelerators".

PRE-INCUBATOR - Pre-incubators offer services related to the pre-incubation phase of the incubation stage. Incubators offer expert opinion (training and direct consulting) and capacities, in order to provide support to potential entrepreneurs in the development of their business ideas, business plans and finding markets.

PROCESS INNOVATION – Process innovation means implementation of a new or significantly improved production or delivery method (including significant changes in techniques, equipment or software), excluding minor changes or improvements, increases in production or service capabilities through the addition of manufacturing or logistical systems which are very similar to those already in use, ceasing to use a process,
simple capital replacement or extension, changes resulting purely from changes in factor prices, customization, localization, regular, seasonal and other cyclical changes and trading of new or significantly improved products.

**RADICAL FOUNDATION** of an economic activity domain. In this case of structural change, the discovery is that R&D and innovation in a certain field has the potential to make some activities progressive and attractive that had not been previously.

**RESEARCH AND DEVELOPMENT** – Research and development includes systematic creative work directed toward increasing knowledge about nature, man, culture and society and its practical application. It is divided into basic research, applied research and experimental development where the latter may include the realization of technological demonstrators, i.e., devices that demonstrate the performance of a new concept or a new technology in a relevant or representative environment. Research and development does not include the making and qualification of pre-production prototypes, tools and industrial engineering, industrial design or manufacture.

**RESEARCH AND DEVELOPMENT PROJECT** – Research and development project means an operation that includes activities spanning over one or several categories of research and development defined in the Framework for state aid for research and development and innovation published by the European Commission, and that is intended to accomplish an indivisible task of a precise economic, scientific or technical nature with clearly pre-defined goals. A R&D project may consist of several work packages, activities or services, and includes clear objectives, activities to be carried out to achieve those objectives (including their expected costs), and concrete deliverables to identify the outcomes of those activities and compare them with the relevant objectives. When two or more R&D projects are not clearly separable from each other and in particular when they do not have independent probabilities of technological success, they are considered as a single project.

**RESEARCH AND KNOWLEDGE DISSEMINATION ORGANISATION** - Research and knowledge dissemination organization means an entity (such as universities or research institutes, technology transfer agencies, innovation intermediaries, research-oriented physical or virtual collaborative entities), irrespective of its legal status (organized under public or private law) or way of financing, whose primary goal is to independently conduct fundamental research, industrial research or experimental development or to widely disseminate the results of such activities by way of teaching, publication or knowledge transfer. Where such entity also pursues economic activities, the financing, the costs and the revenues of those economic activities must be accounted for separately. Undertakings that can exert a decisive influence upon such an entity, for example in the quality of shareholders or members, may not enjoy a preferential access to the results generated by it.

**RESEARCH INFRASTRUCTURE**- Research infrastructure means facilities, resources and related services that are used by the scientific community to conduct top-level research in their respective fields and covers scientific equipment or sets of instruments, knowledge-based resources such as collections, archives or structured scientific information, enabling information and communication technology-based infrastructures such as grid, computing, software and communication, or any other entity of a unique nature essential to conduct research. Such infrastructures may be ‘single-sited’ (a single resource at a single location), ‘distributed’ (an organized network of resources) or ‘virtual’ (the service is provided electronically). \(^1\)

**RESEARCH ORGANISATION** – According to the national Act on Scientific Activity and Higher Education, research organisations carry out scientific activity. Research organisations include universities and their entities, public research institutes, research institutes, Croatian academy of Science and Arts and other institutions and their organisational units that are enlisted in the Research organisations register managed by the Ministry of science, Education and Sports\(^2\).

**RESULT/OUTCOME INDICATORS** – Result/outcome indicators cover specific dimensions of well-being and progress that are intended to be influenced (positively or negatively) by the policy actions.

**SERVICE INNOVATION** - Service innovation includes new or significantly improved service concepts and offerings as such, irrespective of whether they are introduced by service companies or manufacturing companies, as well as innovation in the service process, service infrastructure, customer processing, business models, commercialization (sales, marketing, delivery), service productivity and hybrid forms of innovation serving several user groups in different ways simultaneously.

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\(^2\) See Act on Scientific Activity and Higher Education (OJ 123/03, 198/03, 105/04, 174/04, 2/07, 46/07, 45/09, 63/11, 94/13, 139/13, 101/14, 60/15)
SMART GRIDS – electricity networks that can efficiently integrate the behaviour and actions of all users connected to it - generators, customers and those that do both - in order to ensure economically efficient, sustainable power system with low loss and high quality, and security of supply (SOS) and safety.

SMART SPECIALIZATION - Smart specialization means defining unique characteristics and potentials of each country and region, highlighting the competitive advantages as well as gathering of regional stakeholders and resources around the vision of a future based on excellence. It also includes strengthening of national and regional innovation systems, identification and development of thematic innovation platforms and increasing the exchange of knowledge, as well as dissemination of the benefits of innovation throughout the entire economy. Smart specialization is a new innovation policy concept designed to promote the efficient and effective use of public investment in research. Its goal is to boost regional innovation in order to achieve economic growth and prosperity, by enabling regions to focus on their strengths.

SOCIAL INNOVATIONS - Social innovations include new and innovative solutions to various social problems; they are consisted of new strategies, concepts, business models, tools, methodologies or policies to create new solutions for meeting social needs. Social innovations are innovations that are social in both their ends and their means – new ideas (products, services and models) that simultaneously meet social needs (more effectively than alternatives) and create new social relationships or collaborations. Social innovations take place across boundaries between the public sector, the private sector, the third sector and the household.

SPIN OFF - The term spin off means a part of the business separated from the parent company in order to enable its freer growth and development. While a spin off (subsidiary company) operates independently of the parent company (it may have new work premises, employees, brand etc.), it is still owned and operated by the parent company which invested capital into it.

SPIN OUT - Spin out is a term used to describe the process through which employees identify an opportunity for commercialization of the research elements or knowledge base within a university. Usually, the desired outcome is the establishment of a new independent company, although it may keep strong ties with the university which it was derived from. There may also be necessary legal frameworks within which future use of research will be conducted, enabled access to intellectual property rights etc. Many universities and regions believe that the Massachusetts Institute of Technology (MIT) in the United States is one of the most successful models where spin outs contributed to the economic development based on first-class knowledge present in their environment.

START UP – Start up is a term which describes new companies (registered in the last two years), which are in their initial stages of growth and development, i.e. finding markets. Start-ups are usually the most risky companies attracting investors, since they are at the beginning of their businesses, without clear market positioning and at this stage needing institutional and advisory assistance. On the other hand, start-ups enable self-employment, i.e. starting own business with relatively low costs and are based on knowledge with great growth potential.

THEMATIC INNOVATION PLATFORM – Thematic innovation platforms are part of the Innovation Network for the Industry of the Republic of Croatia established for thematic priority areas and cross-sectoral themes defined through the Smart Specialization Strategy of the Republic of Croatia. Thematic innovation platform is consisted of a network of stakeholders from the economy, public and research sector, connected on the basis of development and effective application of the scientific-research infrastructure, allowing use of new technologies and commercialization of innovation in order to strengthen competitiveness of one or more priority industrial sectors and the Croatian economy as a whole. Institutions within thematic innovation platforms are interconnected through a web communication platform.

THREE STAR METHODOLOGY FOR CLUSTER MAPPING - The mapping of “agglomerations” is based on the “three stars” methodology developed by the European Cluster Observatory for mapping and assessing cluster. The methodology utilizes employment data in order to identify different categories of agglomerations. Each “agglomeration” defined by its NACE code, is given a one, two or three stars against the following criteria: Size, Dominance and Specialisation.

VALUE CHAIN - Value chain includes activities required for the product to come from its initial development and design, origin of raw materials and other inputs, its marketing and distribution to the final consumer. When activities are required to be coordinated globally, the used term is global value chain.

TRANSITION is one pattern of structural changes that a smart specialization strategy is likely to generate. Transition occurs when a new economic domain emerges from existing industrial commons (a collection of R&D, engineering, and manufacturing capabilities that sustain innovation).
1. INTRODUCTION

1.1. Rationale for the Smart Specialization Strategy (S3)

1.1.1. The European Union rationale

In the context of an adverse external economic environment and challenging demographics, improvements in the living standards and long-term growth can be catalyzed through smart investments in innovation, research and human capital. The European Union launched the Smart Specialization Strategies initiative (RIS3), a new approach to economic development that is anchored on targeted support for research and innovation. Member States focus on creating a new economic growth model that will increase the EU’s overall competitiveness and reduce the heterogeneity among its 28 economies. The new Cohesion Policy for programming period 2014 - 2020 requires, as an ex-ante condition that the country identifies the knowledge specialization that best fits its innovation potential, based on its assets and capabilities for the use of EU resources in the field of research and innovation. The goal is to allow a more efficient use of structural funds and to increase synergies between the EU, national and regional authorities.

Smart Specialization Strategy (S3) outline should be based on available resources and attitudes, through identifying the competitive advantages and the technological specializations consistent with potential for innovation. Finally, S3 will help country to detail the public and private investments in research, technology development and innovation. Rather than following a top-down approach, primarily involving public authorities, this new innovation investment agenda needs to be bottom-up, crafted by a collaborative effort of ‘entrepreneurial discovery’ that involves the private sector and the academic community, building on each country/region’s inherent strengths, entrepreneurship and competitive advantages. S3s can unleash economic transformation through modernization, diversification, transition or radical innovation in all countries/regions of the EU. This is not a ‘one-size-fits-all’ approach, but an innovation-driven, place-based, entrepreneurial process. It targets the economic transformation of the EU regions towards higher added value and more knowledge intensive activities.

The S3 attempts to make two critical and somewhat conflicting requirements compatible: (1) identifying priorities in a vertical logic (specialization) and (2) keeping market forces working to reveal domains and areas where priorities should be selected (smart). However, implementing such policy is very complex and requires good institutions and strong policy capabilities at national and regional level.

1.1.2. The importance of the S3 for Croatia

This document on the Croatian S3 presents a comprehensive assessment of the country’s governance structure, innovation facilitating instruments, and key innovation assets – research and human capital. It proposes a strong monitoring and evaluation (M&E) framework and provides a sectoral analysis of five priority sectors of the economy and their innovation potential.

Development of the S3 for Croatia, a new EU member state, comes at a time of intensive national reforms and policy changes. A number of major strategies have recently been adopted or are in a process of elaboration and/or revision. The S3 seek to unify all the relevant aspects from the various

sectoral strategies in a framework that has a long-term perspective (2020) and will be basis for smart growth.

Croatian Strategy for Smart Specialization is integrated, place-based economic transformation agenda with the following features:

- Focused policy support and investments on key national priorities, challenges and needs for knowledge-based development;
- Assessment of strengths, competitive advantages and potential for excellence in R&D;
- Instruments aimed to support technological and practice-based innovation with aim to stimulate private sector investment and to promote structural changes of Croatian economy;
- Instruments aimed on fostering synergies and identifying complementarities between public support mechanisms for RDI, industrial promotion and human capital and training;
- Detailed plan how will stakeholders involved in innovation development become co-operative in decision-making mechanism and development of innovation in key priority R&D intensive economic sectors

The main purpose of Smart Specialization is to transform the Croatian economy and increase its competitiveness by concentrating knowledge resources and linking them to a limited number of priorities. The identification of the Smart Specialization priorities will allow concentration of research capacities and infrastructure. This will provide advantage to both public and private sector and will bring together the critical mass of researchers who will jointly work on strategic R&D topics with goal of research excellence and its commercialization.

Croatia’s S3 document goes beyond the formal requirements set forth by the EC. The S3 is to be a guiding principle that brings together the business community, knowledge institutions, citizens and authorities with the primary aim of developing and using innovation to foster economic growth and competitiveness. This can best be achieved by implementation of S3 through actions foreseen not only under ERDF, but also through actions envisaged under ESF, EAFRD, EMFF and other financial sources for RDI on national/EU level. The Croatian S3 embraces a broader concept of innovation, not only investment in research of manufacturing sector, but also building competitiveness through social and service innovation, new business models and practice-based innovation.

Croatia’s S3 blends existing knowledge, human potential and natural geographical advantages to help country’s control of its economic and social cohesion. The S3 offers a clear opportunity to complete the Croatia’s transition to a market economy, to apply existing national knowledge base and competencies to a market based opportunities and tackle emerging societal challenges to drive economic growth. It also offers an opportunity to turn Croatia from primarily a touristic destination to a country of well-educated, skilled citizens working on development of R&D for innovation as a basis of economic prosperity.

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4 Economic transformation is understood as structural change that leads to growth of economic activities characterised by high productivity, knowledge and human capital intensity. A priority is defined as thematic priority areas that have high potential to transform Croatian economy, while concentrating available research, development and innovation (RDI) potential and responding to global trends and challenges.

5 The Croatian S3 embraces product, process, service, marketing and organisational innovations in line with the definitions laid out in the Oslo Manual: (1) product innovations - market introduction of a new or significantly improved good or service with respect to its capabilities, user friendliness, components or sub-systems; (2) process innovations - implementation of a new or significantly improved production process, distribution method, or supporting activity; (3) marketing innovations - significant changes to design, packaging, product promotion, placement, and pricing; (4) organisational innovations - new or improved business practices for organising procedures, work responsibilities and decision making, service delivery, and external relations.
1.2. Main principles, methodology and conceptual framework of the S3 document

Croatia is a small country with a very open economy. Its size is comparable to the size of regions in large EU member states and this is a reason why the concept of smart specialization has not been applied in a formal regional dimension, but remained only at the national level.

Preparation of Croatian S3 required an integrated and place-based approach to policy design and delivery with aim to create conditions for development of the Croatia as a whole, while respecting regional specifications. Strategy promotes efficient, effective and synergetic use of public RDI specifically targeted towards diversifying and upgrading existing industries through stimulation of structural changes in Croatian economy towards a growth based on increasing innovation ability and excellence in research and innovation.

Presently, Croatian economy faces major challenges and new approach that country will take in solving these through S3 proposed measures is essential. Through S3 Croatia is addressing several major obstacles preventing its higher economic growth:

1. Croatia’s innovation performance over the last decade has fallen short of expectations. The innovation system is operating below its potential, whether measured by the system’s inputs, outputs or by the contribution of innovation to economic growth
2. Croatia is significantly below EU-average in innovation and belongs to a group of countries considered as moderate innovators.
3. Croatia is performing below the EU average in most dimensions but above the EU average in human resources, due to above average performance in new doctorate graduates and youth with upper secondary level education.
4. There are three factors that impede innovation: tax regime, lack of early stage financing (first and second round of investment), and business environment. One structural problem that Croatia faces is that the volume of business R&D is low, despite the generosity of existing tax breaks.
5. High-value products and services remain a negligible part of exports, and the country’s skills and technological capabilities have remained stagnant. This trend is reflected in Croatia’s export and technological performance and competitiveness rankings, as benchmarked against comparator countries.

The ICT skills gap between Croatia and the EU has a negative impact on the take up of e-commerce, e-government, e-practices in general. The current situation requires adopting concrete, clearly formulated and quantified measures for the 2014-2020 periods. New strategies and changes in national economic policies are necessary, especially in relation to the funding and management of education, research, innovation and support of business. Due to the limited resources and capacities, the strategy concentrates on a limited number of priority sectors that are defined based on strengths and R&D potential for innovation development with basis for export. Proposed measures in S3 are focused on avoiding fragmentation of research, on concentration of structural funds, public budgets and private resources on priorities with competitive advantage and with the highest development potential.

In order to render the smart specialization process as efficient as possible and given the specific situation in which important segments and stakeholders in process are lacking the necessary culture for RDI investments (mainly business sector), Croatia will have to elevate preparedness level of all stakeholders who will be involved in S3 implementation.

Specific measures will be implemented to raise competitiveness of Thematic and Sub-thematic Priority Areas through promoting RDI activities and investments, both in research organizations and business sector. This will be accomplished in parallel with support measures for RDI investments, delivery mechanisms targeted towards establishment of joint innovation ecosystem promoting coherent and connected RDI investments from both scientific and business sector. This means that
delivery mechanisms related to enhancing the business RDI and commercialization will have to be directed towards more narrow (specific) niches in vertical manner. On the other hand, investments related towards the scientific sector will remain within Thematic Priority Areas and Sub-thematic Priority Areas more horizontally. In this respect, the functioning of the innovation ecosystem will be more efficient and effective. The scientific sector will be focused but also opened for future new developments/niches/directions. The business sector will be more focused and oriented towards specific niches with the aim of commercialization and taking their market shares on the international level.

Recently, Croatia initiated National project for development of Innovation Network for Industry - INI, Project "Science and Technology Foresight" and “Smart skills foresights”. The main result of these activities will be focused on RDI strategies for business sector related to each selected Thematic Priority Area, long term science & technology foresights for science sector and smart skills foresight related to development of human capital needed for development of those R&D intensive sectors identified in Thematic and Sub-thematic Priority Areas in this document.

The overall strategic framework will serve as support in strengthening of national innovation ecosystem and for in-depth future business sector investments in RDI for each Thematic and Sub-thematic Priority Area. On the other hand, the results obtained through Science and Technology Foresight project will give direction for future development of each sector and its impact on economy. Future new niches with economic potential will be determined.

The S3 is based on 4 general principles (“4 C’s”): (1) Choices and Critical mass (C1), (2) Competitive Advantage (C2), (3) Connectivity and Clusters (C3) and (4) Collaborative leadership (C4). Croatia made clear choices for specialization based on achieving critical mass (C1). This was a particular issue for the country as it has a high proportion of micro and small businesses and a low population compared to most other Member States. Croatia builds the S3 on clearly identified and verifiable competitive advantages and excellence (C2). Substantial analysis has been undertaken for the purposes of developing the S3 using robust economic and RDI indicators and including an analysis of KET deployment in Croatia. Policy is directed towards cooperation and synergy in both, national and international context (C3). Building national and international networks for both, business sector and research institutions, including through initiatives such as the Horizon 2020, Teaming activity, integration in KICs (Knowledge and Innovation Communities) and EU technological platforms, is at the heart of the S3 strategy for Croatia. Finally, the proposed actions for Croatia are based on achieving close collaboration between private business sector, government, and publically funded science & technology (S&T) sector (C4).

In developing the S3, Croatia used the EU S3-Platform and the development of the S3 has also closely followed the 6 steps defined by the RIS3-Guide as shown in Figure 1.

**Figure 1 Steps in the S3 design**

1. Analysing the innovational potential
2. Setting out the S3 process and governance
3. Developing a vision
4. Identifying the priorities
5. Defining policy mix, road maps and action plan
6. Monitoring and evaluating

The results of the analysis have been combined in a coherent manner to translate existing strengths and emerging potentials into smart, inclusive and sustainable economic growth. This approach is presented in Figure 2.
Smart specialization covers many policy areas, which are governed by different ministries. This inter-ministerial dimension has been addressed in Croatia by the establishment of an S3-Interministerial Steering Group (ISG) and an S3-Interministerial Working Group (IWG) representing all relevant government institutions led by the Ministry of Economy. The work of the Steering and Working groups has been facilitated by the Partnership Consultation Group (PCG).

Figure 2 The analytical approach to identifying thematic priority areas for the S3

What distinguishes the preparation of the S3 in Croatia from the more traditional industrial and innovation policies is mainly the formed process defined as “entrepreneurial discovery” (EPD) - an interactive process in which market forces and the private sector are discovering and producing information about new activities and the government assesses the outcomes and empowers those actors most capable of realizing the potential. This process of discovery needs to be attached to broader political goals and must identify governance mechanisms and criteria to guide choices. Entrepreneurial actors were included in the process of smart specialization in Croatia from 2012 through Triple Helix networking and establishment of 12 competitiveness clusters and further more through preparation of the S3 document and future implementation (a result of entrepreneurial discovery and partnership consultation is given in Annex 1).

The outcome of the preparatory analysis for the S3 document and policy choices were critically explored through discussions with a variety of stakeholders from the business sector, universities, societal groups and the government sector, including international experts. Priorities for the S3 have been defined based on the evidences along with clear indications of the conditions required for successful development of the Thematic Priority Areas (TPAs). The priorities have been translated into strategic actions through a coherent policy mix, roadmap and action plan. Finally, robust governance, monitoring and evaluation mechanisms for assessing the S3 implementation have been developed and agreed along with mechanisms for future update. The S3 fosters also an “openness to other regions” approach. For that purpose, co-operation with other countries/regions with complementary capabilities and strategies is very important, for example, creation of cross-border technological platform, participation in CBC, Transnational and Interregional Programmes and KICs and EU technological platform, etc.

The concept of “entrepreneurial discovery” used in smart specialisation has its origins in the development economics literature, particular in Hausmann and Rodrik’s (2003) work on a “self-discovery process” in development. The Croatian competitiveness clusters (CCCs) were established in 2012 by the Ministry of Economy to bring together private and publicly owned companies, science and research institutions, government bodies and intermediary organizations in order to increase competitiveness and innovation in specific sectors of the Croatian economy. Initially 12 CCCs were set up (food, wood, pharmacy, textiles, construction, electronics, machinery, defence, ICT, chemicals, maritime industry and creative services).
2. ANALYSIS

Analysis presented in this document is based on several comprehensive evaluations of the Croatian National Innovation System conducted by the OECD (2013), the World Bank (2014), questionnaire surveys and several background studies conducted during preparatory development of the country’s S3 conducted by the Ecorys (2014). Data presented here are based on few interrelated factors particularly relevant for the development of smart specialization strategy: (i) macroeconomic performance and productivity, (ii) business sector competitiveness, (iii) R&D and innovation (RDI) performance and (iv) potential of human capital and smart skills. The analysis provides information about the strengths, main constraints and opportunities that Croatia’s Innovation System faces, and provides a clear vision how will interventions through S3 foster country’s economic development and progress.

2.1. Macroeconomic performance and productivity growth

2.1.1. GDP and economic growth

In 2014, Croatian GDP per capita measured in purchasing power standard (PPS) was around 15,900.00 EUR (59.0 % of the EU28 average) and the nominal GDP value was 43,084.90 million EUR.

In the period 2003-2008, growth in income and the country’s economic expansion were fueled by a growth pattern based on domestic consumption, growing current account deficit and increasing dependence on international finance. High and sustained rates of economic growth, at a time when the size of population was declining, resulted in consistent growth in per capita income. As a result, per capita income converged, partly as a result of the catch-up effect after the dramatic drop in the early 1990s, with levels in the richest economies: GDP per capita rose from 22.84% of the EU average to 37.8% between 2000 and 2008. Since the beginning of global recession in 2008, the Croatian economy has been contracting steadily. Starting from 2008, the cumulative GDP decrease is estimated to be 12%. The most evident obstacle for the sustainability of the current growth path is the related large and growing external financial account.

Croatia’s economic performance remained constantly downward sloping since 2009, with a fall of real GDP of -0.4 % in 2014. However, real GDP increased by 1.2 percent in the second quarter of 2015 when compared to the same period in the previous year, while seasonally adjusted GDP went up by 0.5 percent when compared to the first quarter of 2015, making it a fourth consecutive quarter-on-quarter positive output growth rate. It is expected this pickup in activity to continue into the third quarter and to have an overall positive effect on the growth rate in 2015 as a whole. In light of the latest available data the Institute of Economics, Zagreb has revised its GDP forecasts upward by 0.1 and 0.2 percentage points, which now stand at 0.5 and 1.1 percent for 2015 and 2016.8 Conclusively, Croatia came out of recession and its GDP is expected to grow further. In order to accelerate growth in the coming decades, Croatia needs to shift towards a more productivity-based and export-led growth pattern.

2.1.2. Trends in productivity

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Labour productivity, measured as GDP per person employed, improved between 2002 and 2012 in Croatia from about 72% to 80% of the EU27 average. Croatia’s level was high relative to the other transition countries, though Croatia’s low labour force participation and the high degree of informality in the labour market complicate international comparisons. Over the last decade, Croatia improved productivity by 11%, compared to the improvements of 31% in Estonia, 29% in the Slovak Republic and 23% in Poland, albeit these countries started from a lower level. It has reached level of Slovenia and Slovakia and is above Czech Republic, Portugal, Hungary and Poland, for example. However, Croatia lags behind in terms of GDP per capita in PPS. In that respect, it is only above Latvia and all previously mentioned countries are ahead.

Conclusively, Croatia stands much better in terms of productivity, measured by GDP per person employed than GDP per capita towards the EU countries. So, this suggests that the firm level productivity is probably not the major constraint and that firms that have survived transition process are relatively competitive. However, current economic sector is too small and not dynamic enough that can sustain and ensure high income per capita. The lack of entrepreneurship, technological diversification and dynamism that would create new employment represents the main obstacles. This is reflected in very low employment rates. In 2014, Croatia was at the bottom of the EU28 scale as its employment rate was only 54.6% (Eurostat data). Croatian employment rate was higher only than in Greece (49.4%). According to Croatian Bureau of Statistics data, for the first three months of 2015, Croatian employment rate was 42.7%.

This suggests that Croatian economic sector is able to generate relatively high levels of productivity and thus presumably has relatively good production capability but it has very low capacity for growth and for job generation. From the S3 perspective, in this document, the Croatian government is presenting the proposal of policy changes, measures and interventions that is going to implement in order to increase Croatia’s potential to generate growth. This will be accomplished not through employment as such but primarily potential for employment via productivity increases, technology upgrading and diversification.

2.1.3. International trade and foreign direct investments (FDI) performance

International trade and cross-border investment can be significant drivers of economic growth and development, particularly for small countries as they benefit from increases in the size of markets. Competing in global markets encourages national specialization and can result in solid productivity improvements. Trade and imports in particular, are major channels for the diffusion of knowledge embodied in goods. Links to global production chains, through FDI and by domestic firm international trade in intermediate goods, provide additional opportunities for knowledge transfer and national capability accumulation. Exports, particularly in sectors of growing global demand, are crucial to sustainable increases in national income. In an open economy, the ability to diversify the national production structure in line with changing patterns of global demand is essential. Croatia participates in international trade less than comparable countries in the EU. International trade openness (the ratio of the average of imports and exports to GDP) stood at just under 30% in 2012 as in 2002. For example, neighboring Slovenia was considerably more open to trade in 2002 (an openness ratio of 46%) and following the EU accession its trade openness increased to 70%. Being a small country of roughly 4.3 million people and having been in a recession for the past six years, Croatia’s export performance is critical for growth and employment generation.

The regional distribution of exports has changed little over the past decade, but there was a shift within Croatia’s main export partners in Europe. Between 2002 and 2012 European countries remained the main export destinations for Croatian exports. While exports to European markets represented 86% of total exports in 2002, this share declined slightly to 80% in 2012. However, the market composition within Europe changed. While the traditional block of the 15 older members of the EU (the EU15) is still important, the export share declined from 53 to 41% and the export share to the new EU12 member countries, by contrast, increased from 13 to 17% over the period. According to field
interviews, their growing significance can be explained by easier market access, as well as by similar tastes and business practices. Croatia’s export share to non-EU members within Europe also increased from 20 to 22% for reasons similar to those of the EU12 markets. Finally, Croatia’s export share to MENA and NAFTA also increased from 3 to 9%. Five sectors covered about two thirds of Croatia’s export basket in 2012. In the same year Croatia sold its products to 77 export markets. These products were predominantly minerals and mineral fuels (15.1%), metals (10.8%), chemicals (9.7%), machinery (17.9%) and transport goods (9.1%). All these sectors, except transportation goods, posted double-digit growth figures of annual growth in the past decade (Table 1). Besides the aforementioned five dominant sectors, only foodstuff report 15% of export values in 2012. Meanwhile, the importance of the textile sector declined from 11.7% to 4.9% of total exports between 2002 and 2012.

Growth in the broad sectors in which Croatia’s specializes is subdued. Products in which Croatia expanded its market share in world exports, but whose world import demand growth increased at a relatively low rate between 2008 and 2012 (“winners in declining sectors”) include, in particular, iron and steel and fertilizers – the sector with the largest export value. In addition, Croatia had several important sectors (in terms of overall export value) which both lost market share in world exports and faced lower import demand (“losers in declining sectors”), including clothing/textiles, wood products, articles of iron, steel, aluminum products, vehicles, ships, boats and other floating structures. Many of these sectors accomplish large export values that raise some cause for concern. Unfortunately, Croatia expanded only very limitedly its share in world exports for products whose import demand between 2008 and 2012 increased strongly (“winners in growing sectors”). Croatia’s exports in this category included only one sector at the 2-digit level: pearls, precious stones, etc. In addition, Croatia had a few products: footwear, sugars and sugar confectionery, mineral fuels, plastics products, and other food with growing world demand and declining world market export shares (“losers in growing sectors”). Out of 3,407 products at the HS-6 digit level that Croatia exported in 2012, only four were winners in growing sectors. These products are: medicaments and antibiotics, cane of beet sugar in solid form, articles of leather or of composition leather and revolvers and pistols. These sectors had a positive growth of world imports in the period 2008-2012 associated to an increase of Croatia’s share of world exports over the same period of time.

Table 1 Croatia’s exports 2002 and 2012

<table>
<thead>
<tr>
<th>Export products</th>
<th>% total exports</th>
<th>Revealed comparative advantage (RCA)</th>
<th>annual growth rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-05 Animal</td>
<td>2.1</td>
<td>2.3</td>
<td>1.0</td>
</tr>
<tr>
<td>06-15 Vegetable</td>
<td>1.8</td>
<td>2.9</td>
<td>0.6</td>
</tr>
<tr>
<td>16-24 Foodstuffs</td>
<td>7.6</td>
<td>7.6</td>
<td>2.4</td>
</tr>
<tr>
<td>25-27 Minerals</td>
<td>11.4</td>
<td>15.1</td>
<td>1.1</td>
</tr>
<tr>
<td>28-38 Chemicals</td>
<td>7.6</td>
<td>9.7</td>
<td>0.8</td>
</tr>
<tr>
<td>39-40 Plastic/Rubber</td>
<td>3.8</td>
<td>2.2</td>
<td>0.9</td>
</tr>
<tr>
<td>41-43 Hides, Skin</td>
<td>1.6</td>
<td>1.4</td>
<td>1.9</td>
</tr>
<tr>
<td>44-49 Wood</td>
<td>7.3</td>
<td>6.9</td>
<td>2.0</td>
</tr>
<tr>
<td>50-63 Textiles, Clothing</td>
<td>11.7</td>
<td>4.9</td>
<td>2.0</td>
</tr>
<tr>
<td>64-67 Footwear</td>
<td>3.1</td>
<td>1.7</td>
<td>3.1</td>
</tr>
<tr>
<td>68-70 Stone/Glass</td>
<td>2.5</td>
<td>2.4</td>
<td>2.3</td>
</tr>
<tr>
<td>71-83 Metals</td>
<td>6.0</td>
<td>10.8</td>
<td>0.7</td>
</tr>
<tr>
<td>84-85 Mach/Elec</td>
<td>14.6</td>
<td>17.9</td>
<td>0.5</td>
</tr>
<tr>
<td>86-89 Transportation</td>
<td>14.1</td>
<td>9.1</td>
<td>1.2</td>
</tr>
<tr>
<td>90-97 Miscellaneous</td>
<td>4.8</td>
<td>5.0</td>
<td>0.8</td>
</tr>
</tbody>
</table>
While Croatia’s economic complexity has increased over the past decade, it still lags behind peers in the region. Croatia’s Economic Complexity Index (ECI) increased from 0.7 in 2000 to 1 in 2008, but it still stands below peers like Slovenia, Hungary, Slovak Republic and Poland. Indeed, many exported products of Croatia are low to medium in complexity and sophistication. Table 2 lists the top 20 export products at the SITC 4-digit level for 2011-2012 in terms of complexity.

None of the most important 15 export sectors of Croatia ranks in the top decile by economic complexity. Of the nearly 200 products with RCA>1, about half are clustered around the middle deciles (ranking between 244th and 540th out of 786). Some emerging exports, however, are promising. The 16th largest export sector specialized industrial machinery and parts (SITC 7284), ranks among the most complex 100 sectors. Accounting for 1.1% of total exports in 2011-2012, it is also the most complex export sector of Croatia. Other sizeable exports that are moderately high in complexity include vehicle parts (SITC 7849), contributing 1.1% and ranked 62nd in complexity; medicaments (SITC 5417) contributing 3.8% and ranked 161st in complexity; and switchboards, relays and fuses (SITC 7721) contributing 0.96% and ranked 127th in complexity. These exports are “emerging” because they grew in size and significance over the past ten years, starting from a low base. These results indicate that Croatia is evolving towards a more complex export basket.

Croatian manufacturing is still yet to be dominated by industries where quality competition is more important than price competition. Using the taxonomy of Aiginger (2001), we classify exports belonging to industries that have high, medium and low Relative Quality Elasticity (RQE). Industries with high RQE compete on quality, whereas industries with low RQE compete on price. Figures 3 and 4 show that Croatia’s share of export industries that are quality-dominated (high RQE) is almost identical with the share of industries dominated by price competition (low RQE). In comparison with other selected countries in the region, the quality-dominated ratio is much higher for all other peer countries, except Bulgaria. This is yet another indicator that points out that Croatia has significant catching up to do. However, having the highest share of medium-RQE industries among peers may help the transition towards quality-dominated manufactures. Just like the breakthrough in some pharmaceutical and industrial machinery exports, with medicaments (SITC 5417) and electrical transformers (SITC 7711) doubling their share in the past decade, many emerging exports have the potential to be differentiated and made more quality-responsive.

### Table 2 Top Exports and their product complexity rank

<table>
<thead>
<tr>
<th>SITC</th>
<th>Export</th>
<th>Share in 2011-2012 (%)</th>
<th>Complexity rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>7932 Ships &amp; boats</td>
<td>7.21</td>
<td>272</td>
</tr>
<tr>
<td>2</td>
<td>5417 Medicaments</td>
<td>3.79</td>
<td>161</td>
</tr>
<tr>
<td>3</td>
<td>7711 Electrical transformers</td>
<td>2.32</td>
<td>363</td>
</tr>
<tr>
<td>4</td>
<td>2483 Worked wood of non-coniferous</td>
<td>2.18</td>
<td>687</td>
</tr>
<tr>
<td>5</td>
<td>6842 Worked aluminum &amp; aluminum alloys</td>
<td>1.89</td>
<td>317</td>
</tr>
<tr>
<td>6</td>
<td>5621 Nitrogenous fertilizers</td>
<td>1.73</td>
<td>641</td>
</tr>
<tr>
<td>7</td>
<td>7938 Special floating structures</td>
<td>1.68</td>
<td>631</td>
</tr>
<tr>
<td>8</td>
<td>8211 Chairs &amp; seats</td>
<td>1.67</td>
<td>318</td>
</tr>
<tr>
<td>9</td>
<td>2820 Iron &amp; steel waste</td>
<td>1.62</td>
<td>542</td>
</tr>
</tbody>
</table>

9 The economic complexity of a country is dependent on the complexity of the products it exports. A country is considered “complex” if it exports not only highly complex products, but also a large number of different products. Product Complexity is determined by calculating the average diversity of countries that make a specific product, and the average ubiquity of the other products that these countries make. Diversity is a measure of how many different types of products a country is able to make while ubiquity measures the number of countries that are able to make a product. For a formal illustration of this concept, see http://atlas.cid.harvard.edu/about/glossary/.
FDI is another important dimension of Croatian international economic integration. Analysis of the FDI characteristics showed a small part of inward FDI is in knowledge-intensive or R&D-performing sectors. FDI inflows have been motivated primarily by the opportunities that have arisen from privatization and market access. While, in countries such as the Czech Republic, Hungary and the Slovak Republic, FDI implied a substantial shift in production and export structures and facilitated integration in European production networks, FDI in Croatia was concentrated predominantly in non-tradable sectors such as financial intermediation, which unlike manufacturing, present little opportunity for knowledge spillovers.\(^\text{10}\). Moreover, little investment was directed to newly established companies.\(^\text{11}\)

The distribution of inward FDI across sectors had two phases: manufacturing accounted for more than 70% of total FDI between 1990 and 1998, while in the period 2000-2013, FDI was mostly oriented towards services (e.g. banking, trade, real estate services and telecommunications). In common


with other countries in South-Eastern Europe, the Croatian banking sector is characterized by high foreign penetration (over 90% of bank assets) (Bartlett and Prica, 2011). When observing the sectorial distribution of inward FDI for 2000-2013, it can be noted that finance (33%) and trade (11%) accounted for the bulk of FDI inflows to Croatia, followed by the combined shares of extractive industries and utilities (15%), owing to the acquisitions of important stakes in formerly state-owned companies. Hotels and restaurants and real estate activities accounted for about 8% of FDI inflows.

According to the OECD, the past decade has seen a worldwide surge in FDI in R&D. In Croatia, a number of recent policy initiatives may help facilitate international investment in R&D, including tax incentives and other support foreseen in the Act on Investment Promotion and Development of the Investment Climate and the establishment of the Agency for Investment and Competitiveness (European Commission, 2013).

2.2. Business sector competitiveness

2.2.1. Global competitiveness performance

With regards to the barriers and facilitators of business activity in Croatia, the World Bank’s “Doing Business” surveys provide an annual cross-country assessment of business regulations. In 2014 doing business rank Croatia was 67th out of 189 countries, and in 2015 65th, which shows a slight improvement (World Bank, 2014; World Bank, 2015). Starting a business rank of Croatia is worse off in 2015 (88th) compared to 2014 (85th). Although the number of administrative procedures involved in starting a business decreased over time, the pace of change in Croatia is slower than elsewhere. The distance to frontier score aids in assessing the absolute level of regulatory performance and how it improves over time while it shows the distance of each economy to the “frontier,” which represents the best performance observed on each of the indicators across all economies in the Doing Business sample since 2005. Compared to 2014, this indicator for Croatia increased by 0.71% in 2015, which represents a slight improvement.

A comprehensive top-down analysis of innovation performance in Croatia and in the EU, as well as global perspective is provided by the Innovation Union Scoreboard (IUS), the Global Innovation and Global Competitiveness reports. According to the IUS 2015, Croatia has been defined as moderate innovator placing it on the 23rd place among the member states and putting it in the third performance group (out of four) together with Cyprus, Czech Republic, Estonia, Greece, Hungary, Italy, Lithuania, Malta, Poland, Portugal, Slovakia and Spain.. Group is composed of the countries where the innovation performance is below that of the EU average at relative performance rates between 50% and 90% of the EU average. Croatia’s innovation performance has improved in comparison to 2014, but at rate below that of the EU, meaning that country’s relative performance has decreased.

Croatia is performing below the EU average in most dimensions, but above the EU average in Human resources, due to above average performance in New doctorate graduates and Youth with upper secondary level education. The weakest performing dimensions are Open, excellent and attractive research systems and Intellectual assets. For four indicators performance is above the EU average, with Non-R&D innovation expenditures being the strongest of these.

Significant performance increases in dimensions are observed in Linkages and entrepreneurship (9.5%), Open, excellent and attractive research systems (8.3%) and Human resources (8.1%), with the largest improvement for Community trademarks (26%) at the indicator level. Performance has worsened slightly in Economic effects, Innovators and Finance and support, with the indicators declining most being PCT patent applications and License and patent revenue from abroad.
Croatia’s global competitiveness can also be assessed through the World Economic Forum (WEF) Global Competitiveness Index (GCI). WEF Global Competitiveness Report 2014-2015 ranks Croatia at 77th place among 144 observed countries and at 87th place according to the Innovation and sophistication factors sub-index. Compared to some countries from comparator group, belonging as Croatia to the group of “moderate innovators” and also the EU members (Italy, Hungary and Czech Republic), Croatia stands poorer. Czech Republic is on the 37th place, Italy on 49th and Hungary on 60th place among 144 countries.

2.2.2. Firm demographics

Croatian enterprise sector in 2013 numbered 146,292 registered enterprises, and 145,904 out of them are SMEs (2014 SBA Fact Sheet). Distribution of the number of firms, employment and value added across firm size is similar in Croatia to that of the EU. Small and medium-sized enterprises (SMEs) account for over 99% of firms. Importantly, while Croatia’s SMEs account for a greater share of employment than the EU28 SMEs (67.9% and 66.9%, respectively), the shares of value added show a reverse relation (54.1% in Croatia and 58.1% in the EU28), which is an indication that Croatia’s SMEs are less productive than SMEs in the rest of the EU.

Also, Croatian SMEs are less productive than their counterparts elsewhere in the EU, especially in traditional SME-relevant sectors such as construction and tourism, but also in high-tech manufacturing and knowledge-intensive services (European Commission, 2013).

The ratio of new businesses to the total number of businesses (firm birth rate) is an indicator that may be suggestive of the country’s entrepreneurial potential. Firm entry may be motivated by the identification of market niches and/or the commercialization of new products, services or business processes that provide opportunities for firm growth. However, it may also reflect an inflexible labour market, with the primary motivation behind firm formation the provision of employment for its founders.

Figures 5 and 6 compare high growth firms and gazelles for Croatia and some selected countries. Results suggest that Croatia visibly lags behind in terms of both high growth firms and gazelles. Conclusively, it can be stated that there are weaknesses in the mechanism of firms’ formation and growth of firms in Croatia which cause underperformance of Croatian entrepreneurs.

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OECD definitions: High growth firms are firms having an annual growth rate of 20% or more as measured in sales revenue or number of employees in the period of three years, with ten or more employees in the beginning year of observation. Gazelles are high growth firms which are not represented on the market for more than 5 years.
2.2.3. Gross value added and employment by economic activities

Economic activity in Croatia is currently dominated by service industries, with the overall share of services accounting for about 57% of employment and 55% of value added in 2012. Industry (mining, manufacturing and utilities) accounts for just over 31.5% of employment and 38% of value added in the same year. Within industry, manufacturing is the leading industrial activity with around 26% of employment and 24% of value added.

Most manufacturing employment in Croatia is in low and medium-low technology, and the country’s overall distribution is more similar to that of Poland and Estonia than to that of Slovenia or the Czech
Republic. In relative terms, Croatia had the lowest share of high-technology manufacturing employment in the comparator group (less than 1%) and above Estonia only in terms of the share of employment in medium-high technology sectors.

When analyzing services, they are divided into those that use high-level knowledge and skills (KIS) and those that use lower levels of knowledge (LKIS). In Croatia, the largest share accounts to activities that have low levels of knowledge used, which are employing 350,078 people. Services with the need for a high level of knowledge are divided into financial (KIS-FIN), sales (KIS-MKT) and other services (KIS-OTHER) while the highest level of knowledge is required in activities KIS-HIGH-TECH, which employ 29.6 thousand people. The largest number of employees is present in the service sector, in particular those with low or high knowledge component (LKIS – 350,096, KIS-OTHER – 324,096). At the same time those groups of activities also have the largest shares of scientists employed (KIS OTHER has 67560 and LKIS 15,170). All industries combined, regardless of the technological level, employ only 10,040 scientists and experts. With a share of 1.73% of the total number of employees, Croatia has a higher proportion of employment in hi-tech industries of the EU average, which is 1.1%. The share of employment in KIS hi-tech sector in the EU is a bit higher than in Croatia (2.53%) and amounts to 2.73%.

Most human resources are present in services, rather than production activities, which is a result of a lack of investments in the development of the industry in the previous period, which would have required employment of highly educated staff, particularly engineers. Services KIS-OTHER include veterinary services, public administration, defense, compulsory insurance, education as well as health, arts and recreation, most jobs that are considered relatively “safe” and which managed to attract a large number of highly educated people in the periods in which there was a decline in demand in the industry.

In a ten-year period from 2001 to 2011, Croatia as well as relatively comparable European countries\(^\text{13}\), manifested notable structural changes in terms of value added across sectors. Croatia was the only country in which value added in manufacturing decreased, whereas for example in the Slovak Republic and the Czech Republic it increased by 14 and 11 percentage points. However, value added in the services sector increased significantly in contrast with most peer countries.

### 2.2.4. International trade and RCA by economic activities

The main characteristics of international trade in Croatia are: significant growth in trade in last twenty years, high level of trade deficit in goods, strong export concentration, high importance of services exports.

In the analysis of merchandize trade, two opposite cycles should be especially mentioned, one before the global recession began (up until 2008), and the second after it began (after 2008). In the period until 2008 foreign trade had significantly grown. The growth of import has been given credit for this. With liberalization and opening the domestic market the import sector has grown as a result of the weakened domestic production. These trends have caused certain movements in international trade in the foreign trade balance in which a big foreign trade deficit has been achieved. Its value in kunas in 2008 was 4.9 times higher in comparison to 1995. Changes in foreign trade trends were brought by the global recession which began mid 2008. Foreign demand fell during the crisis on world markets. In 2009 export decreased by 16.0%. At the same time a weakened domestic demand significantly reduced import (by 23.9%). Following a sharp decrease of exports and imports in 2008 and the first half of 2009, the second half of 2009 brought a stabilization. Export and import trends were slightly positive in the period 2010-2014. In that period export increased by 26.2%, and import by 20.0%. A

\(^{13}\) Comparable in terms of size, position and/or economic indicators related to growth and development. The comparator group includes Austria, Czech Republic, Estonia, Finland, Hungary, Poland, Slovak Republic and Slovenia.
higher increase in export than in import resulted in the improvement of trade balance in goods. The export-import coverage ratio increased from 57.7% to 60.6%.

A distinguishing feature of Croatia's economy is the importance of services exports. While similar countries export a greater value of goods than the value of services, Croatia's services exports are about equal to its goods exports. Croatia's services exports are, though, unusually concentrated in tourism, whereas high income countries' services exports are more heavily concentrated in business services. In the period 2010-2014 services exports in Croatia increased by 19.6%. With its share expanding from 68% in 2000 to 73% in 2014 travel dominates commercial services exports.

The latest trends in total trade (goods and services) show that in 2013 positive changes can be observed, where exports of goods and services grew 3% in volume change over previous period. The positive trend increased further in 2014 with a 6.3% growth resulting with the total exports of goods and services value of 19.7 billion EUR. Exports in 2014 show a higher value when compared with values in 2005 (12.2% higher) and 2010 (11.8% higher). In 2014 the total trade balance was positive and the export-import coverage ratio accounted 104.6%.

The product-space map of Croatia reveals a moderate level of structural transformation over the past two decades. Using the tools pioneered by Hidalgo et al, there are close to 800 tradable products in which Croatia has a Revealed Comparative Advantage (RCA) in 1992-1993, 2001-2002 and 2011-2012. Table 3 shows that the number of apparel and footwear exports with RCA>1 decreased from 21 to 13 over the last 10 years; similarly the number of exports with RCA>1 related to the chemicals industry has dropped by half, from 24 to 12. In contrast, the number of products with RCA>1 has increased the most in the higher-technology machinery sector, from 15 to 43. While the top export has remained “ships, boats, other vessels”, the churning is reflected in the shifting significance of top exports. Sawn wood, certain apparel and footwear, and aluminium alloys have become less significant now than 10 or 20 years ago, overtaken by products like medicaments and electrical transformers. The latter are products in which Croatia has performed better (or attained more than its fair share) in world markets compared to the export performance of the world as a single economic unit. Nonetheless, Croatia has begun to have a foothold in advanced manufacturing activities.

Over the past decade, in nominal terms, the apparel sector has had the slowest growth rate among all the sectors. In contrast, the chemicals-related exports increased nearly three-fold in value, even though the number of exports decreased, suggesting that there was greater consolidation around some successful products. The machinery and equipment industries within manufacturing has clearly been the best performing sector over the past decade both in terms of aggregate growth and the number of products with enhanced competitiveness.

### Table 3 Number of exports with RCA>1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01. Food and beverages</td>
<td>36</td>
<td>32</td>
<td>39</td>
</tr>
<tr>
<td>02. Agricultural raw materials</td>
<td>14</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>03. Fuel, ores, metals</td>
<td>16</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>04. Chemicals</td>
<td>24</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>05. Material-based manufactures</td>
<td>51</td>
<td>52</td>
<td>47</td>
</tr>
<tr>
<td>06. Machinery &amp; Equipment</td>
<td>15</td>
<td>29</td>
<td>43</td>
</tr>
<tr>
<td>07. Apparel, footwear</td>
<td>21</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>08. Other manufactures</td>
<td>15</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>192</strong></td>
<td><strong>190</strong></td>
<td><strong>199</strong></td>
</tr>
</tbody>
</table>

Source: Calculated by Ferrantino et al. (2014) based on data from UN Comtrade.

---

The identification of new high-value exports begins with stock-taking of the relative performance of existing exports. Table 4 filters products through the lens of significance in four categories. We define “significant” exports as those that had RCA>1 in both 2001-2002 and 2011-2012. There were 135 of these at the SITC 4-digit level, with 10 accounting for a quarter of the country’s export earnings in 2012. The most important export concerns shipbuilding, followed by electrical transformers, sawn wood, aluminum alloys, and chemical fertilizers. Further, we define “emerging” exports as those that had RCA<1 in 2001-2002 but RCA>1 in 2011-2012. There were at least 64 of these, including a prominent category of medicaments, specialized industrial machinery, leather articles and engine parts.

These four emergent products alone accounted for 7% of merchandise earnings in the period 2011-2012. What is positive about this list is that more than half of the 12 top emerging exports are also deemed to be highly complex in the amount of knowledge and capabilities they require. Indeed, specialized industrial machinery was ranked the world’s most complex export to produce. Hundreds of Croatia’s exports are identified as “marginal”, but only 26 had a share of more than 0.1% in national exports in recent years. This is clear an indication that these marginal exports are potentially not so marginal, after all. Many are likely to evolve into emergent exports and possibly become the mainstay of Croatian trade, such as motor vehicle accessories, electrical appliances, parts of internal combustion engine, taps, valves for industrial pipe, diodes & transistors. These are all fairly complex in production technique, and can potentially become part of global value chains. Among notable marginal is also an agricultural product: soya beans that contributed about 0.25% to total earnings in the period 2011-2012.

Table 4 Evolution of significance of exports from 2002 to 2012

<table>
<thead>
<tr>
<th>Status</th>
<th>SITC Code</th>
<th>Product</th>
<th>RCA in 2002</th>
<th>RCA in 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant</td>
<td>7932</td>
<td>Ships &amp; boats</td>
<td>22</td>
<td>9.6</td>
</tr>
<tr>
<td>Significant</td>
<td>7711</td>
<td>Electrical transformers</td>
<td>8.5</td>
<td>18.9</td>
</tr>
<tr>
<td>Significant</td>
<td>2483</td>
<td>Wood of non-coniferous species, sawn, planed, tongued, grooved, etc.</td>
<td>23.8</td>
<td>33.4</td>
</tr>
<tr>
<td>Significant</td>
<td>6842</td>
<td>Worked aluminum &amp; aluminum alloys</td>
<td>3.7</td>
<td>4.9</td>
</tr>
<tr>
<td>Significant</td>
<td>5621</td>
<td>Nitrogenous fertilizers</td>
<td>10.9</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>7938</td>
<td>Special floating structures</td>
<td>7.8</td>
<td>4.9</td>
</tr>
<tr>
<td>Significant</td>
<td>8211</td>
<td>Chairs &amp; seats</td>
<td>4</td>
<td>4.6</td>
</tr>
<tr>
<td>Significant</td>
<td>2820</td>
<td>Iron &amp; steel waste</td>
<td>2.4</td>
<td>5.2</td>
</tr>
<tr>
<td>Significant</td>
<td>612</td>
<td>Refined sugar</td>
<td>14.2</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>7731</td>
<td>Electric wire</td>
<td>2.3</td>
<td>2.4</td>
</tr>
<tr>
<td>Significant</td>
<td>980</td>
<td>Edible products N.E.S.</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>8510</td>
<td>Footwear</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>5629</td>
<td>Fertilizers</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>6612</td>
<td>Cement</td>
<td>16.6</td>
<td></td>
</tr>
<tr>
<td>Marginal</td>
<td>9710</td>
<td>Gold, non-monetary</td>
<td>0</td>
<td>0.9</td>
</tr>
<tr>
<td>Marginal</td>
<td>7849</td>
<td>Other vehicles parts</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Marginal</td>
<td>7721</td>
<td>Switchboards, relays &amp; fuses</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Marginal</td>
<td>8939</td>
<td>Miscellaneous articles of plastic</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Marginal</td>
<td>7492</td>
<td>Valves</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Marginal</td>
<td>7139</td>
<td>Piston engines parts N.E.S.</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Marginal</td>
<td>7763</td>
<td>Diodes &amp; transistors</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Emerging</td>
<td>5417</td>
<td>Medicaments</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Emerging</td>
<td>7284</td>
<td>Specialized industry machinery &amp; parts N.E.S.</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Emerging</td>
<td>6129</td>
<td>Other articles of leather</td>
<td>63.3</td>
<td></td>
</tr>
<tr>
<td>Emerging</td>
<td>7149</td>
<td>Parts of gas &amp; reaction engines</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Emerging</td>
<td>5530</td>
<td>Perfumery &amp; cosmetics</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Emerging</td>
<td>7499</td>
<td>Non-electric parts of machinery N.E.S.</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Emerging</td>
<td>3510</td>
<td>Electric current</td>
<td>2.3</td>
<td></td>
</tr>
</tbody>
</table>
The distance between products on the Product Space map is used to compute how closely they are surrounded by the currently competitive basket of goods. Higher density implies the ease with which existing capabilities can be used to export products. We calculate which products identified as marginal in the preceding analysis are closest to Croatia’s existing export basket with RCA. Table 5 lists 26 marginal exports with a share of at least 0.1%. At least 22 of these products belong to manufacturing, with an overwhelming majority belonging to the category of machinery and transport equipment. This includes products as varied as lifting and loading machinery, switchboards, relays and fuses, piston engine parts to auto parts and mechanical tools for building.

### Table 5 Prominent marginal exports with high density

<table>
<thead>
<tr>
<th>SITC Code</th>
<th>Product</th>
<th>Density&lt;sup&gt;15&lt;/sup&gt;</th>
<th>Share in 2012</th>
<th>RCA 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1121</td>
<td>Wine</td>
<td>0.33</td>
<td>0.12</td>
<td>0.6</td>
</tr>
<tr>
<td>8124</td>
<td>Lighting fixture &amp; lamp parts N.E.S.</td>
<td>0.32</td>
<td>0.1</td>
<td>0.5</td>
</tr>
<tr>
<td>5834</td>
<td>Polyvinyl chloride</td>
<td>0.32</td>
<td>0.12</td>
<td>0.8</td>
</tr>
<tr>
<td>6991</td>
<td>Base metal locksmiths wares N.E.S.</td>
<td>0.31</td>
<td>0.1</td>
<td>0.5</td>
</tr>
<tr>
<td>8939</td>
<td>Miscellaneous articles of plastic</td>
<td>0.31</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>7442</td>
<td>Lifting &amp; loading machinery</td>
<td>0.30</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>7849</td>
<td>Other vehicles parts</td>
<td>0.30</td>
<td>1.09</td>
<td>0.5</td>
</tr>
<tr>
<td>7721</td>
<td>Switchboards, relays &amp; fuses</td>
<td>0.29</td>
<td>0.96</td>
<td>1</td>
</tr>
<tr>
<td>7492</td>
<td>Valves</td>
<td>0.29</td>
<td>0.32</td>
<td>0.7</td>
</tr>
<tr>
<td>7139</td>
<td>Piston engines parts N.E.S.</td>
<td>0.29</td>
<td>0.32</td>
<td>0.8</td>
</tr>
<tr>
<td>114</td>
<td>Poultry meat</td>
<td>0.28</td>
<td>0.11</td>
<td>0.7</td>
</tr>
<tr>
<td>7821</td>
<td>Trucks &amp; vans</td>
<td>0.28</td>
<td>0.12</td>
<td>0.2</td>
</tr>
<tr>
<td>7452</td>
<td>Non-electrical machines parts N.E.S.</td>
<td>0.27</td>
<td>0.23</td>
<td>0.8</td>
</tr>
<tr>
<td>7783</td>
<td>Auto parts</td>
<td>0.27</td>
<td>0.13</td>
<td>0.5</td>
</tr>
<tr>
<td>7649</td>
<td>Parts of telecom &amp; sound recording equipment</td>
<td>0.27</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>7493</td>
<td>Mechanical tools for building</td>
<td>0.27</td>
<td>0.12</td>
<td>0.4</td>
</tr>
<tr>
<td>6940</td>
<td>Nails, nuts &amp; bolts</td>
<td>0.27</td>
<td>0.18</td>
<td>0.8</td>
</tr>
<tr>
<td>7781</td>
<td>Batteries</td>
<td>0.26</td>
<td>0.11</td>
<td>0.5</td>
</tr>
<tr>
<td>6954</td>
<td>Interchangeable hand and machine tools</td>
<td>0.26</td>
<td>0.12</td>
<td>0.6</td>
</tr>
<tr>
<td>9710</td>
<td>Gold, non-monetary</td>
<td>0.26</td>
<td>1.16</td>
<td>0.9</td>
</tr>
<tr>
<td>7415</td>
<td>Air conditioning machines</td>
<td>0.26</td>
<td>0.11</td>
<td>0.5</td>
</tr>
<tr>
<td>7234</td>
<td>Construction &amp; mining machinery</td>
<td>0.26</td>
<td>0.16</td>
<td>0.4</td>
</tr>
<tr>
<td>5989</td>
<td>Chemical products</td>
<td>0.23</td>
<td>0.22</td>
<td>0.3</td>
</tr>
<tr>
<td>2222</td>
<td>Soya beans</td>
<td>0.23</td>
<td>0.24</td>
<td>0.8</td>
</tr>
<tr>
<td>7929</td>
<td>Aircraft equipment parts N.E.S.</td>
<td>0.21</td>
<td>0.13</td>
<td>0.4</td>
</tr>
<tr>
<td>7763</td>
<td>Diodes &amp; transistors</td>
<td>0.20</td>
<td>0.3</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<sup>15</sup> The "density" is defined as a new product’s proximity to a given country’s current set of products. A high density reflects that a country has many developed products surrounding the unoccupied product j. Density values can range from 0 to 1, with the highest margin corresponding to the closest products and hence pointing to a larger probability that respective products will be included in the country’s exports in the future.
Croatia also has an advantage in processed food and beverages. The list of high-potential marginal exports also includes processed food and beverages such as wine and poultry meat. In many trade classifications, processed food and beverages are subsumed in the broader category of primary (agricultural goods). Yet, processed foods have highly desirable properties: First, the income and price elasticity’s of demand for processed food are higher compared to most traditional primary agricultural products; therefore diversification of the export mix into this commodity category can bring in faster export growth combined with terms of trade gains; the second, final stages of food processing is labor-intensive, in contrast to minerals or other material-based manufacturing, helping create jobs; and third, processed food products typically have a greater domestic input content, and hence a greater potential for domestic value addition.

Building on the history of food being a strategic sector, Croatia is well-placed geographically to become a pan-European food hub; as pointed out by MGI (2013), labor costs are about a quarter of those in Western Europe, and savings in materials and other costs outweigh higher transportation costs. This would require fresh investments to consolidate and modernize contract farming, and provide know-how and capital for state of the art techniques.

Finally, among Croatian exports that have some of the desirable traits mentioned above, yet are far from the competencies acquired by the existing export basket are products such as aircraft equipment parts N.E.S., chemical products, heterocyclic compound nucleic acid; drawing & mathematical calculating instruments, pro-vitamins & vitamins, and scientific instruments N.E.S. Note that all these products are highly complex, and share many of the desirable properties in terms of growth and stake in world trade. While they are being produced in Croatia in small quantities they could be candidates for scaling up.

A closer look at few key sectors sheds further light on the potential for Croatia to develop in the context of Global Value Chains. In transport vehicles, parts and equipment, Croatia missed the FDI inflow in this sector in the 1990s and early 2000s because of the war, and not having a strong automotive production base before the 1990s to be attractive in the first place for brownfield investment. Meanwhile, Croatia’s emerging success in several industrial machinery and electronic products could work in its favor. The nature of procurement of parts and components within global production networks differs between the automotive and other manufacturing industries. While it is not clear to what extent Croatia is already part of global value chains in the non-auto industries, the overall export of parts and components has more than tripled in the past decade, from about 0.6 billion USD to over 2 billion USD. This marks a respectable nominal growth (13% per year), but is still low compared to peer countries in the region such as Latvia (22.4%), Lithuania (17%), Poland (18%), Serbia (24%) and the Slovak Republic (22%). However, the share of parts and component exports in overall manufactured exports in Croatia is higher than in some peers (Figure 7).

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In conclusion, Croatia’s positioning in GVCs, both in terms of products and markets is optimistic for the country, but much more effort must be put for the potentials to be maximized.

### 2.2.5. Manufacturing and natural resources

In order to determine which activities are important for the Croatian manufacturing industry, performance of the activities was analyzed and the results are shown in Table 6.
<table>
<thead>
<tr>
<th>Activity (NACE rev. 2)</th>
<th>Technological Intensity</th>
<th>EBITDA* per person employed (thousand EUR)</th>
<th>Ratio of exports and imports</th>
<th>Share of exports in total revenue of each activity (%)</th>
<th>Share of gross value added in total gross value added of Manufacturing (%)</th>
<th>Share of number of persons employed in total of Manufacturing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C – Manufacturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations</td>
<td>high</td>
<td>11.13</td>
<td>1.812</td>
<td>34.54</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>C26 - Manufacture of computer, electronic and optical products</td>
<td>high</td>
<td>8.79</td>
<td>0.879</td>
<td>41.27</td>
<td>3.19</td>
<td>2.62</td>
</tr>
<tr>
<td>C20 - Manufacture of chemicals and chemical products</td>
<td>medium high</td>
<td>1.37</td>
<td>1.387</td>
<td>45.06</td>
<td>2.35</td>
<td>3.20</td>
</tr>
<tr>
<td>C27 - Manufacture of electrical equipment</td>
<td>medium high</td>
<td>9.76</td>
<td>1.886</td>
<td>53.14</td>
<td>4.62</td>
<td>4.00</td>
</tr>
<tr>
<td>C28 - Manufacture of machinery and equipment n.e.c.</td>
<td>medium high</td>
<td>7.24</td>
<td>2.641</td>
<td>52.47</td>
<td>3.81</td>
<td>4.77</td>
</tr>
<tr>
<td>C29 - Manufacture of motor vehicles, trailers and semi-trailers</td>
<td>medium high</td>
<td>5.14</td>
<td>1.028</td>
<td>54.35</td>
<td>1.06</td>
<td>1.32</td>
</tr>
<tr>
<td>C30 - Manufacture of other transport equipment</td>
<td>medium high</td>
<td>39.79</td>
<td>3.193</td>
<td>31.60</td>
<td>12.30</td>
<td>5.25</td>
</tr>
<tr>
<td>C19 - Manufacture of coke and refined petroleum products</td>
<td>medium low</td>
<td>54.27</td>
<td>32.223</td>
<td>33.24</td>
<td>12.56</td>
<td>3.93</td>
</tr>
<tr>
<td>C22 - Manufacture of rubber and plastic products</td>
<td>medium low</td>
<td>6.27</td>
<td>0.748</td>
<td>27.93</td>
<td>1.99</td>
<td>2.94</td>
</tr>
<tr>
<td>C23 - Manufacture of other non-metallic mineral products</td>
<td>medium low</td>
<td>8.73</td>
<td>1.521</td>
<td>33.18</td>
<td>4.48</td>
<td>4.52</td>
</tr>
<tr>
<td>C24 - Manufacture of basic metals</td>
<td>medium low</td>
<td>19.02</td>
<td>1.322</td>
<td>49.84</td>
<td>2.61</td>
<td>2.13</td>
</tr>
<tr>
<td>C25 - Manufacture of fabricated metal products, except machinery and equipment</td>
<td>medium low</td>
<td>6.49</td>
<td>2.237</td>
<td>42.02</td>
<td>8.98</td>
<td>12.01</td>
</tr>
<tr>
<td>C33 - Repair and installation of machinery and equipment</td>
<td>medium low</td>
<td>47.72</td>
<td>4.090</td>
<td>15.19</td>
<td>5.46</td>
<td>2.35</td>
</tr>
<tr>
<td>C10 - Manufacture of food products</td>
<td>low</td>
<td>6.94</td>
<td>0.998</td>
<td>15.51</td>
<td>14.04</td>
<td>19.53</td>
</tr>
<tr>
<td>C11 - Manufacture of beverages</td>
<td>low</td>
<td>19.22</td>
<td>1.002</td>
<td>12.46</td>
<td>4.59</td>
<td>2.69</td>
</tr>
<tr>
<td>C13 - Manufacture of textiles</td>
<td>low</td>
<td>2.57</td>
<td>1.106</td>
<td>35.24</td>
<td>0.70</td>
<td>1.55</td>
</tr>
<tr>
<td>C14 - Manufacture of wearing apparel</td>
<td>low</td>
<td>1.85</td>
<td>3.152</td>
<td>61.13</td>
<td>2.49</td>
<td>6.81</td>
</tr>
<tr>
<td>C15 - Manufacture of leather and related products</td>
<td>low</td>
<td>0.35</td>
<td>1.342</td>
<td>81.00</td>
<td>1.16</td>
<td>3.73</td>
</tr>
<tr>
<td>C16 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials</td>
<td>low</td>
<td>2.97</td>
<td>1.342</td>
<td>47.63</td>
<td>2.33</td>
<td>5.32</td>
</tr>
<tr>
<td>C17 - Manufacture of paper and paper products</td>
<td>low</td>
<td>-7.61</td>
<td>1.211</td>
<td>36.80</td>
<td>0.74</td>
<td>1.59</td>
</tr>
<tr>
<td>C18 - Printing and reproduction of recorded media</td>
<td>low</td>
<td>6.29</td>
<td>0.785</td>
<td>8.28</td>
<td>2.00</td>
<td>2.63</td>
</tr>
<tr>
<td>C31 - Manufacture of furniture</td>
<td>low</td>
<td>2.07</td>
<td>2.059</td>
<td>39.77</td>
<td>1.76</td>
<td>4.03</td>
</tr>
</tbody>
</table>

Source: Calculations of Ministry of Economy based on data from Financial Agency (Fina).
High technology activities show relative big values of EBITDA per person employed. From the group of medium high technology, all activities were profitable. When observing the relation between EBITDA per person employed and the ratio of exports and imports, there appears to be a significant positive correlation between the two variables, which suggest that higher export propensity in general pairs with higher profitability levels of the sectors.

More than third of the total revenue generated in the manufacturing industry comes from exports (34.54% in 2012). There are differences among activities in the same group of technology level considering observed data. Most of the high and medium high technology activities have export shares of around half of the total revenue of the sectors. Based on macroeconomic indicators and the results of the industry analysis, it can be expected that export orientation will be one of the main determinants of future industrial growth.

The food and beverage sector has a significant share of the economy and accounts for the largest part of manufacturing in terms of employment and revenue. Even though export accounts for much lesser share of their total revenues than in other industrial sectors, in comparison to other EU countries share of food industry in total goods export is among the highest ones. While such outcome is mainly due to differences in the production structure and consequently the export structure, it nevertheless confirms a very important role of the sector for the overall Croatia’s export competitiveness. Sector is also characterized by the dominance of several major companies with very strong tradition, production assets and know-how. Recent analysis have further confirmed the strategic importance of the sector in terms of its multiplier effect on the total output, by putting it on the third place among all manufacturing sectors. The sector has strong regional presence, most notably in City of Zagreb and Zagreb County, Varaždin County and Osijek-Baranja County.

Marine and fresh water fisheries represent important food industry sectors in Croatia. The fishing industry includes sea fishing, fish farming and producers of fish feed - the entire value chain from ‘sea to table’. Estimates of the direct GDP share of fisheries vary between 0.2% and 0.7%; however, the sectors’ real contribution is under-rated and, if the value of accompanying activities is included, the contribution to national GDP exceeds 1%. The whole fisheries sector employs around 25,000 people either directly or indirectly. Data show that total catches and production have doubled in period 2005-2014, with similar trend in export, indicating that strong sector’s development in last decade has taken place. Aquaculture represent particularly important sector with significant potential for the overall fishery industry. By 2010 the share of aquaculture in the total fishery production exceeded 21 percent, which is higher than the EU average of 20.4 percent.

Production of pharmaceuticals is one of the leading manufacturing sectors in terms of technological sophistication, R&D investments, export orientation and profit. Currently, the pharmaceutical sub-sector employs around 4,500 people in 37 companies, but when also taking into account the wider supply chain, this number increases to about 10,000 people with overall annual revenue of over 700 mln EUR. Sector is dominated by several large companies, among which Pliva is best known, particularly due to the discovery of the innovative antibiotic azithromycin. Sector’s employment level has increased in last five years (2009-2014) for 8% and average yearly investment in R&D has reached 5.5% of the total revenue. Problems with payments collection on the domestic market have further stimulated companies to explore foreign markets and increase their export activities with expected share of export in total revenues reaching 80% in 2015. According to the Association of pharmaceuticals producers, in 2014 around 280 mil EUR worth investments were realized in this sector, mainly in the increase of production capacities and improvement of technology.

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18 Ibid.
Production of medical equipment and devices is much smaller, but emerging sector which also shows a good performance in area of health industry. This sub-sector employs around 1400 workers in about 200 companies and generates revenue of around 100 mil EUR annually.

Manufacture of fabricated metal products had a positive EBITDA of 6.49 thousand euro per person employed and is significantly export oriented: in 2012 ratio of exports and imports was 2,237 and 42.02% of revenue in the sector was generated by exports. Manufacture of electrical equipment also shows favourable values in profitability (EBITDA of 9.76 thousand euro per person employed in 2012) and export orientation (export/import ratio of 1.886 and 53.14% of revenue generated by exports). Manufacture of machinery and equipment had positive results as well – EBITDA of 7.24 thousand euro per person employed, export/import ratio of 2.641 and share of exports in total revenue of 52.47%. It is evident that the three mentioned sectors had very favourable performance and belong to the group of most successful manufacturing activities of the Croatian economy. One of the particularly successful producers group was the one of defence related suppliers where we have witnessed a very strong export performance over the last decade20. Data from table 4 on significance of exports also reveal that Croatia has strong position in products related to energy sector such as electrical transformers, parts of gas&reaction engines and parts of electric power machinery. Strong legacy of industrial production related to various types of power plants but most notably to construction and equipment of hydro and thermal power plants still represents a very strong potential for Croatia’s future industrial development.

In 2012 transportation products had a share of 9.1% of products exported, with an RCA of 1.1 and 5.1% annual growth rate. Two manufacturing sectors most directly connected with transportation – covering NACE rev. 2 categories C29 - Manufacture of motor vehicles, trailers and semi-trailers and C30 – Manufacture of other transport equipment had a combined share of around 13.36% of gross value added in total gross value added and around 6.57% of persons employed of all manufacturing activities in 2012. The relevance of these sectors is even more significant considering they have medium high technological intensity, are often characterized as not labour intensive and relying on automatization for boosting competitiveness. Both sectors had a positive EBITDA (5.14 and 39.79 thousand euro per worker for C29 and C30, respectively) and a very high export orientation (Ratio of exports and imports was 1.028 for C29 and 3.193 for C30; Share of exports in total revenue was 54.35% for C29 and 31.6% for C30). It should however be noted that other manufacturing activities covering electronics and machinery have close connection and relevance to the transport sector, which gives opportunity for synergic effects between the sectors.

The important part of the manufacturing sector is the automotive industry which is based on a very diversified range of products and on inherited expertise and a strong tradition in the various sectors providing support to the automotive components manufacturing such as metal processing and metal tool production, plastic product manufacturing, glass product manufacturing and textiles. Croatian companies have successfully integrated into the system of supplying spare parts for the world’s top automobile manufacturers (PSA, GM, Fiat, BMW, Audi, Ford, Renault, Toyota, Volvo, etc.). The majority of the manufacturing facilities are located in Istria, Varaždin, Brod-Posavina, Split-Dalmatia and Zagreb counties. Contribution to the automotive industry in Croatia is expressed in terms of number of entities, employment, turnover and value added in the area of automotive components. In line with the number of enterprises and employees, the sub-sector manufacturing parts and accessories for the motor vehicles represents the largest share of the automotive industry in Croatia and generates roughly 80% of all value-added in the automotive sector. This sub-sector is considered as growing sector and defined as “Guardian industry” according the Industrial groups determined by Industrial strategy of the Republic of Croatia 2014-2020. It is estimated that the automotive industry employs 2.103 people, along with the 7.000 people employed in the supporting industries. Average gross wage

20 Recent World Bank Trade analysis indicates that Croatian defence company HS Produkt is exporting “revolvers and pistols” globally. Their products have been licensed and sold in the United States and dozens of other countries and it is receiving a great international attention for its quality.
in the industry was 1.011 euro in 2012. Around 90% of the revenue of the industry is generated through exports and the share of automotive exports in total exports is 1.8%.

The Croatian automotive industry market is, to a large extent, export-oriented since 85-90% of the products are destined for 1st Tier and OEM companies outside of Croatia. Direct contribution from the automotive industry to exports amounts 167 million EUR. Indirect contribution is higher and estimated to 450 million EUR. This indirect contribution comes from 40 to 50 enterprises manufacturing components for the automotive industry but not classified as NACE 29 in official statistics. These enterprises employ between 6000 and 7000 workers. The majority of automotive companies in Croatia are 2nd and 3rd Tier automotive component suppliers. Very few companies in Croatia’s automotive industry are considered to be Tier 1st suppliers (only five Croatian automotive companies: AD Plastik, Boxmark, LTH, Lipik Glass and PPC Buzet). All of these companies have a long tradition in this industry and in that respect they have acquired the necessary quality standard levels (ISO, VDA Germany, EAQF France and QS).

The shipbuilding sector has kept its importance for the overall manufacturing production and export due to the successful process of privatization and restructuring. The majority of the total revenues is created by a small number of high value ships manufactured by a few large shipyards in Croatia. Industrial strategy identifies shipbuilding as one of the key manufacturing industries in Croatia, but at the same time clearly identifies necessity of improvement of current level of productivity and investments in new technology solutions. The three largest companies based on the criteria of total revenues are Brodosplit Shipyard Ltd., Shipbuilding industry 3 Maj Inc. and shipyard Uljanik Inc. Large Croatian shipyards Uljanik, 3. Maj, Brodosplit and Brodotrogir have as per July 31, 2015 43 ships and floating objects on order of total value more than $1.6 bn which corresponds to approximately 600,000 DWT and 480,000 cGT. Most of these ships are product of own R&D capacity in shipyards and are one of the kind ships like Cutter suction dredger, Jack up platform, Passenger Sailing Ship and Navy patrol vessel. In the past 25 years (starting with 1987), the Croatian shipyards have received numerous international awards for the quality of its built ships.

Wood production represent sector with great growth and export potential. Given its natural resources, the wood production and processing sector in Croatia is highly important: the total area of forests and forestland in Croatia amounts to 2.688.688 ha, accounting for 48 % of the total land area. The wood-processing sector in Croatia includes more than 300 companies employing over 25.000 workers, generating total revenues of approximately 1 billion EUR, while export sales generates around 600 million EUR. The export figures show that the wood-processing sector represents almost 7 % of Croatian manufacturing exports and is one of the rare sectors where Croatia achieves trade surplus in goods. Nevertheless, this sector is lagging behind in terms of technological capabilities and usage of innovative and value added solutions in production and therefore requires further support including better cooperation with public R&D sector.

### 2.2.6. Most important service sectors

While most similar countries export a greater value of goods than services, Croatia’s service export is about equal to its goods exports (services/goods ratio is 97%). Between 2000 and 2012 the average annual rates of change have been positive for all service industries. On average, growth rates have been around 2.5 percentage points higher in Croatia than in the EU28. The only exceptions to this general trend were water transport and architectural and engineering services.

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21 Accelerate your business: Invest in Croatian Automotive Industry, Agency for Investment and Competitiveness
22 According to annual reports these five companies had total income of 535.561 000 € with 6081 employed workers in 2014.
24 http://hb.hr/novosti/knjiga-narduzbi/, accessed September 2015
25 A total of 37 awards for built ships (“SHIP OF THE YEAR”) have been assigned to innovative designs, quality and significance of ships built at an international level. Awards were presented by internationally recognized specialized publications:
Croatia’s service export is unusually concentrated in the **tourism industry**, whereas high-income countries’ service exports are more heavily concentrated in business services. With its share expanding from 68% in 2000 to 73% in 2012, travel continues to dominate commercial services exports. Travel services exports grew by on average 10% per year over the period 2000-2012. Nevertheless, travel services exports grew at a much higher yearly rate of 19% in the pre-crisis period 2000-2008. The large share of travel corresponds to its RCA that strongly increased between 2000 and 2009 and is now the highest across all services sub-sectors.

Meanwhile, **transport and other business services** make up a fifth of commercial services exports making them highly important for the overall service export. Transport and other business services both had similar shares of around 10% in 2012 and RCA lower than 1 in the period 2000-2012. Even though data show a fall in volume of transport services since the economic crisis in 2009, having in mind recent recovery of GDP, future positive trends, but also significant increase of investments into the transport infrastructure (mainly from the public sources) we can expect more competitive and better utilized transport infrastructure in coming years leading to increase of revenues from transport services. Latest data for 2013-2014\(^{26}\) confirm that passenger traffic has again started to increase, and some modest recovery of goods transport is finally taking place in 2015.\(^{27}\)

The **Information and communications technology (ICT) industry** has been the source of major productivity gains in recent decades. Characteristics of the ICT industry are innovation and high dependence on continuous technological progress. It is also a source of dramatic change in business practices of other industrial activities. ICT sector in Croatia had 31,388 employees (2012) which were employed in 4,215 companies and based on its current strengths and prospects it is projected to grow 10% annually. Most of the companies are SMEs and have very active R&D. Of the total number of companies in information and communication industry in Croatia, 98.79% are small enterprises. On the other hand 16 large companies (0.38% of all companies) employ 12,673 people or 40.38% of all employees in the industry. Gross value added in industry in 2012 was 1.5 billion EUR. Industry of information and communication in Croatia consists of mostly telecom operators, with the bulk of production and sales of IT services concentrated in large firms and system integrators. The largest share of value added in total value added of industry information and communications industry in 2012 achieved Telecommunications (share of 60.02%), following by Computer programming, consultancy and related activities (18.82%).

The potential of this sector is extremely high due to global demand trends and the integration of ICT in other economic activities. In particular, for last seven years Croatian ICT sector doubled its numbers in export and employment. The ratio of exports to imports remained below 1 in the period of 2010 – 2012, however it was constantly increasing, as well as the share of exports in total revenue. The trend of increasing export orientation is expected to continue in the following years, especially since the domestic market is small and extremely competitive. The Croatian Industrial Strategy 2014 – 2020 stated that this industry has great potential of growth and employment. The highest potential of growth and employment has been detected in Computer programming, consultancy and related activities. Due to that fact, the ICT is recognized as one of the strategic industries by the Croatian Industry strategy 2014 – 2020, taking into consideration employees' skills, technology level, value added, business performance, export and growth potential.

### 2.2.7. Cluster policy and innovation related instruments

Clusters are important building blocks of the S3. Indeed, cluster dynamics are a force for the economic, industrial and technological specialization of a region or country. Clusters and S3 have

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\(^{26}\) CBS, Transport and communication in 2014, Statistical Reports

\(^{27}\) CBS, Transport in second quarter of 2015, First release.
similarities in: 1) a focus on productivity and innovation as key drivers of competitiveness; and 2) an accent on fostering regional approach with a view to capitalize on the advantages of proximity. S3 focuses on specific innovation-intensive sectors while clusters apply to a broader set of sectors in the economy. S3 aims to exploit emerging linkages between economic activities that can cut across traditional cluster boundaries, the transformation of regional economies around new knowledge-based activity domains – while the goal of cluster policies is often to enhance the performance of existing clusters.

Clusters are identified as a powerful instrument for fostering competitiveness and innovation of Croatian economy due to their capacity to support cooperation between different innovation actors. Croatian Cluster policy consists of Business (under responsibility of Ministry of Entrepreneurship and Crafts) and Competitiveness clusters (under responsibility of Ministry of Economy). Business clusters are mainly networking between SMEs with aim to support collaboration internationalization, supplying of raw materials, promotion and etc. Competitiveness Clusters provide a formal collaboration structure based on Triple Helix model (Triple Helix model including: private sector, research organizations and local/regional government that are identified as key success holders for each of identified CC) of identified industrial sectors of Croatian economy.). The main goal is to jointly work on strategic thinking, actions and projects aimed for the involved stakeholders of identified industrial sectors of Croatian economy and raise competitiveness of the whole sectors. This strategic role and Triple Helix model of collaboration is the main distinction between formed business clusters that represent mainly groups of enterprises answering to certain market driven demand or threat and Competitiveness clusters that represent effective collaboration of identified stakeholders to jointly define strategic goals of entire sector and support this through appropriate action plans. One of the good examples of this effective collaboration is initiative of CC for Health industry that joined the largest pharmaceutical manufacturers (PLIVA Inc., JGL Inc., Pliva Inc.) together with supporting research organizations (Faculty of Medicine, Faculty of pharmacy and biochemistry) to discuss possible establishment of Center of competence dedicated to supporting relevant R&D topics of Croatian pharmaceutical industry. Also, Defence industry cluster in 2015 supported EDA (European Defence Agency) in aspect of preparing Defence related stakeholders to answer the Call for proposal “Supporting dual-use technology projects for access to European Structural and Investment Funds co-financing”. This resulted in increased number of applicants (9 project proposals sent to EDA in 2015, compared not one in 2014) and even 2 projects from Croatia (only 6 project proposals were envisaged to be supported from whole EU) were granted the technical support from EDA to prepare their “dual use” projects.

Twelve Croatian Competitiveness clusters were formed in the first half of 2013, for the following industrial sectors: Automotive, Wood-processing, Food-processing industry, Defense, Health, Chemical, Electro and production machinery and technologies, ICT, Maritime, Construction, Textile and Creative and cultural industries (Table 7.)
Table 7 Number of clusters’ members and planned projects

<table>
<thead>
<tr>
<th>Croatian Competitiveness Cluster (CCC)</th>
<th>Private sector</th>
<th>Local and regional authorities</th>
<th>Support institutions (RDA, Croatian Chamber of commerce)</th>
<th>Science and Research organizations</th>
<th>Number of planned projects in Project pipelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCC for Automotive Sector</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>CCC for Wood Processing Sector</td>
<td>53</td>
<td>9</td>
<td>13</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>CCC for Construction Industry</td>
<td>12</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CCC for ICT Industry</td>
<td>22</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>CCC for Textile, Leather Goods and Footware Industry</td>
<td>28</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CCC for Creative and Cultural Industries</td>
<td>23</td>
<td>5</td>
<td>31</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>CCC for Chemicals, Plastics and Rubber Industry</td>
<td>13</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>CCC for Defence Industry</td>
<td>22</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>CCC for Maritime Industry</td>
<td>15</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>CCC for Food Processing Sector</td>
<td>21</td>
<td>11</td>
<td>15</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>CCC for Electrical and Manufacturing Machinery and Technology Sector</td>
<td>25</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>CCC for Health Industry</td>
<td>14</td>
<td>2</td>
<td>3</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>256</strong></td>
<td><strong>36</strong></td>
<td><strong>94</strong></td>
<td><strong>77</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>

Source: Ministry of Economy

The twelve existing competitiveness clusters were the first step for the entrepreneurial discovery process in designing the Croatian S3 and served as a main link for direct involvement of business sector in the process of creating the S3 and project pipelines.
In 2014 Ministry of Economy supported, through national funding, Competitiveness Clusters for activities of preparation of sectoral analysis, strategic guidelines, sectoral mapping, sectoral promotion etc. Competitiveness Clusters were provided support in the amount of 100,000 HRK per Cluster (in total 1.2 mln HRK). Since Clusters are non-profit organizations, support was needed for financing their activities while they are in their early stages of project preparation through which they are expected to ensure their own funding sources in the future period. On the basis of the performance analysis i.e. results evaluation and analysis of expenditures made in the scope of provided funding, a second round of Cluster financing is envisaged through national funding in 2015. Proposed financing amounts per Cluster will take into consideration the Cluster performance and track record and funding will be provided for preparation of tender documentation for RDI projects in Cluster’s sector of activity.

Croatian clusters policy is focused on performing the following list of tasks:

- **Supporting platforms or cluster initiative organizations.** Funding is provided to a secretariat that organizes activities to connect the organizations in the cluster, provides information about markets or relevant government programs, and markets the cluster externally.
- **Supporting collaborative actions.** Funding is provided for specific joint actions by organizations in the cluster, for example a joint R&D effort or the development of a collaborative educational program.
- **Upgrading the cluster-specific business environment.** Eg. Cluster provides funding and support to a research organization of a common interest.
- **Different sectoral cluster programs**
- **Clusters provide project review and selection based on interest of national economy**
- **Clusters will have an important role in future Centers of Competence funding**

Some examples of cluster activities are provided in further text.

**Example of direct benefit to cluster members is networking of its members with available support from technical and financial assistance.** Ministry of Economy and later Ministry of Regional Development and EU funds implemented (in the period 2013-2015) TA project *Preparation of Future Programming Documents and Accompanying Project Pipelines* co-financed through ERDF, RCOP 2007-2013. One component of this project provided assistance in preparation of a number of strategically selected infrastructure projects and national projects identified under the Structural Funds RCOP pipeline. This has covered substantial coaching and training of the applicants in the form of the transfer of methodologies and best practices in project preparation that enabled them to successfully prepare all the documents that are needed in order to apply for and receive the ERDF funding. Croatia initiated policy that Clusters contribute in selection process of high quality projects of national interest (identified through Competitiveness Clusters). Project teams evaluated the submitted proposals based on the maturity of the project, capacity of the beneficiary, sustainability and impact of the project on the national and regional development. The project team produced project development plans (PDPs) for all the selected projects detailing the mode of implementation, the needs for inputs from the beneficiary/applicant, in terms of expertise and timing for each of the selected projects and capacity of the TA support. The PDPs contained the list of all the project documents that are to be produced (such as feasibility studies, cost benefit analysis, environment impact assessment, etc.). The PDPs in particular outlined the needs for support of the projects’ promoters and tailored them according to the capacity of this TA project.

**Based on Clusters’ recommendations, assistance was provided** (within the TA project *Preparation of Future Programming Documents and Accompanying Project Pipelines*) **for the project preparation of the following project ideas:** Centre of Competence Healthy Food Chain at University of Osijek; National reference laboratory for emissions from IC engines and motor vehicles University of Zagreb; INNOTECH Competence Center of Innovative Food Products and National
Culinary in Koprivnica; The Specialized Business Incubator for Creative Industries in Zadar; Expansion, reconstruction and equipping of Centre for technological development (CTD) in Slavonski Brod and The Centre of Competence for development of parts for automotive industry. Support was provided in the form of preparation of some or all of the following documentation: State aid assessment, Feasibility study with financial model and the cost-benefit-analysis, Environmental impact assessment, Tender documentation, Application form for structural funds, Project development / description of the scope of the project / TNA / project structure & management, Technical issues / engineering expertise – preliminary design; Detailed description of technical scope / engineering, architectural support.

Future cluster development is important since it will represent continuous process of entrepreneurial discovery and will contribute to preparation and implementation of thematic-based RDI strategies addressing new societal challenges and creating new competitive advantages through identification of RDI projects with common benefits for one or more priority thematic and sub-thematic areas. CCCs will assist and support the Government in its efforts to improve Croatian position in global value chains combining the assessment of promising products and targeted efforts in areas with reforms that allow market selection to work and entrepreneurial performance to improve, so that competitiveness emerges as a result of entry, exit and specialization.

Competitiveness Clusters will also have an important strategic role regarding the definition of CoCs’ research orientation. In order to be eligible for financing through the pertaining grant scheme planned by the Ministry of Economy, proposed CoCs will be obliged to provide a label from the Cluster of the domain of their envisaged RDI field, through which the Cluster will give confirmation that the CoCs proposed RDI activities are in line with the strategic guidelines of the pertaining sector. This will provide assurance that the CoC’s line of work is industry oriented and ensure demand for their services, ensuring sustainability of the CoC in the future period. Furthermore, in 2017 for the second call of the Ministry of Economy grant scheme for financing RDI projects, Clusters will have an additional important role through giving labels for all collaborative projects proposed for financing through the grant scheme, which will strengthen further their relevance in boosting the connection between the industry and the research sector.

2.3. Research, Development and Innovation (RDI)

2.3.1. Croatian RDI potential

Since 2009, following the global economic and financial crisis, the level of investment in R&D decreased from 1.05 to 0.75% of GDP in 2012, with a slight increase to 0.81% in 2013. Croatia is the only new member states from Central and Eastern Europe whose GERD/GDP is lower in 2013 when compared to 2002. This level of expenditure has stagnated since 2010 and it is well below the EU average of 2.02% (2013). In absolute terms, Croatia spent about 354.7 million EUR in 2013 on R&D (Eurostat, 2014). From total GERD amount, 50.1% comes from the business enterprise expenditure on R&D (BERD), in comparison with the EU average of 63.8%. Investments in R&D from the private business sector (BERD) make a total of 0.41% of the GDP, which is comparable to for example Slovakia (0.38%) and Poland (0.38%), however lower than Czech Republic (1.03%) and Slovenia (1.98%) and also below the EU average (1.28%).

In comparative terms, Croatia had the second-lowest growth rate of GERD (around 0.8%) among all ERA countries over the period 2000-2009. As a result, Croatia did not meet its own target to invest 1% of its GDP in R&D by 2010. Most countries spend around half of GERD on engineering and technology and anywhere between a fifth and a third on the natural sciences. Croatia spends around 39% of GERD on engineering and technology, life sciences follow with 21% and biomedicine and health with 17%. A comparison of the place of performance of R&D, the source of the associated
funding, as well as the breakdown of the government R&D expenditures by sectors of performance shows a dominance of the public sector in R&D expenditure (Figure 8).

Figure 8 GERD performers in Croatia 2013

Source: Eurostat

Analyzing R&D expenditures by major cost categories reveals that over 50% R&D expenditures goes to salaries and wages, while material costs contribute with a little less than 40%, meaning that just less than 10% goes to capital expenditures investment. Funding of these investments mainly comes from R&D institution’s resources. Seker (2011) shows that estimated rates of returns on R&D in Croatia (73%) are at least double the value of returns in infrastructure (between 24-34%) and seven times higher than on education. Higher returns for R&D in Croatia are consistent with the relatively lower stock of R&D capital vis-à-vis the stock of infrastructure and human capital in the country.

The employment rate in “knowledge intensive” sectors was 28% as opposed to the EU average of 40% and it has not changed from 2002 to 2008. A continuation of this trend might result in structural stagnation and a direction not aligned with a sustainable economic growth (OECD, 2014). On the other hand, the share of business sector in the overall R&D activities has been constant at over 40% in the last decade. In terms of the business shares in the R&D activities, Croatia has a steady rise in the last two years and, at 41% shows better results than Poland, Romania, Latvia and Lithuania. The rise in 2013 is important to note since in 2011 Croatia and Slovakia were the only two countries with a decline of BERD compared to the previous decade. This was confirmed by the World Economic Forum’s Global Competitiveness Report that marked a staggering fall in ranks for companies spending on R&D – from 45th place in 2008 to 75th place in 2014. The perception of this decline within the business sector was recognized and marked as important.

Based on the OECD data from 2012, around 3% of state resources are spent on R&D in private sector in Croatia. Compared to the average of 8.9% in OECD countries and 7.2% in EU member states, it is clear that this is a result of a limited use of state aid by the private sector, mostly through tax incentives (OECD, 2014). It is important to note that the previously mentioned increase in 2013 is marking a change of direction due to the transformation of framework conditions inherent to the EU membership, international openness and competitiveness. Perhaps the biggest challenge of all is the strengthening of the policy governance and institutional framework in order to increase RDI spending impact on Croatian economy, since previous public fund allocation points to insufficient result orientation.

2.3.2. Analysis of legal, institutional and fiscal framework for RDI

2.3.2.1. Legal framework for RDI
The legal basis for public and private investments, state aid and tax deductions regarding RDI are stated in various Croatian Acts, Regulations and Guidelines, such as:

- Act on Scientific Activity and Higher Education; Regulation on issuing permits for conducting scientific activity, conditions for reaccreditation of scientific organizations and permit’s content; Regulation on permit’s content and conditions on issuing permits for conducting activities in higher education, delivery of study programs and reaccreditation of higher education institutions.
- Act on investment promotion and development of investment climate, Small Business Act, Act on Promotion of Entrepreneurial Infrastructure and Business Environment

These and related acts and regulations describe and define the authority of state administration bodies and public and private research institutions, including their financial and institutional rights. Moreover, Croatia has joined the Western Balkans Regional R&D Strategy for Innovation. As part of this initiative the countries will implement programs in order to improve the research base and conditions for research excellence, promote science-industry collaboration and technology transfer, enable business innovation and innovative start-ups, and strengthen the governance of national research and innovation policies. The comprehensive, sector-wide approach complements the treatment of other regional initiatives, such as the Danube and Adriatic Ionic Strategies.

2.3.2.2. Institutional framework for RDI

The system of Croatian institutions in charge of governing RDI shares many similarities with other European countries. A higher level of governance in charge of steering and programming innovation policy includes the parliament and three central government ministries: Ministry of Science, Education and Sports (MSES), the Ministry of Economy (MoE) and the Ministry of Entrepreneurship and Crafts (MoEC). Additionally, delivery of some activities has been delegated to a set of different stakeholders. Implementation, monitoring and funding involve various intermediaries in the form of councils, agencies and other public and state bodies, although some funding functions remain in the ministries. The chart depicting the most important players of the Croatian Innovation System is shown in Figure 9.

Figure 9 The most important players of the Croatian Innovation System
Source: MSES based on OECD Report (2014)
The central institution of the Croatian research system is the Ministry of Science, Education and Sports (MSES), which is responsible for the entire research and higher education system. The Croatian Science Foundation (CSF) is the main funding body for competition-based fundamental scientific research since 1 July 2013 when the allocation of competitive research grants was transferred from MSES to the Foundation. It is important to stress out that CSF (and previously MSES) mainly finances fundamental research projects. In addition, CSF develops programmes that support collaboration between research organisations and industry by funding the scientific research with the possible technological application, as well as programmes supporting the future excellent researchers by funding the development of their research careers (since 2014). Furthermore, the Unity through Knowledge Fund (UKF) has been affiliated with the CSF in 2014 in order to maximize its efficiency. UKF is a funding instrument that Croatia introduced since 2006 through the World Bank funded Science and Technology Project. Grants delivered through the UKF programs included a scientific Diaspora28 as well, and were highly internationally competitive providing excellent results in funding R&D for Innovation. More than 70% of researchers from both public and private sectors in Croatia who received the UKF funding also received EU funding through FP7 instruments. Since 2013 MSES allocated around 30 million EUR for development of CSF programmes. However, raising the quality of scientific research in Croatia will require additional effort, with more proactive approaches and instruments at CSF and reform of HEIs and PRIs coupled with systematic monitoring and evaluation of policy support measures.

The highest advisory body for the scientific research, higher education and technology is the National Council for Science, Higher Education and Technology Development established by fusion of previously separated National Science Council (NSC) and the National Council for Higher Education (NCHE). The Agency for Science and Higher Education (ASHE) is responsible for setting up a national network for quality assurance and evaluation of scientific research and higher education. The Agency for Science and Higher Education (ASHE) founded in 2005, now has the external quality assurance competences of the two national councils and is in charge of initial accreditation/reaccreditation, thematic evaluation and audit, and recognition of foreign educational qualifications. ASHE is in charge of setting up a national network for quality assurance in higher education and providing professional assistance to the NSC, NCHE, SHEFC and CESHE. Within ASHE, the National ENIC/NARIC (European Network of Information Centres-National Academic Recognition Information Centres) office operates as a reporting centre for academic mobility and the recognition of higher education qualifications. Since 2009, ASHE is also responsible for collecting information on Croatian higher education and research developments, for providing support for the implementation of the state matura (a secondary-level graduation examination linked to access to university) and for administering the centralised applications and admissions to higher education. ASHE acts as a link to the international and European higher education policy and regulatory community. It is a member of relevant international associations, such as the International Network for Quality Assurance Agencies in Higher Education and the Network of Central and Eastern European Quality Assurance Agencies in Higher Education; it is an associate of the European Association for Quality Assurance in Higher Education (ENQA) (ERAWATCH, 2010). Membership in such bodies serves to transfer international standards, both to ASHE and to the Croatian higher education system.

Vocational education is the responsibility of the Agency for Vocational Education, Training and Adult Education (AVETAE’s) activities are defined by the Vocational Education and Training Act. One of its primary tasks is to develop a modern vocational education and training (VET) system, as outlined in the Vocational Education and Training System Development Strategy of the Republic of Croatia 2008-2013. Another of the Agency’s tasks is the development of adult learning to facilitate labour market inclusiveness. Agency for Mobility and EU Programmes (AMPEU) has implemented EU programmes on lifelong learning since 2009 and currently is NCP for Horizon 2020.

28 The programmes are aiming at the development of research cooperation between Croatian researchers from Croatia and from abroad, with the goal to connect them with international research institutions and to attract the talents in the Croatian research system.
The State Intellectual Property Office (SIPO) is the administrative body with responsibilities for IPR protection. It carries out the procedures for granting industrial property rights (patents, trademarks, industrial designs, geographical indications and designations of origin, topographies of semiconductor products) and performs the accompanying professional and legislative activity. In addition to its legislative and professional activities, a significant part of SIPO’s activities involves provision of information and services relating to intellectual property (IP), co-operation with other institutions to support innovation activity, and co-operation with economic and R&D entities.

The Committee for the Hosting of Foreign Researchers in Croatia (CHFRC) was established in 2009. Its purpose is to facilitate the hosting of foreign researchers participating in research projects in Croatia. The Code of Procedures for the Approval of Temporary Stay permits foreign researchers to work in private and public research and education institutions without a work permit. Moreover, to strengthen co-operation of Croatian researchers with their international peers, the Committee for the Mobility of Researchers (CMR) was also established in 2009 and prepared the action plan for researcher mobility (Švarc and Račić, 2012).

The National Competitiveness Council (NCC) was established in 2002 to improve Croatia’s competitiveness and prepare its entry into the EU. It is an independent advisory body which includes representatives of the government, business and academic sectors, and trade unions. Its recommendations have covered a wide array of policy issues, including education, market regulation, cost competitiveness, innovation, development of SMEs and regional development. The National Council for the Information Society (NCIS) provides advice on proposed strategic and policy documents, laws and projects relating to the information society and also initiates and co-ordinates the activities of various stakeholders. The council has 14 members, with representatives from government, civil society, academia and the business sector.

The Business and innovation agency of Croatia (BICRO), previously central implementation institution for technological development has been merged with the Croatian Agency for Small Businesses and Investments (HAMAG) into a single agency called the Croatian Agency for Small Business, Innovation and Investment – HAMAG-BICRO. The merger was a logical move to better link up-stream and down-stream interventions. The Agency’s activities include the promotion of establishment and development of small business entities, financing operation and development of small business entities by loans and guarantees issuing for approved loans by creditors as well as promotion of investments in small business. The Agency’s also provides financial support to innovative and technology-oriented enterprises in Croatia by increasing commercialization of knowledge and awareness about the value of innovations, supporting the transfer of knowledge and technological solutions from the scientific sector to economy, promoting the establishment and development of technology infrastructure and participation in the creation and development of venture capital industry.

In 2013 the Croatian government launched the Second Science and Technology Project (STP II) a common project of the MSES and World Bank. The aim of the project is to support Croatia to absorb EU Funds in the research and innovation sector through capacity building of selected public sector organizations and stimulating demand for those funds from the business and scientific communities. Project beneficiaries include: policy-makers in the research and innovation sector - particularly MSES, CSF and HAMAG BICRO; and other organizations from the research and innovation sector, including SMEs engaged in research and innovation activities, knowledge-based start-ups and technology transfer offices (TTOs) of Croatian universities and research institutes aiming to improve ESI funds absorption capacity of RDI institutions. This project is partly a follow up of STP I since it finances

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29 SIPO has concluded co-operation and non-disclosure agreements (NDAs) on IP information services and other services with former HIT/BICRO, Ruder Innovations and the CSF. Through its Information Centre (INCENTIV), SIPO provides IP pre-diagnostic services to SMEs (following the methodology of France’s INPI), which include estimating the company’s innovative and IP potential. SIPO also provides information on various aspects of IP to universities, PRLs, public-private research, technology organisations and SMEs.
previously supported programs tailored to maintain and increase the pool of SMEs and researchers that could apply to EU-financed grant schemes. These programs are Program I (PoC - Proof of Concept; Program II (RAZUM - Development Program for Knowledge-Based Companies; Program III (SPREAD - Sponsored Research and Development Program) as well as programmes developed within Unity Through Knowledge Fund including Research Cooperability and Connectivity Program. Also, there’s a new program developed under the STP II - Technology Transfer Office (TTO) Support Program. Objective of this program is to strengthen TTOs in Croatia to perform commercialization related services for researchers and create pipeline of projects in R&D sector in order to apply for EU funds. In 2015, 3 mil EUR is available for RAZUM and 2 mil EUR for SPREAD and PoC programs. The STP II will last until July 30, 2017.

2.3.2.2.1. Research organization and research infrastructure

The national R&D system, besides government bodies responsible for research, innovation policies and their implementation, covers different types of research organisations (RO) that can be divided into research institutes (public and private), higher education institutions (HEIs) and other entities listed in Register of Scientific Organizations like business entities and technology and development centres performing R&D. HEIs in Croatia are composed of universities and polytechnics. Currently there are 122 higher education institutions in Croatia, namely: 7 public universities, 3 private universities, 67 faculties and academies, 3 private polytechnics, 12 public polytechnics, 23 schools of professionally oriented higher education, and 3 public schools of professionally oriented higher education. Furthermore, there are 25 public research institutes (PRI) in Croatia managed by MSES. Apart from PRI’s, there are several private research institutes that are not part of the government sector, even though they might derive a substantial proportion of its income from public procurement and fulfill important public missions. Altogether, there are 184 legal entities recognized as ROs in the MSES registry, including private research organizations.

Research infrastructure, as previously mentioned, takes the smallest share when it comes to R&D investment. Having in mind the continuing decline in the R&D investments, especially during the economic crisis, it does not come as a surprise that the prioritization - focus on human resources and material costs - resulted in outdated and scattered equipment, that needs to be modernized and improved in order to enable high level research. In the period 2001-2009, around 43 million EUR was invested in capital equipment of public ROs by the Croatian government, but since 2010, no financial support from public funds was available to the PROs and HEIs for procurement of capital equipment or improvement of existing research facilities. According to data from the Register of Capital Equipment, an “average age” of the procured capital equipment is eleven years. National research and innovation infrastructure roadmap adopted in 2014\(^ {30} \) represented the first step towards strategic development of RDI infrastructure on national level aiming to coordinate research infrastructure investment policies and to lay down the groundwork for long-term investment planning for research infrastructure. Previously, each public research organization planned the purchase of capital equipment separately.

To improve the situation, Croatia has recently created a pipeline of RDI infrastructural projects in order to prepare their implementation through Structural Funds for the period 2014-2020. Currently, the Strategic document Research Infrastructure Roadmap is being revised in order to be more closely linked to S3 priorities. Other strategically important projects are already on the way, like the (i) Biosciences Technology Commercialization and Incubation Centre (BIOCentre), which is an important tool to support the biotechnology sector and to increase the deployment of Industrial Biotechnology KETs. (ii) Another infrastructural project financed through the Regional Competitiveness Operational Programme 2007-2013 is “Research Infrastructure for Campus-based Laboratories” at the University of Rijeka which will create the potential for commercially exploitable

\(^ {30} \) Croatian Research and Innovation Infrastructures Roadmap, Zagreb, 2014.
research results in several fields (biomedicine, nanotechnologies, mechanics and ICT) as well as answering the priorities defined in national strategic documents.

**Croatia has been a member of the European Strategy Forum on Research Infrastructures (ESFRI) since October 2010.** In line with its strategic roadmap, the priority areas for the development of research infrastructure in the Republic of Croatia are the following:

- biomedicine (neurosciences, immunology and microbiology, biochemistry, genetics and molecular biology, public health);
- biotechnical sciences (biotechnology, forestry and wood technology, sustainable agriculture, fisheries and aquaculture);
- natural sciences (environment sciences, physics and astronomy, chemistry);
- technical sciences (ICT, materials sciences and production technologies, secure, clean and efficient energy);
- social sciences and humanities (societal challenges, demographic changes, inclusive, innovative and secure society, national sciences of special importance (philology, history);
- interdisciplinary sciences.

Despite of the limited financial resources when it comes to research infrastructure, Croatia currently participates in several ESFRI projects: CLARIN, DARIAH, CERIC and ESS. In 2014 MSES took preliminary steps for participation in Teaming 2014-2020 and the first ERC project was awarded in 2014. Also, in 2014, a national procedure was developed regarding creating the legal framework for Croatia’s official membership in European Research Infrastructure Consortiums (ERIC). These projects and ERIC membership present first steps towards achieving the objective set in National research and Innovation Infrastructure Roadmap, e.g. follow European initiatives in the establishment and usage of research infrastructure and actively participate in some relevant infrastructure projects. As such, they represent efforts to remain a relevant/up to date stakeholder at a European level and to prepare for future capital investments at national level. As a result of multilateral agreements, Croatia is a member of the European Molecular Biology Organization (EMBO) and Conference and the European Centre for Medium-Range Weather Forecasts (ECMWF). Croatia is also engaged in the programme of the European Organization for Nuclear Research and European Space Agency. Currently, 200 bilateral agreements are being implemented with different organizations. One of the key aspects within the bilateral agreements is research project cooperation. Furthermore, five Croatian research infrastructures have been recognized in the MERIL project (Mapping of the European Research Infrastructure Landscape) which provides an inventory of the most excellent research infrastructures (RIs) in Europe, mostly related to information technologies. Also, MSES supported the establishment of the Croatian National Grid Infrastructure CRO NGI. Moreover, MSES has been constantly improving the CARNet network implementing the program of distant learning and jointly with RBI launched the Center for on-line data base project.

### 2.3.2.2. Innovation infrastructure

The innovation infrastructure includes public and private institutions aimed at encouraging innovation commercialization and application of technology in the economic sector, and refers to the centres of competence, living labs, centres for new product development, quality testing centres, design centres, and other institutions aimed at developing new products, services, technology, improving business processes and management models.

Croatia is in the process of further analysing research and innovation related infrastructure (MSES, 2014; OECD, 2014). This will help in further fostering of the effective system that would be recognized by the private sector. R&D system needs to provide added value by focusing on RDI and the S3 can serve as a great opportunity to fine-tune the Croatian Innovation System. Revival of the much needed innovation infrastructure will be based on the actual needs of the economy. Initial steps towards this goal were already made through the identification of prosperous industrial sectors in Croatia and through enabling networking of stakeholders within competitiveness clusters.
Future Thematic innovation platforms will help to accomplish this goal. Competitiveness clusters will prepare projects for **Centres of Competence (in Croatian CEKOM)**, which represent specialized businesses conducting research projects (development or production) with competence in certain areas. Such centres will be focused on development and applied research, IP protection and commercialization. Centres of competence will be part of the innovation infrastructure of the Republic of Croatia and the key instruments for the strengthening the innovation value chain. CoCs will encourage innovation process in business sector and its correlation with scientific and research institutions.

**Other types of innovation infrastructure are technology parks and business incubators.** In terms of the Science and Technology Parks (STPs), Croatia is yet to embark on a systematic approach in terms of the much-needed enhancement of the existing framework because country’s experience on this matter is limited. Croatia has only one STP established so far - the Science and Technology Park of the University of Rijeka (Step Ri). First steps towards the widening of the legal, economic and institutional scope have already been taken, e.g. investments in infrastructure, absorption capacity and human resources development of STPs are recognized as important chain in commercialization of RDI results and incorporated as priority measures in the relevant strategic framework for the period 2014 – 2020.

2.3.2.3. **Fiscal framework for RDI**

In the run-up to the EU accession, Croatia adopted the Budget Act in 2009 and the Fiscal Responsibility Law in 2011. The latter was amended in January 2014 with the aim of transposing the Council Directive 2011/85 on requirements for budgetary frameworks of the Member States. Fiscal measures to promote private investments in R&D include tax reliefs and the exemption of custom duties. The regulations on reduced taxation of profits for R&D allowed companies to reduce the tax base for eligible costs of scientific and developmental research projects by 150% for fundamental research, 125% for industrial research and 100% for development research. Eligible costs included personnel, equipment and property, costs of obtaining technical know-how and licensing patents, consultancy and operating costs. Enterprises classified their R&D projects into one of three categories: (i) basic R&D, (ii) applied R&D and (iii) experimental development. As expected, the majority of business expenditure on R&D went to experimental development projects, since this is the type of R&D focused on creating new products and services or improving existing ones. **Described programme of tax relief for R&D was one of the most generous incentives compared to OECD countries.** The country provided a subsidy rate of about 35% for 1 USD of R&D, second only to France (42% in 2008). Despite of the fact that small enterprises represented the majority of the R&D tax incentives beneficiaries, large enterprises carried out the largest share of the benefits in total. Tax incentives were also highly concentrated by sector. Two industrial sectors, (1) manufacture of radio, television and communication equipment and apparatus and (2) manufacture of chemicals, chemical products and man-made fibers accounted for 77.8% of R&D tax incentives in 2008 and 62.1% in 2009. Most of the benefits accrued in the city of Zagreb (93.7%) (Švaljek, 2012). As perceived by enterprises, the greatest obstacle in applying R&D projects for tax reliefs was the uncertainty related to their assessment by tax offices or other bodies.

**New state aid programme for R&D projects,** in line with EC regulations on state support31, (for the period 2015-2020 in a form of tax relief will also include small, medium and large enterprises but it will include some improvements regarding application and evaluation process, in cooperation with other stakeholders and beneficiaries. Further efforts will be made in establishing a comprehensive system for monitoring of state aid for RDI as to ensure efficiency and transparency. Although the state

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aid for R&D investment is very much needed, further development of a much wider spectrum of state aid instruments is as important for the development of efficient RDI eco-system.

R&D tax incentives were significantly larger than the respective direct resource transfers in the form of grants and other funding measures until 2014, while only recently instruments like venture capital are being introduced. For instance, according to Tax Administration, in 2013 the total amount of 74.8 mil EUR were granted in form of tax incentives for R&D projects, compared to 66 mil EUR granted for the entire period 2007-2013 for 7 programs administered by BICRO\(^2\) (Table 8). It is expected that this trend will change in following programming period (2014-2020) in favour of grants, loans and other instruments.

### 2.3.3. Scientific activity, excellence and science-industry collaboration

The ongoing restructuring of the public research institutes’ network, with the aim to consolidate the scientific resources of institutes and universities, is important in order to increase competitiveness and scientific productivity. Following international practice, a number of measures were implemented with the help of the European Union (IPA IIIc) and the World Bank (Science and Technology Project I and II). The focus of these measures is related to development of specialized infrastructure for technology transfer and incubation, increasing absorption capacities for EU funds, while improving the interaction between HEIs and PRIs. On the other hand, collaboration between private and public sector R&D actors is insufficient. Therefore, a support for joint industry-research projects with demonstrated benefits for both enterprises and the public sector researchers is considered a priority.

In terms of the scientific publications of Croatian scientists in 2012, the greatest share of published articles pertained to these fields of science: Medicine Social Sciences, Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Physics and Astronomy and Engineering. The SCImago database for Croatia in 2012 highlights particular publication strengths in: medicine (20.4%), followed by social sciences (9.6%), agriculture and biological sciences (8.75%) and biochemistry, genetics and molecular biology (7%). Also notable are physics and astronomy (6.7%) and engineering (5.4%). Citation-based impact can be considered a proxy of the quality of scientific research. According to Innovation Union Scoreboard 2014, EU average for highly-cited publications (scientific publications within the 10 % most cited scientific publications worldwide, as % of country’s total scientific publications) is at 10%. In that context, Croatia had a very modest score (3.2 %) as Bulgaria and Romania, for example. The average citation impact for Croatia during the period 2003-2010 is 0.65, while it is 1.31 for the EU. The country concentrates most of its output in higher education institutions (75%), followed by health-related institutions (31%) and institutions in the public sector (24%). Institutions with more than 1,000 publications during the period from 2003 to 2010 include: University of Zagreb, RBI, University Hospital Centre Zagreb, University of Split, University of Rijeka, Josip Juraj Strossmayer University of Osijek, and University Hospital Sisters of Mercy (Western Balkans Regional R&D Strategy for innovation, 2013).

Although the number of scientific co-publications per million population in 2011 was higher than for the EU average (405.1 in Croatia versus 331.3 in the EU) the country is below the standards of the EU in the share of international publications (document ratio whose affiliation includes more than one country address) in total publications. In the case of Croatia, the share of international publications in total publications increased from 25% in 2003 to about 33% in 2012, which remains far below the values observed for the EU (44%) (SCIMAGO, 2012).The main scientific fields with publications in international journals are: clinical medicine (about 27.6% of all publications), biology (17.6%), engineering and technology (15.4%), and chemistry (10.8%)\(^3\). However, judging by the rate of international co-publications, international scientific collaboration is quite important given that Croatia

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\(^2\)POC, RAZUM, IRCRO, TECHCRO, TEST, EUREKA and KONCRO – grants, conditional loans and consultancy services for both public and business sector beneficiaries.

\(^3\)Western Balkans Regional R&D Strategy for Innovation, 2013.
is performing above the EU average (125%)\textsuperscript{34}. Another indicator of international scientific cooperation shows that Croatian research organizations are fairly successful in international funding programs absorption. Croatia’s level of participation in FP7 was good with a success rate of about 17% compared to the EU27 Member States of 20.5%. More on the Croatian participation in FP7 in part 2.6.1.

Among other programmes in the area of research excellence and researcher mobility, Croatia’s Unity through Knowledge Fund (UKF) can be highlighted as a successful initiative. In the period 2007-2010, 325 project applications were submitted (representing a demand of 24.8 million EUR) of which 91 were funded corresponding to 7.8 million EUR benefiting 544 researchers from 260 institutions. Scientific output of UKF projects was measured by peer-reviewed publications as it follows: 268 articles are published in peer-reviewed publications (of which 230 with impact factor), 36 books/book chapters and also 116 conference abstracts. The number of stated conference abstracts is definitely higher because not all project leaders included these papers within the project results. Also, the projects financed within the Fund had great success among the applications for call for proposals in the FP7 program—success thereof is in the 28% range. The Fund invested 4.6 million EUR in terms of accepted projects, and an additional 9.03 million EUR was absorbed from the FP7 program, entitled to Croatian partners. In addition to the financing, success of the Fund’s projects within FP7 provided Croatian research groups with international recognition, visibility and competitiveness in a worldwide scope.

An important measure to increase research productivity and excellence is related to system of research funding. Thus, the revision of Act on Science and Higher Education (adopted in July 2013) marked the beginning of a series of reforms. The Act brought changes in the financing and governance system of the public research activities aiming at increasing the efficiency of the RDI system. Part of the state budget allocated to scientific activities is provided directly, via multiannual performance based contracts, to the autonomous disposal of public universities and public research institutes, thus increasing their responsibility, accountability and promoting the abandonment of direct state management of science activities. Still, in order to improve overall results further efforts are needed in the next period.

With the aim of raising the scientific quality and excellence, the National Science Council adopted the criteria for the establishment of Centres of Research Excellence (CoRE) in 2013 and the first seven CoREs were declared in November 2014. Their purpose is, among other things, to increase and improve the international scientific, industrial and social cohesion, as well as to establish a framework for a stable system of funding which will not depend exclusively on public investments. CoREs will enable focusing resources on research groups, facilities and projects on the frontiers of science, ensuring international relevance regarding quality and vision, but also addressing national strategic priorities.

One of the most important barriers to innovation is the lack of adequate linkages between research institutions and the business sector. The country performs poorly in the number of public-private co-publications per million population, 27.4 versus 52.8 for the EU. According to bibliometric data, collaborations as measured by co-publications between private and higher education institutions in Croatia represent 0.79% of total collaborations, less than half of the EU average. Data suggest a different trend in the uses of scientific information for innovation. Universities and R&D companies are rarely seen as sources of information for innovation: only 6.9% of firms in Croatia would turn to universities for innovation. The Croatian innovation system is still strongly oriented towards fundamental research in the public sector, which is also reflected in funding as shown in Figure 10. In comparison to Croatia most of EU15 member states are more oriented towards applied research.

\textsuperscript{34} Innovation Union Scoreboard, 2104, p. 53.
In order to address this issue and to initiate innovation development in the R&D public sector during the last several years, Technology Transfer Offices (TTOs) were established at the universities of Zagreb, Split, Rijeka and Osijek and some efforts have been made by particular faculties to organize units specialized in technology transfer (Faculty of Electrical Engineering and Computing and School of Medicine, University of Zagreb). Also, RBI, Croatia’s largest life science research institute established Ruđer Innovations Ltd in order to enable technology transfer, primarily in the area of spin-off companies, and IP protection.

In terms of Debackere’s concept of three stages of development for TTOs, Croatian TTOs are still in the Stage 1, since they are still situated at the periphery of the academic activity spectrum. The main problem lies in the fact that activities related to technology or knowledge transfer are not recognized as important. As stated above, out of seven public universities only four established some kind of office for technology transfer. Technology and knowledge transfer are not planed strategically and these kind of activities more often than not occurred accidentally as a secondary result of basic or applied research. It is devastating fact that TT activities are not taken into the account when assessing academic performance of individual researchers. Therefore, it is fair to conclude that TTOs are still not “the third mission” of Croatian universities. One of the main characteristics of TTO’s in the Stage 1 of their development is the absence of business plan and strategic documents. Also TTO’s rarely have permanent employees, most of them are project contracted which presents a possible bottleneck. Despite of the problems, through STP I and Science and Innovation Investment Fund – SIIF projects, two TTOs have managed to override the difficulties to an extent: University of Zagreb’s Centre for Research, Development and Technology Transfer and University of Split’s TTO. Within STPII MSES developed TTO Support Program which complements SIIF Program by making available funds for research commercialisation, rather than capacity building or overall operational costs (as supported by


Stage 1 is characteristic for the first generation of TTO activities, when TTO’s operated mainly as “isolated islands of technology transfer activity” within the university. Technology transfer was situated rather at the periphery of the academic activity spectrum. TTO activities were confined to the legal aspects of contract negotiation and monitoring, and the TTO performance was not taken into account when assessing academic performance of individual scientists. This “stage 1 mode of operation” lasted well into the mid-nineties.
STP I). It includes, particularly, IP protection of research results in order to increase number of commercially relevant technologies being licensed by industry and number of new start-ups born out of higher level research. The capacity building and the enhancement of the critical role that TTOs have in the innovation eco system are imminent and they are recognized in all of the RDI related strategic documents in Croatia for the period 2014-2020.

So far, there were no clear guidelines or legal framework regarding spin-off creation by scientists and Government is in the process of addressing this issue. Several universities such as University of Zagreb, University of Rijeka, and University of Split, are developing their own IPR regulations and guidelines as well as some research institutes (e.g. RBI, Institute of Physics) whose IPR manuals include incentives for individual scientists to commercialise R&D results.

### 2.3.4. Patenting activity

Patenting activity in Croatia is low compared to other member states having in mind the number of PCT applications per billion GDP and has been decreasing in the last few years\(^\text{37}\). Croatia was at 43% of EU average regarding the PCT applications in 2013 according to Innovation Union Scoreboard.

Based on data on patenting applications to the European Patent Office (EPO), Croatia has amongst the lowest level of patenting intensity, with approximately 4.26 patents per million populations, in comparison to an EU average of 110\(^\text{38}\). Patenting activity in Croatia is only slightly above the level of patenting per million populations in Bulgaria and Romania, and is comparable to Slovakia. When considering patenting by GERD the gap between Croatia and the EU average decreases slightly but remains large. The number of patents of Croatian applicants and inventors that were granted by the EPO indicates that Pharmaceuticals remained a strong technological domain for Croatia and that novelty and inventiveness are also recognized in Biotechnology, Medical Technology and ICT.

As per technical fields (IPC classes), according to State Intellectual Property Office, at the end of 2014, the majority of the total number of valid patents in Croatia were in following fields: preparations for medical or dental purposes (22.4%), organic chemistry (20.4%) and transportation (7.4%). Two conclusions can be drawn from the study of the patent data: (1) the use of international IPR strategies for Croatian inventors and applicants is diminished and (2) Croatia has defendable industrial strengths in the areas of: Pharmaceuticals, Biotechnology, Medical Technology and ICT.

Although number of patents demonstrates the country’s ability to commercialise innovation and is interrelated to productivity of R&D activity, it is also closely linked to and depending on measures that encourage and enhance patenting. In this sense, researchers do not receive any incentives or benefit for their academic career development for patenting activity, as they do for publishing and conducting basic research. Consequently, in order to tackle this issue, the overall transformation of the IPR system is envisioned in the National innovation strategy for the period 2014-2020\(^\text{39}\). An establishment of a transparent governance system in the field of intellectual property and the protection of the intellectual property rights (IPR) should enable a clear, simple and motivating system of IPR governing.

### 2.3.5. RDI potential of business sector

\(^{37}\) SIPO Annual Report 2014, Zagreb, 2015, p. 32 et passim: “In 2014, a total of 200 patent applications were filed with the Office via national route, which is the lowest recorded annual number of applications via the national route and represents a decrease of 21% compared to the previous year.” For further information and annual reports on patenting activity: http://www.dziv.hr/en/about-sipo/annual-report/archive/

\(^{38}\) Though this average is driven largely by a relatively small number of highly patent intensive countries.

2.3.5.1. Business environment and RDI determinants

By the Companies Act and Amendments to the Companies Act specific measures have been introduced for reducing the time needed to set-up business up to 3 working days and for reducing the cost of setting-up business to max. 100 €. The criteria were successfully applied to all types of entities in the small business sector and have shown practical improvements with regard to the criteria demands.

Some improvements in the business environment were made as a result of the reforms reducing the regulatory complexity and costs. Regarding the cutting of red tape in the construction permitting, Croatia made notable improvements through Building Act and Physical Planning Act that took effect on 1st January 2014. As a result of the changes in obtaining building permits, the number of procedures required to comply with the formalities to build a warehouse in Croatia fell from 22 to 21, the time from 379 days to 188 and the cost by 0.3% of the warehouse value. Other notable positive reforms introduced in Croatia in 2013/2014 include making starting a business easier by reducing notary fees and making trading across borders easier by implementing a new electronic customs system (Doing Business Report, 2015).

A number of factors contributing to the relatively poor R&D performance, i.e. small investment in R&D of Croatia’s business sector include: a decreased number of R&D performing firms, the lack of early stage financing and barriers to science-industry collaboration. In contrast to the decline of R&D activities in traditionally large performers, there is a growing niche of innovative, technology-based SMEs that have been systematically supported by public funding through HAMAG-BICRO programs. As already mentioned, HAMAG-BICRO is the Croatian innovation and technology-implementing agency, and it has a key central role in the national innovation system.

HAMAG-BICRO programs have had a crucial positive impact for the Croatian innovation system and represent an important source of funding but also beyond that, professional and networking capacities for customized support and mentoring for innovative SMEs. National experience in design and implementation of private sector-targeted innovation programs through BICRO, as well as outputs of BICRO programs provide a solid ground for further growth of private sector R&D and innovation activities and investments. BICRO programs focused on business R&D have been instrumental in supporting early-stage innovation in Croatia: Proof of Concept, IRCRO and RAZUM. Also BICRO program TEHCRO financed development of innovation infrastructure such as business incubators, technology parks and competence centers. Croatian Institute of Technology (HIT), which merged, with BICRO in beginning of 2013 financed applied technology development projects from public research organizations.

Proof of Concept program supports pre-commercial activities or entrepreneurs (PoC Public) and researchers (PoC Private) at an early stage of development of innovation with high commercial potential. It ensures availability of pre-commercial capital for the technical and commercial verification of innovative concept. RAZUM is a pre-seed program, which covers starting funding for newly founded companies and financing the development of a new product/service in existing companies. Collaborations on joint R&D projects for the benefit of the industry are stimulated through the IRCRO programme, through funding based on 50:50 matching grants. The overall programme objective is to stimulate private-sector investments in R&D through cooperative projects for the benefit of SMEs. IRCRO is used to stimulate small and middle sized enterprises into cooperation with research team in order to start their own (R&D) activities. All projects in this program have to include cooperation between SME and research organization. Project is mutually financed by IRCRO program and SME, while intellectual property remains as ownership of the

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40 Based on conclusions of the ex-post evaluation report that has been performed within the STP2 project from October 2013 to February 2014 for programs RAZUM, IRCRO, TEHCRO and TEST (83 projects in total) by Technopolis Vienna team, led by Fritz Ohler, the company director.

41 Funding is available in the form of repayable advances (conditional loans), up to 70% of total projects costs.
company. In the period 2007-2013 the total number of IRCRO projects was 24 (total of 5 mil EUR). Ex post evaluation has shown that IRCRO has been aiming at the right goals. It also concluded that the poor level of R&D and innovation in the Croatian economy in general and the poor interaction between public research and the economic sector in particular provides a strong reason to put R&D and innovation and a more systematic interaction between the two sectors a high priority. Contribution from research partner is sometimes know-how and sometimes managed niche labour market. The conclusion of evaluation was that IRCRO program gave a right incentive to young researchers to try and continue their careers in business sector.

**Key achievements of these programs included:** (i) more research outputs commercialized; (ii) improved scientific and technological cooperation; and (iii) more firms investing in R&D activities. Currently all three programmes are financed out of the World Bank loan for Second Technology project. These programmes as well as other measures are included in the programme “Business impulse” - the underlying government programme to encourage small businesses and crafts, which includes support for innovative entrepreneurship in the next financing period.

The Table 8 provides overview of number of projects and contracted amounts for R&D programs run by HAMAG-BICRO and its predecessors (BICRO/HIT) in the period from 2007 to 2013. In the course of 2007-2013 BICRO (BICRO/HIT) has contracted 299 projects with contracted value of EUR 38 mil. In February 2015 HAMAG-BICRO opened three innovation related calls under responsibility of MSES within Second Science and Technology Project financed from loan by the World Bank (program for supporting R&D in SMEs – RAZUM – 3 mil EUR, program for supporting contracted R&D- IRCRO – 2 mil EUR, and program for supporting technology transfer activities of University and Research institutes’ Technology Transfer Offices – 1,5 mil EUR).

<table>
<thead>
<tr>
<th>Table 8 BICRO Agency (BICRO/HIT) funding in period 2007-2013</th>
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<tr>
<td><strong>Preapplications Number</strong></td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>POC (Proof of Concept)</td>
</tr>
<tr>
<td>RAZUM (Conditional grant/loan)</td>
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<tr>
<td>IRCRO (Cooperation projects)</td>
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<tr>
<td>TECRO (Technology infrastructure)</td>
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<td>TEST (Technology development projects)</td>
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<tr>
<td>EUREKA</td>
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<tr>
<td>KONCRO (Business consultancy for SMEs)</td>
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<tr>
<td>TOTAL</td>
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Note: Some of the results achieved by these programs achieved by 2013 are summarized in Figure 1.
**Figure 11 Results of selected BICRO/HIT programs**

**Product launches & export revenue**
- POC 1,2,3 – 21 product launched with EUR 0.7 mil
- RAZUM, IRCRO – 21 products launched with revenues EUR 3.8 mil (2011 and 2012) of which EUR 2.65 mil is export
- RAZUM, IRCRO – 29 products launched in cumulative incl 2013 with expected revenue in 2013 EUR 21 mil

**Employment**
- POC 1,2,3 – 35 new jobs (23 R&D)
- RAZUM – 82 new jobs (55 R&D)
- IRCRO – 26 new jobs (12 R&D)
- TEHCR0 – 360 new jobs (255 R&D and value added)
- TEST 205 – researchers working on projects
- TEST – one spin-off created

- at least 50 product launches with expected revenue in 2013 of cca 22 EUR mil (mostly export)

- 57 patent applications
- 37 trademark and design applications

- 593 new jobs created of which 345 R&D and high value added

**Firm investments**
- EUR 21.5 mil contracted through POC, RAZUM, IRCRO, EUREKA with additional EUR 14 mil invested by SMEs

**Intellectual assets**
- POC 1,2,3 – 23 patent applications
- RAZUM – 9 patent applications, 2 trademarks
- IRCRO – 4 patent applications, 6 trademarks
- TEST 4 patents approved, 8 patent applications, 4 international design registrations, 3 trademark registrations (part of rights is assigned to scientists)
- FIDES - 9 patent applications, 24 – trademark and design applications

**Human Resources**
- on average 1 PhD per TEST project

Source: BICRO data

**Figure 12 Investment in R&D projects by BICRO and HIT, 2006-2014**

- Advanced Materials 16%
- Food and Agriculture 10%
- Health, Biotechnology and Life Sciences 7%
- Energy and Environment 7%
- Transport, Mobility and Engineering 10%
- ICT 26%
- Other sectors incl. security 24%

Source: HAMAG-BICRO.
Based on data presented in Figure 12, ICT projects were the most successful in obtaining competitive HAMAG-BICRO funding. Together with FP7 these data indicate for each of the S3 selected sectors its potential for technology development.

2.3.5.2. Business investment in RDI

Based on the most recent indicators compiled by the Innovation Union Scoreboard, as already mentioned, Croatia ranks as a moderate innovator among the EU members, behind comparators such as Slovenia, Slovakia or Estonia. When focusing on firm performance, data shows that the share of innovative firms is relatively low compared to other countries in the region. Croatia ranks 22nd out of 30 countries when it comes to the share of innovative enterprises (42%) out of total enterprises participating in the survey. The country performs better when it comes to the share of companies conducting in-house R&D, (17.5%) and the share of companies undertaking external R&D, which is 7.5%.

Large companies appear more innovative than SMEs. Approximately 40% of Croatia’s small firms (10-49 employees) are involved in innovation. The share of SMEs introducing marketing or organizational innovations falls below the average of the EU. In addition, this share decreased during the period 2000-2011. In the case of the Croatia’s medium-sized companies (20-249 employees) the country ranks 21st, but since more than 70% of large firms (250+ employees) are involved in innovation, this indicator increases country rank to 19th. These results can be reflection of industry structure i.e. low share of R&D intensive industries in which medium firms operate.

According to the 2010 Community Innovation Survey (CIS), limited access to internal and external resources (funds, qualified personnel) as well as market factors including unfair competition and uncertain demand, are regarded as the major barriers by at least 25% of the respondents. These findings are confirmed by other studies about innovation in Croatia. Based on findings by Radas and Božić (2009), financing and innovation costs remain the most important hurdle for Croatian companies to innovate, followed by lack of qualified employees and limited information about technology and markets. A study conducted by the OECD shows that lack of qualified personnel was ranked as the second most important barrier to innovation, although only 44% of Croatian firms claim to face difficulty in finding skilled employees. According to the study, employees frequently lack experience (80%) or the education system does not equip them with the right set of skills (40%).

Croatia’s SMEs perform much better in terms of non-R&D innovativeness than in terms of R&D. In terms of SMEs introducing products and process innovations, the share of total SMEs is not too far from the EU27 average. Despite the economic benefits that RDI can have for the private sector, Croatian enterprises are not sufficiently involved in R&D activities. Croatia displays a low level of business enterprise R&D (BERD) as percentage of GDP, compared with the average of the EU27. Data from Eurostat shows that in Croatia BERD has been continually below both the EU27 average and Slovenia, one of its main comparators when it comes to the share of business expenditure in GERD since the middle of the previous decade. This trend is confirmed by the BERD data on a per capita basis which shows that although both Slovenia and the EU average have increased the levels of BERD per inhabitant between 2006 and 2012, in Croatia this indicator has stagnated.

Business investment in R&D is concentrated within a few multinational companies. In Croatia, business R&D is almost entirely performed by a few large companies in the pharmaceutical, telecommunications, agricultural, and food and beverage industries (Figure 13). The overall R&D intensity of the country is 1.17% (6th place in EU27). In that respect, Croatia is close to Netherlands and Austria, and above Spain, France, and Italy. However, the R&D intensity of small firms is low at 0.34% (16th place), and that of large firms is high 1.98% (4th position), whereas for medium-sized

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42 Svarc and Racic, 2011
firms it reaches only 0.16% (21st place, Figure 13). This suggest that the R&D intensity of Croatian business sector is largely confined on a few R&D intensive firms while the rest of business sector has very low R&D intensity.

Regarding investment expenditure, large companies which invested close to 61% of total BERD in 2012 dominate. Around 35% of companies who invested into R&D are the medium-sized companies. Micro and small companies contribute only a few percentage points in the total annual R&D expenditure of the private sector (BERD), with a maximum of 8% contribution in 2009. As would be anticipated, large companies contribute the most to R&D expenditure in Croatia. The low R&D intensity of small and medium-sized firms is also confirmed by firm-level data from the Enterprise Survey which indicates the existence of a “missing middle” problem in Croatia as medium firms invest little in R&D. For the “missing middle” problem, some studies point to the fact that in these countries consumers demand different kinds of goods, some point to costly business environments with high taxes and restrictive regulations, (Centre for International Development at Harvard University, 29/6/2015), some by a lack of access to financial capital and thus face difficulties in growing to become middle-sized firms (Hsieh and Olken, 2014). These studies can also be put in the context of Croatia as the there is an overall lack of dynamism of Croatian companies when it comes to the investments in RDI.

![Figure 13 R&D intensity (all firms)](source: Eurostat)

![Figure 14 R&D intensity (small firms)](source: Eurostat)

In the period 2008-2012, expenditure on R&D as well as the number of companies that filed for tax breaks both show a cumulative decline. In 2010 there was a fall of more than 61% in the number of companies that field for tax breaks, while in 2011 there was a jump of almost 100%, meaning that in 2011 a number of tax applications have doubled. The discrepancies of the numbers of companies shown in the Table 9, but also among the different databases (from the Croatian Tax Authority (CTA), Ministry of science, education and sports, Croatian bureau of statistics) are mainly because of the different methodologies for collecting the data. CTA uses annual financial reports from enterprises which shows the real amount of tax breaks filed as they are on fiscal year basis. The CBS uses annual surveys to collect data among the companies that are classified as companies doing research and development, while the database of Ministry of science, education and sport shows numbers that are approved by the Ministry as projects that can file to CTA through annual financial reports for tax breaks.

| Table 9 Business expenditures on R&D in Croatia 2008 - 2012 |
|---------------|-------|-------|-------|-------|-------|
|                | 2008  | 2009  | 2010  | 2011  | 2012  |
| Denmark        |       |       |       |       |       |
| Estonia        |       |       |       |       |       |
| Finland        |       |       |       |       |       |
| France         |       |       |       |       |       |
| Germany        |       |       |       |       |       |
| Greece         |       |       |       |       |       |
| Italy          |       |       |       |       |       |
| Luxembourg     |       |       |       |       |       |
| Malta          |       |       |       |       |       |
| Netherlands    |       |       |       |       |       |
| Portugal       |       |       |       |       |       |
| Spain          |       |       |       |       |       |
| Sweden         |       |       |       |       |       |
| Switzerland    |       |       |       |       |       |
| United Kingdom |       |       |       |       |       |
| Ireland        |       |       |       |       |       |
| Croatia        |       |       |       |       |       |
| Romania        |       |       |       |       |       |
| Cyprus         |       |       |       |       |       |
| Bulgaria       |       |       |       |       |       |
Number of companies | 257 | 247 | 94 | 185 | 164  
|-------------------|-----|-----|----|-----|-----  
| annual change     | -3.9% | -61.9% | 96.8% | -11.4% |   
| R&D expenditures (EUR) | 112,429,222.98 | 72,580,437.75 | 71,871,094.82 | 60,481,066.74 | 67,657,076.75  
| annual change     | -35.4% | -1.0% | -15.8% | 11.9% |   
Source: Croatian Tax Authority.

2.3.5.3. The financing gap for venture capital in Croatia

In general, Croatia as the whole South East Europe region does not feature well developed venture capital and private equity market. According to the Venture Capital and Private Equity Country Attractiveness Index 2013, the country is positioned on the 65th position when it comes to the most attractive destination for PE/VC.

Croatian SMEs, especially those innovative and high risk, or in sectors with lower rates of return, are facing a challenging environment for financing. Bank lending is unavailable and expensive, and requires sufficient collateral, what is the main problem for SMEs. In addition, commercial banks are highly risk averse, especially for SMEs. On the other hand, underdeveloped capital markets, low levels of business investment opportunities and divestment (market powers) are resulting in virtual lack of VC industry, i.e. limited Venture Capital (VC) investment available at the moment.

A number of reasons have been identified why Croatian PE/VC funds are not suited to provide early stage funding:

- such funds tend to seek the safety and capital preservation that comes from investing in more established companies;
- such funds invest over shorter time frames and plan exit their investments after three to five years and the time period needed for investments in start-ups tends to last from seven to ten years;
- PE funds seek to make investments that are too large for start-ups.

The Government has launched measures in the previous years with attempt to decrease market distortion. Thus a number of private equity funds have entered the market in 2010, after the launch of the “Economic Cooperation Funds program”, which committed 0.9 billion HRK (approximately 165.6 million USD or 125 million EUR) to match 1-to-1 financing through domestic institutional and private equity industry with Republic of Croatia budgetary resources.

In 2011, five domestic funds managed to attract the necessary co-finance and began operating. However, this has not been enough.

Further on, the Government in 2015 launched Innovation and Entrepreneurship Venture Capital Project aimed at fostering innovation, entrepreneurship, and private sector growth by strengthening the risk capital financing for innovative SMEs, including start-ups The cca 30 million EUR program will be implemented over ten years and will have three components: (i) a pilot venture capital fund; (ii) a seed co-investment fund; (iii) technical assistance. The amount of 20 million EUR (government participation) will be funded from The World Bank loan.

The proposed program follows up from the World Bank's STP and STP II programs by assisting the government to close the financing gap for young knowledge intensive SMEs. It will do this by three means. It will contribute to creating a venture capital segment interested in financing knowledge-based, innovative SMEs; it will contribute to generate deal flow from such firms; and it will increase the Croatian government's ability to spend European Structural and Investment funds.
Finally, and according to conducted ex-ante assessment\textsuperscript{43}, the financing gap for VC in Croatia still amounts in between 22 and 52 million EUR according to the calculation\textsuperscript{44} covering the current programming period.

In 2015 Croatian Government has established Venture Capital Fund, which will distribute funds for SMEs, and in particular for high technology SMEs. Venture capital for investments targets amounts higher than other financial instruments offered (e.g. between €1-3 million) and will be realised primarily in sectors with high growth potential. Venture capital programme will be entrusted to the EIF and/or other international finance institution who will successively select financial intermediaries based on co-investment facility. The entrustment however shall be made in sync with the actual progress of the implementation of the VC scheme financed from the World Bank resources.

Objective of this activity, which will be financed from ERDF, is to develop and modernize Croatian financial market and solve the problem of financing gap by introducing VC funds, with aim to ease access for innovative and risk preferable SMEs.

2.3.5.4. R&D performing employees

R&D performing companies in Croatia employ around 48000 workers, while only around 2500 of them based on FTE are involved in R&D. Conclusively, out of 1.3 million people currently working in Croatia only around 2500 (0.19\%) work on R&D activities in private sector.

Large companies employ around 88\% of all R&D performing workers in the private sector. During the five-year period (2008-2012) the number of employees rose in R&D performing companies (with total 48,866 in 2012), but the number of people in R&D activities remained fairly constant (around 9\%). Also, differences are recorded in ratios between companies’ size; generally, the proportion of employed in R&D activities is higher in smaller companies. In contrast to the decline of R&D activities in traditionally large performers, there is a growing niche of innovative, technology-based SMEs that has been systematically supported by public funding through HAMAG BICRO programs\textsuperscript{45}. For example, the companies benefiting from IRCRO funding are to a large extent micro companies (60\%), employing less than ten employees. Half of the total of beneficiaries employ less than five persons. All others, except for one, are small companies\textsuperscript{46}.

The structure of business expenditures on R&D in 2011 reveals that Croatia is presently lacking companies capable of performing and investing in R&D. The traditional large R&D performers have undergone restructuring in which the role of R&D was reduced. One of the conclusions is that research in Croatia is predominantly the remit of the public research institutions while businesses are focused more on development activities. According to CBS data, in 2013 72.4\% of all basic research was performed by public research institutions (HEI included), while 76.8\% of all experimental development activities was done by business sector\textsuperscript{47}. In Croatia the largest number of researchers is employed in the higher education and government sectors (75\%). This lack of R&D expertise in the commercial sector presents additional obstacles to further growth because it is generally regarded that

\textsuperscript{43} Ex ante assessment was conducted in the preparatory phase before launching financial instruments under OP Competitiveness and Cohesion.

\textsuperscript{44} The range is based on two different approaches in the calculating method. On the one side, the venture capital gap primarily concerns the size of equity in early stages of development and growth phase of enterprises (up to 2 years old), computed as the amount of equity and reserves as of end of 2013 multiplied by the number of high growth SMEs and 4\% representing share of SMEs with track record up to 2 years in the total number of SMEs registered as legal entities (this way calculated gap value is 52.8 mil EUR). On the other side, alternate option to calculating the gap includes calculating the fraction of start-ups in the total financing gap calculated (this way calculated gap value is 21.7 mil EUR).

\textsuperscript{45} BICRO has been running innovation programs for SMEs since 2007.

\textsuperscript{46} Based on ex-post evaluation of BICRO programs performed by Technopolis Group Austria in 2014.

company based R&D is more frequently market-driven and R&D intensive businesses tend to have a competitive advantage on the market.

2.4. Identification of economic, research and innovation strengths and potential

Croatia’s trade competitiveness gives several reasons for optimism. First, the country managed to successfully penetrate emerging and fast growth regional markets such as the EU12 (new member states), Russia, or MENA. Second, some technologically advanced niche product categories both in traditional sectors and in new activities are emerging, including specialized industrial machinery and parts; vehicle parts; medicaments; and switchboards, relays and fuses, among others. Third, the country has developed a small set of strong, multi-product exporters as well as regional multinationals to serve the market. Fourth, Croatia managed to develop farm-to-retail supply chains in food processing. Finally, the country is characterized by a supportive soft and hard infrastructure, in particular with regard to its highly trained technical workforce in areas including biotechnology and engineering, ICTs and the transport sector.

To identify economic strengths for the Croatian S3, a detailed analysis was undertaken to define the scope of thematic areas that exhibit relatively high potential growth and excellence in a both national and international perspective. All relevant strategic documents were taken into consideration, including Strategic guidelines from Croatian Competitiveness Clusters, Industrial Strategy of the Republic of Croatia, as well as consultations performed with Ministries and other partner institutions for inputs regarding strengths and potentials of economic areas from their domain of work. The analysis complements the analysis of Croatia’s National Innovation System conducted by OECD (2014), World Bank (2014) and several background studies for the development of the country’s smart specialization strategy conducted by ECORYS (2014).

Also, the analysis methodology was designed to identify economic areas of strong comparative advantages within the pool of industries studied, taking into consideration the assumptions of export orientation as a major source of future growth and their ability to maintain a profitable position on the domestic market with the purpose to achieve a certain level of replacing imports with domestic products. The results of analysis showed that following economic sectors/sub-sectors demonstrate strong competitive advantages and revealed comparative advantages:

- Manufacture of basic pharmaceutical products and pharmaceutical preparations;
- Manufacture of computer, electronic and optical products;
- Manufacture of electrical equipment;
- Manufacture of machinery and equipment n.e.c.;
- Manufacture of motor vehicles, trailers and semi-trailers;
- Manufacture of other transport equipment;
- Manufacture of fabricated metal products, except machinery and equipment
- Computer programming, consultancy and related services.

Emerging priorities on the economic side for the Croatian S3 show good alignment for R&D intensive priority sectors of the Industrial strategy of Republic of Croatia 2014.-2020. According to the Industrial strategy the following industrial activities have the greatest potential:

- Manufacture of basic pharmaceutical products and pharmaceutical preparations;
- Manufacture of computer, electronic and optical products;
- Manufacture of fabricated metal products, except machinery and equipment;
- Computer programming, consultancy and related services;
- Manufacture of electrical equipment;
- Manufacture of machinery and equipment.
Manufacture of food products and Manufacture of furniture have been recognized by the the Industrial Strategy having strategic value for the Croatian economy. This is due to size, tradition, accumulated know-how and restructuring potential. These sectors are also recognized for the same qualities through the S3.

An analysis of strengths in research and development was undertaken for both the public and private sectors. The full analysis presented in two separate reports: Inputs for Croatia’s S3 R&D Analysis and Detailed Analysis of Business Expenditure on Research and Development in Croatia as part of the Inputs for Croatia’s Research and Innovation Strategies for Smart Specialization48, has led to the conclusions below. Conclusions are outlined according to their source.

The EU Croatia country profile highlights relative technological strengths in (Innovation Union progress at country level, 201349):
1. Healthcare sector,
2. Food processing and agro-business,
3. Energy technology,
4. Electronics and Advanced materials,
5. Digital techniques.

The highest reported R&D expenditures in Croatia are linked to the following sectors: scientific research and development (33.0%); manufacture of basic pharmaceutical products and pharmaceutical preparations (18.4%); telecommunications (14.0%) and motor vehicles (7%), food (6%), civil engineering (5%) and financial and other services (4%).

A detailed analysis of BERD data offers the following finding and conclusions:
- CBS data shows that Chemical Sciences, Electrical Engineering, Chemical Engineering and Pharmaceutical Technology are the most R&D intensive subfields of science in the private sector. They are followed by Computer Science and Food Technology;
- Analysis of Croatian Tax Authority shows that ICT and Pharmaceutical technology are the most represented sectors of technology in the private sector R&D investments and together amount to over 80% of all R&D business expenditure, clearly signaling which technology sectors are currently the most promising in Croatia. They are followed by Electronics & Electrical Engineering and Machinery & Shipbuilding.

The structure of the business expenditures on R&D in 2011 reveals that Croatia is missing middle and small size companies capable of performing and investing in R&D. Several large companies that have been investing significantly in R&D through their own research facilities have undergone restructuring in last few years in which the role of R&D was reduced. For instance, PLIVA was the only company from Croatia listed in the 2009 EU Industrial R&D Investment Scoreboard and took 538th place of 1000 non-EU companies, but it faced downsizing of R&D activities.

Related to Scientific strengths, The Ministry of Science, Education and Sports defined priority areas, based on R&D performance and set in Croatian Research and Innovation Infrastructure Roadmap. These areas are biomedicine, biotechnical sciences, natural sciences, technical sciences, social sciences and humanities and interdisciplinary sciences. These priorities are linked to Croatia’s publication performance in the SCImago database. The top ranked subjects are: Medicine, Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Physics and Astronomy, Engineering and Chemistry. As mentioned previously, the main areas with patent applications are Pharmaceuticals, Biotechnology, Medical Technology and ICT.

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48 Prepared under project “Preparation of Future Programming Documents and Accompanying Project Pipelines” (Contract No EUROPEAID/131491/D/SER/HR)
2.4.1. Croatian participation in FP7 reveals strength in different R&D areas

Croatia has been a participant in FP7 since its inception in 2007. It is particularly successful under the scientific themes in which it is also strong at national level. These are: Healthcare, Transport and ICT. Croatia is doing reasonably well in the areas of Security, Biotechnology, Environment and Energy.

Participation of SMEs is also good: out of 225 SME applicants, 57 or more than 25% were selected for funding. Croatia has benefited strongly from Research Potential (FP7-REGPOT), part of FP7 specific programme 'Capacities', with a number of very substantial infrastructure projects. For example, textile technology is a field where considerable investment is being made to assist national industry through the development of expertise in the areas of innovative textile and textile related products\(^{50}\). Detailed analysis of the FP7 programme leads to the conclusion that Croatia is particularly recognized at European level for research in the following areas: health care (translational medicine, bone regeneration, brain repair, some cancer treatment, anti-body technologies); transport; ICT (robotics, UAVs – unmanned aerial vehicles) and geodesics (anti-personnel mines, sub munitions and UXO).

In FP7, Croatia accounts for 394 participations and had a role of coordinator in 39 projects. The FP7 financial contribution per inhabitant (20.5 €/inhabitant) is higher than the EU13 average (17.8 €/inhabitant) but remains far below the EU15 average (95.2 €/inhabitant). The results are shown in Table 10.\(^{51}\)

Table 10 Croatian participation in FP7 in comparison to EU13 (‘NMS’) and EU15 (2007-2013)

<table>
<thead>
<tr>
<th></th>
<th>Croatia (% of FP7)</th>
<th>EU13 (% of FP7)</th>
<th>EU15 (% of FP7)</th>
<th>FP7</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU Contribution (in M€)</td>
<td>90.6 (2.0%)</td>
<td>1 883.6 (4.2%)</td>
<td>37 852.2 (85.3%)</td>
<td>44 364.1</td>
</tr>
<tr>
<td>Number of participations</td>
<td>394 (0.3%)</td>
<td>10 617 (8.0%)</td>
<td>105 731</td>
<td>152 382</td>
</tr>
<tr>
<td>Number of coordinations</td>
<td>39 (0.16%)</td>
<td>1 011(4.0%)</td>
<td>20 301</td>
<td>25 652</td>
</tr>
<tr>
<td>EU Contribution per inhabitant (in €)</td>
<td>20.5</td>
<td>17.6</td>
<td>95.2</td>
<td>78.9</td>
</tr>
</tbody>
</table>

Croatian institutions participated mostly in Cooperation calls (47.4%) followed by Capacities instruments as shown in Table 11.

Table 11 Croatian participation in FP7 calls (2007-2013)

<table>
<thead>
<tr>
<th></th>
<th>% of EU Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Croatia</td>
</tr>
<tr>
<td>COOPERATION</td>
<td>47.4%</td>
</tr>
<tr>
<td>IDEAS</td>
<td>4.1%</td>
</tr>
<tr>
<td>PEOPLE</td>
<td>9.3%</td>
</tr>
<tr>
<td>CAPACITIES</td>
<td>39.1%</td>
</tr>
<tr>
<td>EURATOM</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

Source: JRC/IPTS calculated using the EC FP7 contract database June 2014.

\(^{50}\) Unlocking the Croatian Textile Research Potentials, funded under FP7-REGPOT and coordinated by Faculty of Textile Technology of the University of Zagreb. http://cordis.europa.eu/project/rcn/90195_en.html

\(^{51}\) JRC/IPTS calculated using the EU FP7 contract base June 2014.
FP7 was a great funding source for SME in Europe and Croatian companies participated in different instruments in this program. The number of SMEs was not high but the best success rate was in R&D performing companies active in Health, Environment, etc. The results for the entire funding period are shown in Figure 15.

Figure 15 Number of SMEs in FP7 research

![Bar Chart]

The matching between R&D priority areas that have been selected for the Croatian S3 and Croatian FP7 funded projects should be treated with care in the case of specialization areas which are more detailed than FP7 or conversely less detailed. The theme funded by FP7 encompasses a broad range of activities whereas Specialization areas concern only one or a limited number of activities (Table 12). However, it is very important to analyse these data that serve as a good basis for future planning.

Table 12 Correlation between FP7 funded projects and S3 priority sectors
Based on data presented in Table 12 there is a good correlation between R&D priority sectors selected by S3 and FP7 funded projects. ICT sector received a significant amount of FP7 funds, second to Health and it has been selected as KET in S3.

Croatian financial gain through FP7 project is shown in Table 13.

Before joining the EU, besides FP7, Croatia participated in IPA funded programs. Some of these programs were tailored towards increasing the competitiveness of the Croatian R&D sector and Croatian economy overall. The results of Croatian participation have been shown in Table 14.

Table 13 FP7 funding structure for Croatia: Budget breakdown in percentages

<table>
<thead>
<tr>
<th>Research area</th>
<th>EU Contribution (in M€)</th>
<th>S3 Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food, Agriculture and Fisheries</td>
<td>1.27</td>
<td>yes</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>1.35</td>
<td>yes partially</td>
</tr>
<tr>
<td>Health</td>
<td>10.48</td>
<td>yes partially</td>
</tr>
<tr>
<td>Information &amp; communication technologies (ICT)</td>
<td>6.76</td>
<td></td>
</tr>
<tr>
<td>Nanosciences &amp; Nanotechnologies</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>New production technologies (incl. Construction technologies)</td>
<td>0.66</td>
<td>yes partially</td>
</tr>
<tr>
<td>Energy</td>
<td>3.95</td>
<td>yes partially</td>
</tr>
<tr>
<td>Environment</td>
<td>3.27</td>
<td>yes partially</td>
</tr>
<tr>
<td>Aeronautics</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Space</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>Automotive</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Rail</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>Waterborne</td>
<td>1.29</td>
<td>yes partially</td>
</tr>
<tr>
<td>Urban transport and intermodalities</td>
<td>4.79</td>
<td>yes partially</td>
</tr>
<tr>
<td>Socioeconomic sciences and humanities</td>
<td>1.91</td>
<td></td>
</tr>
<tr>
<td>Security</td>
<td>3.50</td>
<td></td>
</tr>
<tr>
<td>TOTAL Cooperation Programme</td>
<td>42.83</td>
<td></td>
</tr>
<tr>
<td>TOTAL Cooperation Programme related to S3 priorities</td>
<td>30.51 (71.2%)</td>
<td></td>
</tr>
</tbody>
</table>

Source: data: FP7 contracts database June 2014, processed by JRC-IPTS

Table 14 IPA funding in Croatia (2007-2011) (in Euros)
2.4.2. Human potential for S3

The availability of qualified human resources for innovation is an important predictor of the quantity and quality of economically useful innovation. An uninterrupted flow of well-trained scientists, engineers and technologists can be central to the dynamism of an innovation system. An examination of the education and training programmes for such skills can reveal important currents and future bottlenecks in the innovation system. According to Eurostat data from 2013, only 25.6% of 30-34 year-olds have completed tertiary or equivalent education in Croatia (compared to 37.1% in EU 28).

In order to evaluate which fields of studies Croatian students select, in depth analysis has been performed considering five-year period from academic year 2011/2012 until 2015/2016 at all Croatian universities. As indicated in Table 15 more than 50% of students enrolled are selecting social sciences and humanities. Around 60% of students in Croatia study social sciences and humanities, while the number of students enrolled in STEM areas decreases. For example, in 2012 Croatia had 42% of graduates from Social Sciences, Business and Law programmes within entire population of tertiary graduation graduates, compared to 23.4% in Germany and 25.3% in Finland. This share of social sciences and humanities is very high and it is not favourable factor for future Croatian development of RDI. Additionally, Croatia has high drop-out rates in STEM areas with particularly high drop-out of 41% at first year of STEM programs. Croatian Government is taking measures to overt this trend but much improvement is needed.

Table 15 Enrolment of students in the 1st year by field of study

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomedicine and health</td>
<td>2.219</td>
<td>2.211</td>
<td>2.259</td>
<td>2.286</td>
<td>2.360</td>
</tr>
<tr>
<td>Biotechnical sciences</td>
<td>1.779</td>
<td>1.885</td>
<td>1.917</td>
<td>1.942</td>
<td>1.950</td>
</tr>
<tr>
<td>Humanities</td>
<td>3.348</td>
<td>3.317</td>
<td>3.261</td>
<td>3.287</td>
<td>3.315</td>
</tr>
<tr>
<td>Interdisciplinary fields of science</td>
<td>175</td>
<td>191</td>
<td>175</td>
<td>229</td>
<td>276</td>
</tr>
<tr>
<td>Natural sciences</td>
<td>1.470</td>
<td>1.430</td>
<td>1.381</td>
<td>1.409</td>
<td>1.435</td>
</tr>
<tr>
<td>Technical sciences</td>
<td>8.195</td>
<td>8.359</td>
<td>8.305</td>
<td>8.904</td>
<td>8.690</td>
</tr>
<tr>
<td>Arts</td>
<td>463</td>
<td>443</td>
<td>436</td>
<td>474</td>
<td>483</td>
</tr>
<tr>
<td>TOTAL</td>
<td>30.304</td>
<td>29.751</td>
<td>29.562</td>
<td>30.739</td>
<td>30.997</td>
</tr>
</tbody>
</table>


Regarding postgraduate studies and Ph.D. holders, according to the Croatian Central Bureau of Statistics data in 2014, 20.8% of PhD students graduated in the field of social science, 20.6% in the field of engineering and technology, 19.3% in the field of biomedicine and health, 16.2% in humanities, 16.1% in natural sciences, 4.9% in the field of biotechnology and 1.3% in the interdisciplinary field of science. Systematically gathered indicators of the flows of students and

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graduates and figures on the international testing of students in mathematics and science allow for cross-country comparisons (Figure 16). In terms of tertiary education graduates in the fields of mathematics, science and technology, Croatia is not that far from the EU average.

Figure 16 Pisa score for students from different countries (2012)

Another problem related to the human resources in Croatian research system is the low quality of postgraduate studies accompanied with the lack of internationally visible mentors who are partially lacking the skills for high quality mentoring and independent guiding of the excellent young researchers with international experience. Analysis of research conducted within the Modernization of Doctoral Education while implementing the Croatian Qualifications Framework Project (MODOC 2013-2014) and a poll conducted in March 2015 by a network of young scientists (MLAZ) on a sample of 1,225 doctoral students, showed that the existing doctoral programmes generally prepare doctoral candidates to stay in public sector, while the preparation for integration in the business sector or pursuing self-employment (start-ups) is weak or completely missing.

At the same time, according to the results of the MODOC analysis, such a conclusion is corresponding to the conclusion of the employers who are extremely dissatisfied with the competencies of young researchers acquired during doctoral studies which they find not applicable in the business sector. This is one of the reason why the business sector has shown an extremely low demand for people with acquired academic degree of Doctor of Philosophy (Ph.D).

Therefore, one of the key measures in the Strategy of Education, Science and Technology is aimed at establishment of system for the evaluation of researchers, research results and research institutions which shall affirm and incite scientific excellence and international visibility, mutual collaboration and cooperation with the research results users and the social relevance of research. Strong research teams and quality researchers whose work shall be evaluated in accordance with international competitive criteria are a precondition for strengthening international cooperation, competitiveness and economic system based on innovation. The introduction of a new model of career development based on clear and internationally competitive criteria can be considered as a key reform in the system of the promotion of scientists and adaption of universities to rapid changes in science. Also, one measure is stimulating international mobility (incoming and outgoing) of researchers and students and involvement in international programmes and networks. Measures set by this Strategy are fully in line with the National Innovation Strategy 2014-2020, the aim of which is closer linkage of the research...
system and the economy.

A more focused view of knowledge intensity and its potential relevance to innovation activity can be obtained by examining employment shares of researchers, scientists and engineers. Human resources in the science and technology core (HRSTC) include individuals who have completed education in a science and technology subject and are employed in a science and technology profession. The share of HRSTC in total employment, together with the narrower share of scientists and engineers, can be a useful proxy of the pervasiveness of scientific and technological skills in economic activity (Figure 17). Compared to other countries and the EU27 average, Croatia has a low share of both HRSTC and scientists and engineers.

Figure 17 Human resources in the science and technology core

Continuing education and lifelong learning are important components of a dynamic innovation system. Participation in education and on-the-job training of working age adults indicate the acquisition of the new skills and knowledge necessary for the introduction of new workplace processes and organizational innovations in particular. It is also an indication of the extent to which private companies value knowledge and skills. Figure 18 presents the percentage of 25-to-64 year-olds who participate in education and training in Croatia and in the comparator group. Croatia occupies last position, with only Hungary at a comparably low level, and shows little improvement over time.

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53 HRSTC: human resources in science and technology – core, present those people who have successfully completed a tertiary level education AND are employed in an S&T occupation.

54 According to Eurostat indicators on Human Resources in Science and Technology (Annex 1 – HRST stocks) Professionals occupations whose main tasks require a high level of professional knowledge and experience in the fields of physical and life sciences, or social sciences and humanities) are sub-divided into four sub-major groups — physical, mathematical and engineering science professionals; life science and health professionals; teaching professionals; and other professionals. The first two sub-groups are making up the sub-set of scientists and engineers (S&E).

R&D personnel include researchers in addition to other support staff such as technicians and managers. The evolution of the number of R&D personnel and its various subdivisions over time can provide an alternative view of the scale and nature of R&D activity. The patterns here can be expected to correlate with R&D expenditures, as salaries for R&D personnel account for a large proportion of GERD.

At 0.46% of total employment, the share of researchers mirrors Croatia’s GERD intensity for 2011 (0.75%) and is behind all other countries in the comparator group with the exception of Poland (Figure 19). Croatia maintains this position for all other sub-divisions of R&D personnel, except technicians and equivalent staff, where it is at about the same level as Hungary and above Estonia, the Slovak Republic and Poland. The funding shortfall has hit the employment of human resources for research hard. During 2002-08, Croatia had negative growth in total full-time equivalent (FTE) researchers (-4%) and business researchers in particular (-2.2%) (EC, 2011a), a trend that is probably also connected with the downsizing of the former Pliva institute. A closer examination of trends over time reveals that after some volatility in 2003-05, the trend stabilized and was mildly positive until the interruption in 2009. The overall trend for R&D personnel closely mirrored this behaviour, an indication that the determinants of their employment overlap (Figure 20).

**Figure 19 Total R&D personnel, researchers (full-time equivalent), technicians/equivalent staff and other supporting staff as a share of total employment, 2011**

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56 The Adult Education Survey (AES) covers adults’ participation in education and training (formal, non-formal and informal learning) and is one of the main data sources for EU lifelong learning statistics. The AES focuses on people aged 25-64 living in private households. The reference period for the participation in education and training is the twelve months prior to the interview.
Croatia has a difficult and slow transition as far as human resources are concerned due mostly to the recession which created long term unemployment and reduced the relevance of skills of workers and the very slow reform of the education system which continued to produce qualifications out of tune with the needs of the labour market. Combined with the low investment in lifelong learning in general, the skill structure has become a limiting factor for developing competitiveness, innovation and growth. Currently, a system of aligning education with labour market needs is being set up and will partly receive support as well as serve the S3 process.

Figure 21 Labour force (employed and unemployed) by skill areas which correspond to S3 thematic priority areas and cross-cutting themes

Source: Croatian Pension Insurance Institute

From the figure above, it is clear that skill areas or sectors which are relevant for S3 cover about 42% of the labour force in Croatia (2014). Engineering skills have the highest share at 228 thousand or 13%, Transport and mobility 125 thousand or 7%, Health and quality of life 106 thousand and so forth (Figure 21).

Some of the key economic sectors, which have been singled out as having potential, based on export, technological strengths, or other strong competitive advantages in fact have low shares of professionals. For example, manufacture of fabricated metal products and motor vehicles, crop and animal production, manufacture of wood and wood products, manufacture of machinery and equipment have below average shares of employed professionals. The reason for this is based on the fact that mentioned industries have low shares of professionals, but also imply also significant employment of blue collar workers.

HR potential also shows that there might be some potential sectors with excellent human resource base but which have not been selected as S3 priority. These are veterinary sector, architecture, construction and information services. In order to develop relevant skills, a system of assessing labour market needs for timely development of skills is being put in place. This will be achieved through new instruments of future skills assessment and the implementation of the Croatian Qualification Framework as a delivery mechanism and the continuous (annual) financing of its instruments (employers’ survey, occupational and qualification standards, training programmes based on standards, etc.). Mechanisms for understanding future skill needs have to be based on thematic areas that clearly require very different skill sets. Several instruments will be used for assessment of skill

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57 Croatian Pension Insurance Institute data, June 2014
58 There are 25 skill sectors in Croatia which are defined within legislation governing the Croatian Qualification Framework. Each skill sector is a group of homogenous occupations at all levels of complexity which use the knowledge and skills from a particular field of education.
59 This major group includes occupations whose main tasks require a high level of professional knowledge and experience in the fields of physical and life sciences, or social sciences and humanities. The main tasks consist of increasing the existing stock of knowledge, applying scientific and artistic concepts and theories to the solution of problems, and teaching about the foregoing in a systematic manner. Most occupations in this major group require skills at the fourth ISCO skill level. This major group has been divided into four sub-major groups, 18 minor groups and 55 unit groups, reflecting differences in tasks associated with different fields of knowledge and specialisation.
60 Croatian Pension Insurance Institute data, June 2014
needs that can be divided into the activities based on their focus and type of intervention (presented in chapter 6).

2.5. Conclusions

A successful transition to an open, market-based economy and institutional reform underpinned fairly strong pre-crisis growth and convergence and culminated in Croatia’s accession to the EU. However, the financial and economic crises have exposed structural weaknesses of Croatia’s economy and its pre-crisis growth model.

To achieve sustainable income and employment growth and strengthen international competitiveness, Croatia needs to become more competitive and innovative. Sectoral specialization, market orientation, and domestic supply-side factors, all concurred to the negative performance. Facing critical international and domestic challenges, Croatia needs to produce and export innovation-based products, as well as move towards higher value added economic activities. Croatia’s exports have to become sufficiently sophisticated to stand global and regional competition.

The Croatian economy is dominated by traditional and low technology sectors and production and adoption and diffusion of KETs is low. However, there are several globally competitive industry segments, which coincide with also a strong research capacity. Most notably these are in the fields of electronics and advanced materials, energy, digital technologies, biotechnology, food processing and health. Corresponding industry segments (niches) where Croatian companies successfully translated R&D into manufactured products are in transport equipment and specialized vehicles, electrical machinery and products, special machine tools, plastic products, chemicals, healthcare and medical products.

Croatia is poorly integrated into international value chains which may be more important than innovativeness per se as GVC could be levers of growth. This in turn, has significant negative effects in technology transfer, as well as innovation and productivity gains, as global value chains have been an important source of knowledge and incentive for product and process improvements by local providers. However, in some cases, such as automotive parts and components, Croatia’s industry shows good progress and increased ability for stronger integration into GVC, thus indicating a potential for further scaling up its innovation capability.

Croatia still does not have a mature innovation system with a core of highly innovative businesses as a driver. R&D expenditure is low at 0.81% of GDP (with 0.41% share of business sector), compared to 2% in the EU and 2.4% in the OECD. With 37.9% of enterprises which reported innovative activity in period 2010-2012 Croatia is below EU-28 average (48.9%). In comparison to 2006-2008 period, the share of innovative enterprises has dropped from 44.2 to 37.9% indicating a fall in innovation activities, which can be attributed mainly to the economic crisis, but partially also to the lack of proper government innovation promotion programmes.

Policies for business innovation are focused on the commercialization of public research and on high-technology firms. However, innovation, in its diverse forms, is relevant to all businesses. Therefore more efforts should be made to steer policy on a broad concept of innovation, to include, in addition to R&D, marketing, organizational, and service innovation. Raising the share of innovative firms and their capabilities should be a priority and be reflected in the innovation policy mix. A key task is to strengthen companies’ in-house skills in engineering, design, information technology and R&D. There is still much space for improvement of the framework conditions for innovation and in leveraging other government policies (such as regulation and public procurement) to raise demand for innovation.

61 http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey
Croatian Innovation System needs to be better organized, coordinated, implemented and evaluated. Necessary increases should happen alongside the professionalization of delivery, the use of differentiated instruments and rigorous evaluation. Funding is not always the main constraint. Professionalized government agencies, together with business associations, can help in providing information, coaching, and in building communities that link parts of the innovation system. Universities and PRIs are an important part of Croatia’s innovation system and the productivity of researchers is increasing. While improving, scientific publications have a low citation impact, and the research system could benefit from further internationalization. Public research has been held back by limited resources, as well as, complex and inflexible organisation and governance. Fragmentation within universities and among PRIs is a hindrance to effective governance and top performance. Public research funding is insufficiently linked to performance. Competitive research funding has been low and volatile. An empowered Croatian Science Foundation started shifting the balance towards competitive funding, and consequently reinforcing scientific rigor, encouraging internationalisation and social relevance. Yet another drawback is the declining share of students in STEM fields (science, technology, engineering and mathematics).

Balancing factors important for R&D inputs and outputs. Despite the overall low gross expenditure on R&D, Croatia still spends more on R&D per capita than other EU countries at similar income level. However, patenting activity is low. Patenting is a significant indicator because patents provide a link between invention, innovation and the marketplace, but it should not be the only focus of the strengthening knowledge and technology transfer process. Overall, these indicators combined suggest that R&D expenditure is not the only bottleneck to increased innovation in Croatia, but that also the national innovation system is not efficient in commercializing R&D. If smart growth is to be achieved, these challenges need to be addressed through a set of priority measures targeted at improving the functioning and efficiency of the national innovation system.

Croatia is addressing and implementing policies important for development of the National Innovation System. Croatia has taken steps in recent years to strengthen the national research capacity by taking measures and adopting policies that are compatible to the EU policy on the European Research Area and also reform measures by proposing amendments to the Act on Scientific Activity and Higher Education that are aimed at creating a legislative framework for a more programme-based and competitive funding of public research organizations. Recently, Croatia adopted several key strategic documents important for R&D for innovation: Innovation Strategy (2014), Strategy for Education, Science and Technology (2014); it started restructuring of PROs and it is in the process of reforming education curriculum. These are important contributions because they set the stage for improved R&D activity, which combined with investments in research infrastructure, good research management and through improved collaboration between the R&D institutions, universities and the private sector can result in better orientation of R&D activities towards economy needs.

One of the most important barriers to innovation is the lack of adequate linkages between research institutions and the business sector. The country performs poorly in the number of public-private co-publications per million population, 27.4 versus 52.8 for the EU.

Support to joint industry-research projects where there are demonstrated benefits for both enterprises and the public sector researchers is therefore considered a priority. Lack of interest in collaborating from the commercial sector and a lack of motivation for engaging in the research community needs to be addressed. Technology transfer offices of public research organizations can help. Alignment of universities and industry can be facilitated by systematic consultation on skills and curricula, schemes that encourage industry co-funding of tertiary education, tailored university study programmes for those already employed, longer and more selective work placements, and a greater quantity and quality of professional tertiary programmes. A strategic move towards larger, longer-term programmes would help secure commitment from industry and facilitate a coherent upgrading of both business and public R&D capacities, which were additionally lowered due to prolonged recession and its negative effects. Altogether, further enhancement and realization of the crucial role that TTOs have in the
innovation eco system due to their central position for information, education and help to R&D personnel is necessary.

The number of R&D personnel in the business sector is low. In Croatia the largest numbers of researchers are employed in the higher education and government sectors (75%). This lack of R&D expertise in the commercial sector presents additional obstacles to further growth because it is generally regarded that company based R&D is more frequently market-driven and R&D intensive businesses tend to have a competitive advantage on the market. Additionally, Croatia is still bearing the consequences of a large scientific diaspora. Therefore Croatia needs to tackle a major challenge related to human resources and its low share of labour force dedicated to R&D activities, particularly in the business sector in order to increase the scale and quality of the R&D workforce.

Investments in knowledge-intensive clusters and innovation networks are important determinants of Croatia's competitiveness in the global markets. On the other hand, a commitment to the STPs development in Croatia will enable a systematic approach in integrating components of the entire RDI chain. Consequently, this should result in a fully functional innovation eco system with the absorption of the much-needed high skilled professionals and a creation of a sustainable bridge between the private and public sector.

A number of factors contributing to the relatively poor performance of Croatia’s business sector considering R&D spending include: the concentration of tax incentive benefits by sector and firm size, the lack of early stage financing, barriers to science-industry collaboration, and pervasive weaknesses in the governance framework. Although small firms represent the majority of the R&D tax break beneficiaries overall, large firms receive most of the benefits, while tax breaks are also highly concentrated by sector. Lack of early stage financing also raises a major obstacle for the development of innovative start-ups and data indicates that there is a substantial gap between the demand and the supply for venture capital in Croatia. The country’s unique sources of seed and pre-seed capital support for SME R&D projects, the Proof of Concept and RAZUM programs - managed by the HAMAG BICRO are still in pilot phase although a series of assessments have consistently indicated their overall positive impact. The government has not yet properly addressed the financing gap. This has significant negative impact on the country’s overall innovation and economic performance and on its ability to meet the Europe 2020 commitments. One of the most important barriers to innovation is the lack of adequate linkages between research institutions and the private sector. According to a recent report by the European Commission, universities largely rely on individual initiatives and lack a consistent institutional approach for technology transfer. Finally, perhaps the biggest challenge of all is strengthening policy governance for impact. Currently, the system is not fully functional and the technology and innovation policy is still fragmented in Croatia, resulting in programs with overlapping objectives and a lack of rationalization of resources. Moreover, research institutions lack appropriate governance mechanisms including performance-driven career development, transparent recruitment policies, and clear rules regarding ownership and commercialization of intellectual outcomes.

Access to finance, particularly access to venture capital for start-up technology-based businesses in their initial stages, is limited. This is a very important obstacle correlated with the increase in competitiveness and the achievement of economic growth. Currently, Government is establishing VC fund under World Bank funding. This will help with early financing. Due to an undeveloped capital market, the main sources of funding for companies in Croatia are banks, which are highly averse to risk and where long-term loans are, in principle, not available. Introducing new financial instruments can be useful particularly for innovative start-ups as it can be coupled with innovation management assistance, which increases the chances of reaching the technology commercialization stage. At local and regional levels institutions have been established to provide support, in different forms, to entrepreneurs and small businesses (i.e. regional and local development agencies, entrepreneurial centres and business incubators). At present, business support organizations provide general and low value added support services and advices. Furthermore, business support organizations have difficulty in meeting the demand from entrepreneurs and
managers for specific and high value added services including quality management, marketing plans, investment and project appraisal and support, support in relation to intellectual property rights, support related to innovation and new product development.

**S3 is necessity for Croatia.** Taking all this into consideration, the implementation of the S3 is a good opportunity for the country to push itself out of that ‘trap’, by promoting the conditions necessary for continued structural transformations and the renewal of the country’s production sector. Croatia has only a limited set of clear existing or emerging comparative advantages. Smart specialization priorities should support discovery of potential comparative advantages and address those advantages in order to secure long lasting economic impact. The main policy goals to pursue through the process of smart specialization are (i) improving productivity gains by enabling efficient entry and exit conditions, (ii) enhancing innovation by promoting R&D investments by business sector (especially medium-sized firms and by young companies) which will need to be assessed and (iii) improving technology upgrading by moving from low productivity to higher productivity segments through non-RDI.

**Government will take immediate, short term and a long term policy measures:** From a policy standpoint a number of initiatives are being considered in order to streamline the innovation framework, among others: (i) strengthen the connection with the global scientific community including through the expansion of the Unity Through Knowledge Fund and by improving conditions for the mobility of researchers; (ii) advance reforms in the regulation of research profession to further emphasize excellence (e.g. emphasizing publication in high impact factor journals) in career development and (iii) promote better access to research infrastructure through “open access policy”.

To improve linkages between research institutions and the private sector, as this can be an important catalyst for innovation, of course, enhancing and promoting RDI activities will bring to the creation of the demand from business sector. Otherwise, links will be of limited influence. In this area, key policy actions include: (i) streamlining the regulatory framework for IPR and technology transfer; and (ii) setting up incentives for researchers to participate in TT activities such as recognition in career development, rights to participate in licensing revenues and equity participation in new firms. Thirdly, governance of research institutions needs to be improved in line with the goal of enhancing research excellence. Finally, it is necessary to secure coherence between findings of S3 and other key strategic documents which cover the issues of RDI. The following table clearly shows how this coherence has been achieved. **The conclusion of S3 Analysis are in correlation with identified priorities in other key strategic documents which cover the issues of RDI (Table 16).**

**Table 16 Key strategic documents for meeting national RDI targets**

<table>
<thead>
<tr>
<th>Strategy for Education, Science and Technology (SEST)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The aim of the strategy is to create an open and innovative society and economy, with flexibility to adapt to future challenges, emphasizing the key role of human capital and life-long learning in the long-term strategic development. One of the main goals is to create conditions for research and innovation focused on excellence in science, industrial leadership and societal challenges. It also aims to create conditions to provide high-quality education to all on equal terms and to enable science to contribute to job creation and socio-economic prosperity. Many of the priorities and related measures in this strategy response to weaknesses and opportunities recognised in the S3. The following SEST priorities correspond to greatest extent to measures foreseen by the S3:</td>
<td>The aim of the strategy is to create an open and innovative society and economy, with flexibility to adapt to future challenges, emphasizing the key role of human capital and life-long learning in the long-term strategic development. One of the main goals is to create conditions for research and innovation focused on excellence in science, industrial leadership and societal challenges. It also aims to create conditions to provide high-quality education to all on equal terms and to enable science to contribute to job creation and socio-economic prosperity. Many of the priorities and related measures in this strategy response to weaknesses and opportunities recognised in the S3. The following SEST priorities correspond to greatest extent to measures foreseen by the S3:</td>
</tr>
<tr>
<td>▪ Accelerate changes in higher education and science system</td>
<td>▪ Accelerate changes in higher education and science system</td>
</tr>
<tr>
<td>▪ Develop internationally competitive public universities and institutes</td>
<td>▪ Develop internationally competitive public universities and institutes</td>
</tr>
<tr>
<td>▪ Develop stimulating environment to enhance interaction and to push forward transfer mechanisms between research community and innovative economy</td>
<td>▪ Develop stimulating environment to enhance interaction and to push forward transfer mechanisms between research community and innovative economy</td>
</tr>
<tr>
<td>▪ Involve higher education and scientific organization in the process of smart specialization and guidelines for technological development</td>
<td>▪ Involve higher education and scientific organization in the process of smart specialization and guidelines for technological development</td>
</tr>
<tr>
<td>▪ Strengthening national research and innovation infrastructure with public access and connecting with European infrastructures</td>
<td>▪ Strengthening national research and innovation infrastructure with public access and connecting with European infrastructures</td>
</tr>
<tr>
<td>▪ Improving the financing system and promoting investment in R&amp;D from the business sector</td>
<td>▪ Improving the financing system and promoting investment in R&amp;D from the business sector</td>
</tr>
<tr>
<td>▪ Improve the study programmes and redefine related acquired skills and competences</td>
<td>▪ Improve the study programmes and redefine related acquired skills and competences</td>
</tr>
<tr>
<td>▪ Ensure high-quality staff in education and research institutions</td>
<td>▪ Ensure high-quality staff in education and research institutions</td>
</tr>
</tbody>
</table>
- Develop efficient and stimulating system for financing higher education
- Improve ICT and spatial infrastructure
- Promotion of ICT in education
- Stimulate internationalization of studies
- Develop the system for quality assurance and public accountability on all levels of education
- Integration of LLL policies with the strategic objectives of socio-economic, regional and cultural development and employment and social policies
- Improve opportunities for training in or from work places

### Innovation Strategy

<table>
<thead>
<tr>
<th>Thematic pillar 1. Development of innovation system, including regulatory and fiscal framework</th>
<th>Priorities of the thematic pillar 1:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Improving the governance of innovation system</td>
<td></td>
</tr>
<tr>
<td>2. Development and upgrading of innovation value chain</td>
<td></td>
</tr>
<tr>
<td>3. Establishment of regulatory framework</td>
<td></td>
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<tr>
<td>4. Establishment of fiscal framework</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Thematic pillar 2. Strengthening the innovation potential in the Croatian economy</th>
<th>Priorities of the thematic pillar 2:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Support to establishment and growth of innovative SMEs</td>
<td></td>
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<tr>
<td>2. Support to R&amp;D and innovation investments in SMEs</td>
<td></td>
</tr>
<tr>
<td>3. Support to R&amp;D and innovation investments in large enterprises</td>
<td></td>
</tr>
<tr>
<td>4. Facilitating access to finance</td>
<td></td>
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<tr>
<td>5. Facilitating foreign direct investments in high-technology sectors and emerging industries</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Thematic pillar 3. Promotion of cooperation and knowledge transfer between business, public and research sectors</th>
<th>Priorities of the thematic pillar 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Support to interaction between industry and science and research organization</td>
<td></td>
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<tr>
<td>2. Contribution to solving societal challenges through innovation</td>
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<tr>
<th>Thematic pillar 4. Human resource development for innovation and creation of attractive environment for world-class researchers</th>
<th>Priorities of the thematic pillar 4:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. New skills development for R&amp;D and innovation</td>
<td></td>
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<tr>
<td>2. Provision of business support to entrepreneurs in R&amp;D and innovation</td>
<td></td>
</tr>
<tr>
<td>3. Promotion of scientific excellence and internationalization</td>
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</table>

### Industrial Strategy

The Industrial strategy aims at establishing a coherent industrial policy instead of ad-hoc policy for specific branches/sectors. The main objective for Croatian industry for the period of 2014 - 2020 is the repositioning of identified strategic activities in the global value chain towards developing activities that create added value.

The strategic development objectives are:
1. Growth of industrial production at an average annual rate of 2.85%;
2. Growth in the number of new employees by 85,619 by the end of the 2020, of which at least 30% of the highly educated;
3. Growth of labour productivity by 68.9% in the period of 2014 - 2020;
4. Increase in exports in the period 2014 - 2020 by 30% and change in the export structure in favour of export products with high added value.

In accordance with the strategic development objectives, four key priority areas of industrial strategy are defined as follows:
1. Creation of a stable investment environment;
2. Fostering strategic cooperation between industry and the educational system;
3. Restructuring of public management and administration;
4. Development of capital markets (alternative sources of funding).

The list of the sectors which the Industrial strategy has identified as strong is have been part of an extensive analysis undertaken to define S3 priorities:
- Basic pharmaceutical products and preparations production,
- Computer, electronic and optical products production,
- Fabricated metal products production,
- Computer programming, consultancy and related activities (ICT),
- Electrical equipment production,
- Machinery and equipment production. Additionally, the Industrial Strategy also emphasizes the important role of the following economic activities:
  - Food products production,
  - Production of furniture.

### Croatian Research and Innovation Infrastructures Roadmap (ESFRI Roadmap)

The Roadmap was drafted in accordance with ESFRI Roadmap and has been publicly available since April 1, 2014. The Roadmap identifies strategic directions for the development of infrastructure on national level, enabling the use of available EU funds and programs, encouraging institutions to cooperate in planning and implementation of major infrastructure projects of national significance in order to avoid overlapping and to increase investment efficiency, establishing performance monitoring of public policies and investments in science, laying the groundwork for long-term investment planning for the major research infrastructure available to the research community and harmonizing the principles of use and integration into European infrastructures. The Roadmap was designed in line with the key settings of the drafts of the Strategy for Education, Science and Technology, the National Innovation Strategy and the S3. Roadmap’s priorities correspond to some of the industrial activities that have been singled out in Industrial strategy to have the greatest potential for the growth and development of industry.

### Strategy for Cluster Development 2011-2020

Main priorities of the Strategy are: strengthening of export and internationalization of clusters, fostering innovation and technology transfer, strengthening connectivity of complimentary sectors and match-making organizations and increasing quality level by introducing norms and standards. A revision of the Strategy is due in 2015 in order to make it more coherent with the S3 and the Innovation Strategy. In 2012 the Ministry of Economy initiated the establishment of Clusters of competitiveness. Members of these clusters include representatives of companies of specific sectors, research institutes and universities, business associations and other stakeholders, and government organisations. Sectoral strategic guidelines for each of the clusters have been already developed and include all relevant issues: improving the business environment including institutional and infrastructural support, research/technology development/innovation, financing models, positioning and internationalization of the sector, human resources, M&E mechanisms. Secretariat to these clusters of competitiveness is provided through the Agency for Competitiveness and Investments.
3. SWOT ANALYSIS

On the basis of information presented within Analysis chapter, Croatia’s strengths, weaknesses, opportunities and threats in economy and RDI sector are summarized in the SWOT table below. Although weaknesses currently seem to outweigh the strengths, the analysis and consultations with various stakeholders have indicated existing potentials in specific areas, where given megatrends and societal challenges are offering prospects and opportunities for future development in international perspective. Table 17 represents SWOT analysis stemming from the conducted analysis.

Table 17 SWOT analysis

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>WEAKNESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ A privileged geographic location on the Adriatic coast and at the crossroads of Central and South-Eastern Europe, as well as historical links with emerging economies</td>
<td></td>
</tr>
<tr>
<td>▪ Well-educated population in terms of secondary education</td>
<td></td>
</tr>
<tr>
<td>▪ Small drop-out at secondary level education which ensures potentially significant inflow into tertiary education</td>
<td></td>
</tr>
<tr>
<td>▪ Croatian firms possess export strengths in few industries</td>
<td></td>
</tr>
<tr>
<td>▪ Existence of few relatively strong R&amp;D performers (large enterprises)</td>
<td></td>
</tr>
<tr>
<td>▪ Existence of large number of science and R&amp;D institutions</td>
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<tr>
<td>▪ Experience in science and innovation policy design and implementation in the regional context</td>
<td></td>
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<tr>
<td>▪ General commitment on the government level to further development of efficient innovation system</td>
<td></td>
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<tr>
<td>▪ Existence of state-support programmes for innovation on national level</td>
<td></td>
</tr>
<tr>
<td>▪ Lacklustre trade and development performance</td>
<td></td>
</tr>
<tr>
<td>▪ Inadequate/underdeveloped research infrastructure and equipment</td>
<td></td>
</tr>
<tr>
<td>▪ Insufficiently developed and fragmented innovation infrastructure</td>
<td></td>
</tr>
<tr>
<td>▪ Lack of high quality innovation services (business support organizations provide general, insufficiently developed and low value added programmes for SMEs)</td>
<td></td>
</tr>
<tr>
<td>▪ Difficult access to external funding sources</td>
<td></td>
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<tr>
<td>▪ Low level of public resources devoted to R&amp;D in business sector</td>
<td></td>
</tr>
<tr>
<td>▪ Declining share of students in STEM fields (science, technology, engineering and mathematics)</td>
<td></td>
</tr>
<tr>
<td>▪ A mismatch of education/skills of graduates and business needs within education system that is too focused on theoretical knowledge regardless of practical application of knowledge resulting in qualification rather than a competence oriented system</td>
<td></td>
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<tr>
<td>▪ Low share of highly educated labour force in total labour force and unfavorable skill profile in the business sector for RDI</td>
<td></td>
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<tr>
<td>▪ Low mobility of researchers (from research organisations to companies) and low shares of researchers in business sector</td>
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<tr>
<td>▪ Inefficient tertiary education with large drop-out rate</td>
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<tr>
<td>▪ Over focusing on fundamental research within the research system</td>
<td></td>
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<tr>
<td>▪ Low level of R&amp;D collaboration between science and research institutions and business sector</td>
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</tr>
<tr>
<td>▪ Limited capacities with scattered and obsolete infrastructural support for excellent science</td>
<td></td>
</tr>
<tr>
<td>▪ Fragmented and inefficient national innovation system and lack of linkages in innovation value chain</td>
<td></td>
</tr>
<tr>
<td>▪ Insufficient commercialization of research results and insufficient research orientation towards the needs of the economy</td>
<td></td>
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<tr>
<td>▪ Weak RDI capacities of the business sector and low number of laboratories with up-to-date equipment for the implementation of projects with a technological orientation</td>
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<tr>
<td>▪ Insufficient investment in innovation of business sector and limited patenting and commercialisation</td>
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<tr>
<td>OPPORTUNITIES</td>
<td>THREATS</td>
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<tr>
<td>-------------------------------------------------------------------------------</td>
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<tr>
<td>▪ Competitive pressures coming from fully integration into the EU market</td>
<td>▪ Competitive pressures coming from fully integration into the EU market</td>
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<tr>
<td>▪ Access to additional EU funding</td>
<td>▪ Volatility of the international macroeconomic environment</td>
</tr>
<tr>
<td>▪ Implementation of policies and instruments directed at more sophisticated</td>
<td>▪ Non-stimulating macroeconomic framework</td>
</tr>
<tr>
<td>products and higher added value activities</td>
<td>▪ Prolonged recession with a detrimental impact on budget and investments</td>
</tr>
<tr>
<td>▪ Increasing foreign investment in high-tech and emerging industries</td>
<td>▪ Also on FDI</td>
</tr>
<tr>
<td>▪ Internationalization of Croatian enterprises and inclusion and positioning</td>
<td>▪ Further pressure to cut public costs with negative influence on</td>
</tr>
<tr>
<td>within global value and supply chain</td>
<td>strengthening administrative and implementation capacities</td>
</tr>
<tr>
<td>▪ A community of innovation-oriented start-ups and established enterprises</td>
<td>▪ Increased global competition for resources, markets and ideas</td>
</tr>
<tr>
<td>can be found among the country’s SMEs</td>
<td>(concentration of R&amp;D in big hubs)</td>
</tr>
<tr>
<td>▪ Strengthening of existing networks and clusters and implementation of</td>
<td>▪ Increasing international competition from BRIC countries, especially</td>
</tr>
<tr>
<td>cluster initiatives</td>
<td>China</td>
</tr>
<tr>
<td>▪ Strengthening of cooperation between service and manufacturing sector along</td>
<td>▪ Brain drain of researchers and experts, notably in specific fields</td>
</tr>
<tr>
<td>with the enabling of cross sectoral networking.</td>
<td>▪ Continued depopulation and consequently possible stagnation of the</td>
</tr>
<tr>
<td>▪ Bridging the gap in the innovation value chain and creating an enabling</td>
<td>demand, as well as needed workforce</td>
</tr>
<tr>
<td>environment for business RDI through development of innovation platforms</td>
<td>▪ Adoption of the new concept of the innovation policy by all stakeholders</td>
</tr>
<tr>
<td>▪ Enhancing innovation infrastructure and capacities, in particular Centres</td>
<td>▪ Difficulties in coordination, given the number of strategies,</td>
</tr>
<tr>
<td>of Competences</td>
<td>operative documents and institutions involved, with negative impact</td>
</tr>
<tr>
<td>▪ Further enhancement of the technology transfer system through the</td>
<td>on timely programme and project implementation (conflicting</td>
</tr>
<tr>
<td>establishment of Science and Technology Parks and strengthening TTOs</td>
<td>development options; possible lack of close cooperation at all</td>
</tr>
<tr>
<td>▪ Promoting business investment in innovation and research, and developing</td>
<td>political, administrative, economic and social levels)</td>
</tr>
<tr>
<td>links and synergies between enterprises, R&amp;D centres and higher education</td>
<td>▪ Shortfalls in the organisational set-up and governance of HEIs and PRIs</td>
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<tr>
<td>▪ Change of the model of research funding in science and research institutions</td>
<td>▪ National absorption capabilities of the Structural Funds</td>
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<td>– more competitive approach leads to better focus and higher impact of</td>
<td>▪ National absorption capabilities of the Structural Funds</td>
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<tr>
<td>research results</td>
<td>▪ Shortfalls in the organisational set-up and governance of HEIs and</td>
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<tr>
<td>▪ Excellence in few research groups in topics relevant to competitiveness of</td>
<td>PRIs</td>
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<tr>
<td>Croatia and formation of first national Centres of Scientific Excellence</td>
<td>▪ Difficulties in coordination, given the number of strategies,</td>
</tr>
<tr>
<td>▪ Introduction of performance-based and strengthening of competitive</td>
<td>operative documents and institutions involved, with negative impact</td>
</tr>
<tr>
<td>financing of research sector</td>
<td>on timely programme and project implementation (conflicting</td>
</tr>
<tr>
<td>▪ Increased international collaboration and access to international research</td>
<td>development options; possible lack of close cooperation at all</td>
</tr>
<tr>
<td>funding (e.g. Horizon 2020)</td>
<td>political, administrative, economic and social levels)</td>
</tr>
<tr>
<td>▪ Organizational restructuring of HEI and PROs to enhance their efficiency</td>
<td>▪ National absorption capabilities of the Structural Funds</td>
</tr>
<tr>
<td>▪ Solving societal challenges through social innovation projects</td>
<td>▪ Change of the model of research funding in science and research</td>
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<td></td>
<td>institutions – more competitive approach leads to better focus and</td>
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<td>higher impact of research results</td>
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<tr>
<td>▪</td>
<td>Removal of structural imbalances in the area of skills and preparation for future skill needs</td>
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<tr>
<td>▪</td>
<td>Excellence in few research groups in topics relevant to competitiveness of Croatia and formation of first national Centres of Scientific Excellence</td>
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<tr>
<td>▪</td>
<td>Introduction of performance-based and strengthening of competitive financing of scientific sector</td>
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4. CORE STRATEGIES TOWARDS SMART, INCLUSIVE AND SUSTAINABLE GROWTH

Croatian government is committed for Croatia to become an inspiring exemplar of smart, sustainable and inclusive growth as advocated by the Europe 2020. Targeted investments in thematic and sub-thematic priority areas of S3 will become one of the strategic priorities of the national politics. Therefore, innovation will become the overarching priority for the Croatia and the concept of “smart specialisation” a vital part of innovative policy.

4.1. Vision and overall strategic objective

The following vision has been formulated for the S3:

- Croatia will be recognized as knowledge-based economy embracing creativity and innovation at all levels of society for improved quality of life of all its citizens.

The vision has been translated in the following overall strategic objective:

- Focusing knowledge and innovation capacities into areas of greatest potential for Croatia to drive competitiveness and socio economic development and transform Croatian economy through effective RDI activities

To reach this objective, Croatia has taken steps towards a transformation policy approach which focuses on sustainable development (green transport, sustainable food & wood production and processing, renewable energies, clean technologies and bio-products), health and quality of life and security. Through promotion of RDI investment in selected thematic priority areas, with a high innovation and growth potential, as well as large societal impact, Croatia will introduce structural changes (transition, modernization, diversification and radical foundation of economic activity) and give new direction or future development and growth.

The vision and overall strategic objectives have been detailed in six specific strategic objectives that will direct policy initiatives and actions towards increasing smart, inclusive and sustainable growth in Croatia:

1. Increased capacities of RDI sector to perform excellent research and to serve the needs of the economy,
2. Overcoming the fragmentation of innovation value chain and the gap between research and business sector,
3. Modernizing and diversifying Croatian economy through increasing private R&D and non R&D investment,
4. Upgrading in global value chain and promoting internationalization of Croatian enterprises,
5. Working in partnerships to address societal challenges,
6. Creating smart skills - upgrading the qualifications of existing and new work force for smart specialization.

Through delivery instruments Croatia will try to design areas of interventions that will help to improve the supply of innovation, technologies and new solutions. Among the core measures that will be encouraged are support for business sector that aim to deliver more radical eco-innovations or that deploy new environmental and climate-friendly technologies („clean technologies“) and develop new products and services that are more environmentally-friendly.
4.1.1. Specific strategic objective 1: Increased capacities of RDI sector to perform excellent research and to serve the needs of the economy

4.1.1.1. Purpose

The purpose of this specific objective is to raise the level of research excellence in the Croatian research organizations and to create an environment for top class research directed towards the needs of industry and society and contributing to the competitiveness of Croatian economy.

4.1.1.2. Justification

Research organizations (ROs) are vital for innovation and economic performance through their activities in creating, discovering, using and diffusing knowledge. The R&D sector in Croatia is facing different problems that negatively influence performance of the ROs that could be seen through modest achievements in different scientific indicators.

Poor economic and social situation in Croatia as well as modern global competitive market require from Croatian ROs to perform their activities more closely to the needs of the economy. Respectively, it is needed to encourage the pursuit of excellence in research at national and international levels, to provide high-quality environment for competitiveness of Croatian economy by supporting CoRE and enabling ROs to work together with each other as well as with business sector entities in order to mobilize as many resources and jointly contribute to solving of above mentioned problems.

Consequently an important part of innovation chain will be strengthened. The interventions foreseen under this delivery instruments are complementary to Croatian priorities within Horizon 2020 and other initiatives focused on research infrastructure and spreading excellence.
4.1.1.3. **Delivery instrument**

The delivery instruments will be: (1) increase RDI ability for conducting top quality research and cooperation on national and international level; (2) strengthening research excellence by supporting national Centers of Research Excellence and enabling synergies with ERC grants; (3) support to research organizations conducting R&D&I projects directed towards the needs of economy; (4) (5) project "Science and Technology Foresight". See for more details section 6 and Annex 3.

4.1.2. **Specific strategic objective 2: Overcoming the fragmentation of innovation value chain and the gap between research and business sector**

4.1.2.1. **Purpose**

The main purpose of this objective is overcoming the fragmentation of innovation value chain and the gap between research and business sector through strengthening the innovation system, development of innovation infrastructure, clustering and establishment of innovation platforms in thematic priority areas of Croatian economy.

4.1.2.2. **Justification**

The development of the Croatian innovation system is still at a relatively early stage. The role of innovation policy will vary as the system evolves. Innovation policy should therefore set its sights on goals that are both relevant to current stage of development and adequately anticipate the next.

There is still much scope in improving the framework conditions for innovation and in leveraging other government policies (such as regulation and public procurement) to raise demand for innovation. Enterprises must be at the heart of innovations since they detect market opportunities and develop ideas for innovative solutions in order to seize these opportunities. However, Croatia’s entrepreneurs face multiple obstacles and adverse framework conditions in getting ideas to the market.

4.1.2.3. **Delivery instrument**

The delivery instruments will be: (1) development of Innovation Network for Industry and creation of Thematic Innovation Platforms; (2) creation of Centers of Competence and (3) strengthening links between scientific and business sector through support to Technology Transfer Offices and Science Technology Parks. See for more details section 6 and Annex 3.

4.1.3. **Specific strategic objective 3: Modernizing and diversifying Croatian economy through increasing private R&D**

4.1.3.1. **Purpose**

The main purpose of this objective is creating nurturing environment and business culture for the growth of innovative businesses and investments in RDI projects, strengthen relationships between academia and industry, and increase the ability of enterprises to develop, use, adapt and commercialize new technologies and innovative products.
4.1.3.2. **Justification**

Business expenditure for R&D in Croatia has been declining in last few years, a trend that has to be reversed. Innovative firms have lacked the resources and in-house capabilities needed to progress towards new-to-the-market and new-to-the-world innovation. The propensity of businesses to innovate systematically is constrained by characteristics of Croatia's industrial structure, namely: firm size, obsolete technology readiness and usage of new technologies in production processes, sectoral distribution and the relatively low overall share of employment in knowledge-intensive sectors, while the share of employment in knowledge intensive market services is high. The relative decline in the intensity of business-sector R&D (ratio of R&D expenditure to GDP) and the low level of business R&D expenditure (BERD) reveal a widening gap with many advanced and emerging economies. Also, innovation policies have been traditionally linked to science exclusively and lacked broader policy thinking and instruments targeted towards business sector.

Public financial support for business innovation (including tax incentives) has been relatively low. Necessary increases should happen alongside the professionalization of delivery, the use of differentiated instruments, development of entrepreneurial discovery processes targeted towards future needs identification through in-depth RDI strategies, and rigorous evaluation.

Policy for business innovation has been focused on the commercialization of public research and on high-technology firms. However, innovation, in its diverse forms, is relevant to all businesses. Croatia should base its policy on a broad concept of innovation, to include, in addition to R&D, marketing, organizational and service innovation. Raising the share of innovative firms and their capabilities will be a priority and be reflected in the innovation policy mix.

4.1.3.3. **Delivery instrument**

The delivery instruments will be: (1) support to business investment in RDI and (3) Support to SMEs capacities to innovate. See for more details section 6 and Annex 3.

4.1.4. **Specific strategic objective 4: Upgrading in global value chain and promoting internationalization of Croatian economy**

4.1.4.1. **Purpose**

The main purpose of this objective is to focus on investment in knowledge-based capital so as to upgrade to higher-value segments of global value chains and improve Croatia’s position in the global value chain in purpose to increase domestic value added content in export and promoting internationalization of Croatian economy.

4.1.4.2. **Justification**

In today's globalized world, global value chains compete with each other, and the competition between the countries primarily means how each country can join and which part thereof in a structure created by the multinational companies. The ability of a country to participate in global trade and benefit from the transfers that will generate growth and development is now partially linked to its ability to join major GVCs. In order to better understand the value chain, it is essential for Croatian government to have proper insight into the global value movements of trade. The global value chains allow Croatian companies and the economy to carry out that part of the process, which are the best at.
To move up in the value chain, knowledge-based capital and development of business sector through product\textsuperscript{62}, process\textsuperscript{63}, intra-chain\textsuperscript{64} and inter-chain\textsuperscript{65} upgrading, play a key role. Intangible assets, innovation, intellectual property and human resources are the elements in which Croatia must be competitive to be able to assume an increasing role within the value chain and to capture a larger share of value added in global economy.

In the GVC framework, innovation of business sector must contribute to (economic) upgrading (process/product/functional and chain upgrading), increasing the value that business sector and facilitating the transformation and restructuring of existing sectors-enterprises via stimulating their participation in new, global value chains. Upgrading GVC in Croatia will be one of the way how to promote internationalization which becomes a more and more complex issue. It is much more than pure export and FDI, it is about strategic alliances, joint research, co-development, outsourcing, relocation, mergers and acquisitions, licensing IPR, soft landing, technology showcase, etc.

4.1.4.3. Delivery instrument

The delivery instrument will be: (1) Competitiveness Cluster initiatives . See for more details section 6 and Annex 3.

4.1.5. Specific strategic objective 5: Working in partnerships to address societal challenges

4.1.5.1. Purpose

The main purpose of this objective is to overcome fragmentation of individual activities and slow pace of introducing the change. Croatia will mobilize actors across the innovation cycle and across sectors around an overarching target in order to speed up innovative solutions to answer to one or several societal challenges.

4.1.5.2. Justification

Social innovation as a tool which is capable to integrate various stakeholders to address social needs and societal challenge is important for smart development of Croatia and can create new business opportunities and provide new perspective to Croatian citizens. Social innovations are new ideas (products, services and models) that address a social demand or need, contribute to solving a societal challenge (e.g. ageing society, climate change) and, through their process dimension (e.g. new services) they contribute to re-shaping society in the direction of participation, empowerment, co-creation and learning. For this reasons social innovation offer a way of tackling societal challenges when the market and public sector do not respond effectively to the societal needs.

4.1.5.3. Delivery instrument

The delivery instrument will be support to social innovation. See for more details section 6 and Annex 3.

\textsuperscript{62} Firms produce more complex products with higher unit values and specialise in niche products, even in traditionally low-technology industries

\textsuperscript{63} Firms produce more efficiently (i.e. by moving from craft production to mass production)

\textsuperscript{64} Firms gain new functions in the value chain (i.e. develop capacities to design and market products) or move to a different stage of the supply chain (i.e. produce intermediate goods as opposed to final goods or vice-versa)

\textsuperscript{65} Firms use their know-how to participate in a new value chain and/or in a different sector
4.1.6. Specific strategic objective 6: Creating smart skills - upgrading the qualifications of existing and new work force for smart specialization

4.1.6.1. Purpose

The main purpose of this objective is to create adequate work force, capable of pursuing the S3 and acquiring competitiveness of the Croatian economy. Smart, sustainable and inclusive growth requires new/improved/adjusted knowledge and skills. Without continuously upgrading and improving qualifications of existing and new work force, the objective of more knowledge intensive, innovative and creative economy will not be achievable.

4.1.6.2. Justification

The Croatian workforce is relatively well qualified but its skills profile may limit its RDI potential. Compared to the EU and countries with similar income per capita, Croatia has few students and graduates in mathematics, science and engineering, low share of tertiary educated workforce, low rate of employment among tertiary graduates and one of the lowest levels of on-the-job training and lifelong learning. Croatian companies report a lack of qualified personnel in the workforce as an important constraint on innovation. A community of consultants or associated services to support businesses in innovation projects is not widely available. There are also indications of bottlenecks in the transfer of knowledge from abroad, as suggested by the low levels of inward and outward mobility of researchers and the low incidence of international co-publications relative to comparable countries. Furthermore we have relatively low shares of professionals and experts among the employed in key industries for the implementation of S3 and this indicates that domestic knowledge development for innovation may be difficult to achieve. Therefore we will be facing both a lack of the numbers of persons with right skills in the right locations in Croatia.

4.1.6.3. Delivery instrument

The delivery instruments will be: i) Establishing infrastructure for smart skills policies ; ii) Additional instruments put in place for assessing medium term skill needs; iii) Implementing the Croatian Qualification Framework mechanism for delivering timely and standardized training programmes based on future and medium term skill needs . Under the first instrument, the new register of human resources will be designed , as well as the macro econometric forecasting model and the skills foresight which will be used for identifying future smart skill needs. Through second delivery instrument skill sector profiles will be developed for the 25 skill sectors which define medium-term supply and demand for sector occupations by region, economic sector and the supply of labour from education and job seekers. Once these are known, the third delivery instrument, mechanisms of the Croatian Qualification framework will be activated, i.e. surveys on occupational standards will describe the competences needed for work in jobs related to S3, occupational and qualifications standards will be prepared and finally new training programmes will be developed to reflect the new standards. For more details, see section 6 and Annex 4.
Figure 23 Linkage between specific objectives and delivery instruments

<table>
<thead>
<tr>
<th>Specific strategic objective 1</th>
<th>Increased capacities of RDI sector to perform excellent research and to meet the needs of the economy</th>
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<tr>
<td></td>
<td>(1) Increase RDI ability for conducting top quality research and cooperation on national and international level</td>
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<td></td>
<td>(2) Strengthening research excellence by supporting national Centers of Research Excellence and enabling synergies with ERC grants</td>
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<td>(3) Support to research organizations conducting R&amp;D and projects towards the needs of economy</td>
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<td>(4) Project, Science and Technology Forenight</td>
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<tr>
<th>Specific strategic objective 2</th>
<th>Overcoming the fragmentation of innovation value chain and the gap between research and business sector</th>
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<tr>
<td></td>
<td>(1) Development of Innovation Network for Industry and creation of Thematic Innovation Platforms</td>
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<td></td>
<td>(2) Creation of Centers of Competence</td>
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<td></td>
<td>(3) Strengthening links between scientific and business sector through support to Technology Transfer Offices and Science Technology Parks</td>
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<tr>
<th>Specific strategic objective 3</th>
<th>Modernizing and diversifying Croatian economy through increasing private R&amp;D and non R&amp;D investment</th>
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<tr>
<td></td>
<td>(1) Support to business investment in RDI</td>
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<td>(2) Support to SMEs capacities to innovate</td>
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<th>Specific strategic objective 4</th>
<th>Upgrading in global value chain and promoting internationalization of Croatian economy</th>
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<td>(1) Competitiveness Cluster Initiatives</td>
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<th>Specific strategic objective 5</th>
<th>Working in partnerships to address societal challenges</th>
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<td>(1) Support to social innovation</td>
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<tr>
<th>Specific strategic objective 6</th>
<th>Creating smart skills – upgrading the qualifications of existing and new work force for smart specialization</th>
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<tr>
<td></td>
<td>(1) Developing new smart skills instruments</td>
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<td></td>
<td>(2) Implementing the Croatian Qualification Framework mechanism for delivering timely and standardized training programs based on future and medium term skill needs</td>
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<td></td>
<td>(3) Additional instrument put in place for assessing medium term skill needs</td>
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5. PRIORITY THEMATIC AREAS AND CROSS-CUTTING THEMES

5.1. Principles and criteria’s to select the S3 priority thematic areas and cross-cutting themes

A strategy for innovation traditionally consists mainly of horizontal measures and neutral policy aimed at improving general framework conditions and capabilities (good universities, human capital, intellectual property rights, research and ICT infrastructure, competition and openness, and so on). The S3 in Croatia retains this emphasis on horizontal measures but adds a new ‘logic’ about smart specialisation. It centres on a more vertical and non-neutral logic of intervention; that is to a process of identification and selection of desirable thematic areas for intervention, implying choices of technologies, fields, sub-systems that could be favoured within the framework of the policy.

Five policy principles are important in the prioritization of activities:

1. Granularity. The main point here is to identify the right level, between sectors and very micro-activities, at which it is possible to observe in detail the pieces of the knowledge economy that a region can take as a basis for smart specialisation. The relevant level is of “mid-grained” granularity. At this level new activities/projects involve groups of firms and other (research) partners; the aim is to explore a new domain of (technological and market) opportunities and there is potentially a certain weight and a high significance relative to the national economy (in terms of the kind of structural changes it is likely to generate).

2. Entrepreneurial discovery. Smart specialisation involves a self-discovery or entrepreneurial discovery process that reveals what country/region does/will do best in terms of RDI. Linking the two first principles of a smart specialization policy (granularity and entrepreneurial discovery) leads to the following statement: setting priorities in a smart specialization perspective involves identifying (and also constructing) those entrepreneurial discovery projects or new activities aiming at exploring, experimenting with and learning what an industry or subsector should do in terms of RDI to improve its situation.

3. Priorities which do not reach expected results should be abandoned. Also, activities not currently selected, still retain a chance of being supported in the future.

4. Smart specialisation is an inclusive strategy. This means giving every sector a chance to be present in the strategy through project activities. Inclusiveness will imply different paces and tempo of the policy because identifying and prioritizing good projects in the less dynamic parts of the economy will be more difficult and more costly than in the most dynamic parts.

5. The experimental nature of the policy and the need for evaluation. Clear benchmarks and criteria for success and failures are needed. Because of its nature, this policy is experimental and not all investments in new activities will pay off. Evaluation is therefore a central policy task so that the support will not be discontinued too early nor continued so long that subsidies are wasted on non-viable projects.

Furthermore, according to the guidelines of the S3 platform the six criteria to select the priority thematic areas and cross-cutting themes are shown in Figure 24, while the process of priority setting in the context of the S3 for Croatia is provided in Figure 25.

Priorities are set on the basis of a bottom-up entrepreneurial discovery process supported by strategic intelligence about a country’s: (1) challenges, (2) competitive advantages and (3) potential for excellence. Priority setting for the Croatian S3 has taken place through an effective balance of top-down identification of broad objectives aligned with the EU policies and a bottom-up process of emergence of candidate niches for smart specialisation along with areas of experimentation and future development. Experimentation and future development are particularly important for Croatia given the small size of its population and the very high share of microenterprises in the economy. Croatia has
only a few high-tech or knowledge based start-ups each year and extremely low number of gazelles. It is difficult to predict which of these might hold the key to future growth and prosperity, driving new hot-spots for the country in future years and which may disappear quickly due to international competition or a lack of appropriate finance.

Figure 24 Six criteria to select the priority thematic areas and cross-cutting themes according to the guidelines of the S3 platform

Each priority thematic area should make a contribution to smart, inclusive and sustainable growth.

The contents of the chosen priority thematic areas are based on strengths and potentials, and offer sufficient possibilities for cooperation and links to the smart specialization choices in neighbouring countries.

The priority thematic areas will offer opportunities for a variety of sector niches and science and technology areas to link up their potentials for cooperation and development.

There are clear indications that in each of the priority areas tangible results in terms of smart, inclusive and sustainable development can be achieved in the period up to 2030.

Each priority area should make a clear contribution to meeting some of the societal challenges.

There is full support for each of the thematic priority axes from the various stakeholder groups (business sector, research organizations, government) that have been involved throughout the course of the S3 development.

Figure 25 Stages in the process of determination of SS priorities
5.2. Selection and description of thematic priority areas (Building on strengths – Overcoming weaknesses – Securing the future)

The prioritization process (identification of thematic priority areas) has involved a wide range of research and business representatives and has been based on consensus. The risk of pursuing narrow sectoral interests was limited by a consistent application of the methodology and by substantiation of assessments and proposals on the data or other evidence. Such participatory approach has a number of advantages: it promotes the search for collaboration opportunities and synergies, enables the pooling of expert knowledge that is necessary for the interpretation of data, promotes coordination of strategic objectives of research and business organisations etc. This also lays down solid foundations for successful implementation.

Through 4 main rounds of partnership consultations (entrepreneurial discovery), main thematic priority areas (TPAs) have been identified. Detailed information about this process is provided in the Annex 1. In parallel to this process, global trends have been taken into account and strengths and potentials in the business and R&D sector of Croatia have been analyzed. Afore mentioned selection criteria have been applied for the selection of the thematic priority areas. Matching of business and scientific research sectors strengths has been conducted, and their capacities for RDI and the ability to respond to social challenges have been assessed (Annex 2.).

For the purpose of further selection and narrowing of the thematic and sub-thematic priority areas (STPAs) within S3 strategy of the Republic of Croatia, a number of expert working groups composed of public and private R&D experts, as well as a working group composed of state officials, were established. The end result of these processes is the selection of 5 TPAs with relevant technological and production fields as the main focus for the S3 in Croatia: (1) Health and quality of life, (2) Energy and sustainable environment, (3) Transport and mobility, (4) Security and (5) Food and...
bio-economy. Additionally, Croatia has identified two cross-cutting themes able to create the biggest added value and foster the emergence of new economic activities, rising of the productivity of the Croatian economy and the creation of new and sustainable job opportunities. Cross-cutting themes are KETs and ICT. (Figure 26)

Under 5 TPAs there are 13 STPAs and additionally 2 cross-cutting themes. The list of STPAs of potential was distilled from a much broader canvas of potential options and the selection of these areas for prioritization does not imply parity in the allocation of investment as between each of these areas. The priority of Croatia in the first few years of S3 implementation is to create a climate favorable for innovation and to stimulate business sector investments in R&D activities in order to develop new products, services and technologies that will enable modernization and diversification of the Croatian economy. Successful implementation depends on a properly functioning monitoring system that could provide information leading to termination of “unsuccesful” priorities. Proposed priorities are specific and strongly linked with expected results, i. e. development/application of new product and technologies. The future context is envisaged as one in which all research funders must prioritize and must be able to show a return on investment. Majority of available funding will be allocated to the STPAs and certain research and innovation infrastructure that is required to support the STPAs.

Figure 26 The S3 TPAs and cross-cutting themes

Further text explains in details each TPA and related Sub-thematic priority areas.

5.2.1. Health and quality of life

5.2.1.1. Sector overview

Health and quality of life emerges as a top TPA area for smart specialization in Croatia on the basis of strong statistical indicators, analysis and the process of entrepreneurial discovery. The Croatian
Government and EC recognize these sectors as very important for the future development of the Croatian economy. This TPA is characterised as high technology and export-oriented sector (Health industry, ICT) that are widely considered as major contributors to the country's economic growth. This is based on objectively verifiable strengths on both the economic and scientific side and this is reflected in a highly competent and skilled workforce, critical mass of researchers, modern research infrastructure, developed technologies and continuous investments in production.

Development of this TPA in Croatia is primarily influenced by the policies developed by the Ministry of Health (Health care), Ministry of Economy (Health industry), and Ministry of Science, Education and Sports (Health related research). In recent decades, the Croatian Government has placed the development of these sectors high on its agenda. National Health Care Strategy 2012 – 2020\(^6^6\) sets out development directions for the health sector and present framework for policy making and operational decisions, including the distribution of budgetary resources. It is umbrella document determining the context, vision, priorities, and goals for health care in the Republic of Croatia over this period. Some of the key strategic priorities outlined within this Strategy are: (i) informatisation and e-Health development in order to improve efficiency and effectiveness of health care system; (ii) strengthening preventive activities with the objective of improving health indicators; (iii) fostering quality in health care, through, among other measures, Health technology assessment (HTA). Together with National Health Care Strategy 2012 – 2020, the National Strategy for Education, Science and Technology and the Croatian Innovation and Industrial Strategy 2014 – 2020, have laid out the basis for the further development of this TPA. The Croatian National Council for Science, Higher Education and Technology Development additionally adopted relevant new key research priorities that are also related to this TPA.

In 2013 Croatia also established two competitiveness clusters aiming to further develop and raise the strength and value of the healthcare sector: (1) Health cluster (gathering 14 private companies, 13 research institutions and 3 representatives of local and regional authorities) and (2) ICT competitiveness cluster.

TPA covers public research organizations; biotechnology and pharmaceutical companies involved in drug discovery and drug development; companies producing medical equipment and devices; ICT companies developing E-Health solutions; companies involved in the production of diagnostic tools and novel methods; food processing companies producing nutraceuticals (dietary supplements, functional food, enriched food). TPA competitiveness is based on traditionally recognized expertise in R&D as well as in industry applications dating back to early 1960s, which resulted in high quality and value added products and services. The European Commission also recognized Healthcare sector as one of the hotspots in key technologies, important for the economic growth of Croatia\(^6^7\). Furthermore, this TPA contributes to the establishment of a network that connects companies and public research laboratories as an excellent base for further investment in this TPA.

The STPAs under this TPA were selected based on established strengths and potential and are presented in the chart below:

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\(^6^6\) [http://narodne-novine.nn.hr/clanci/sluzbeni/dodatni/423339.pdf](http://narodne-novine.nn.hr/clanci/sluzbeni/dodatni/423339.pdf)

\(^6^7\) [Research and Innovation Performance in EU Member States and Associated Countries, Innovation Union Progress at Country Level, 2013, European Commission](http://www.eea.europa.eu/publications/13029/13029/)
5.2.1.2.  **STPA 1 Pharmaceuticals, biopharmaceuticals, medical equipment and devices**

5.2.1.2.1.  **STPA sector overview**

The 1st STPA, Pharmaceuticals, biopharmaceuticals, medical equipment and devices (in further text referred to as: Health industry) is focused on strengthening Croatia’s position as a hub for manufacturing of health products. This will be accomplished through integrating existing enterprise and research strengths to drive development and manufacture of the next generation of drugs and OTC (over-the-counter drugs) products, medical equipment and devices.

In terms of market structure, the sector is moderately concentrated. It is characterized by a relatively small group of large companies that represent a significant share of the annual Croatian turnover and export. Large companies (PLIVA68, Belupo69, JGL70, Genera71) hold a dominant position on the market and become the leading generic and OTC companies in Central and Eastern Europe.

Overall STPA product portfolios cover production of new chemical and bio-technological entities, generic and patenting drugs (almost all therapeutic groups and active pharmaceutical ingredients), OTC medicines, health products for animals, dermatological cosmetics, herbal medicines and production of medical and dental equipment and devices. The highest concentration of companies working in the STPA and the main production and R&D sites are located in Zagreb, Savski Marof, Koprivnica and Rijeka.

5.2.1.2.2.  **RDI capacity in industry**

Biotechnology & Pharmaceuticals (together with ICT) represent financially the strongest R&D sectors and together amount to over 80% of all R&D business expenditures; clearly signaling which technology sectors are the most promising in Croatia. Strong sides of these sectors in Croatia are the following: (i) Traditionally recognized expertise in research as well as in industry applications; (ii) Relatively good higher education system; (iii) Availability of potential employees with higher education degrees (PhD’s) and a skilled workforce; (iv) Relatively low salaries of biotechnology specialists as compared to other countries; (v) Tradition, skilled and a relatively cheap workforce, good living conditions that are attractive for foreign investments; (vi) Critical mass of researchers and other necessary resources exists for the pursuit of economic prospects; (vii) and a number of good technologies developed.

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68 The broadest portfolio of generic medicines in Central and Eastern Europe.
69 Unique plant in CE Europe in that it allows a continuous operational procedure process, i.e. the flow of materials and workers through physically connected spaces.
70 Global leader in Production Sea based OTC products.
71 One of the global leader in Health products for animals.
The STPA is one of the areas of the Croatian economy in which investing in R&D in the business sector is very extensive. The discovery of the innovative antibiotic azithromycin, one of the best antibiotics today, places Croatia (Croatian chemists at the pharmaceutical company Pliva)\textsuperscript{72} on the map as one of only ten countries in the world that can develop a completely new drug. Overall, Croatia has well performing companies in this industry, which is demonstrated through a high level of in-house R&D of finished dosage forms and active pharmaceutical ingredients.\textsuperscript{73} Also, the patent output data suggest that Croatia has strengths in the health industry. Out of the top 10 private Croatian R&D performers, as identified through the R&D tax credits scheme, two are related to the pharmaceutical industry (ranked 2\textsuperscript{nd} and 4\textsuperscript{th}) (2013). Clearly defined research and project management processes, focus on niche areas, use of state-of-the-art technologies and scientific methods, and systematic protection of intellectual property rights are the basic components of Croatian pharmaceutical companies’ R&D strategies. All leading companies are producing in Good Manufacturing Practice (GMP) conditions and their products can be registered at all international markets worldwide.

The R&D projects of the Croatian Health industry are focused on efficient development of new chemical synthesis processes for generic substances, development of new-finished dosage forms, i.e. generic products, over-the-counter products or new entities (i.e. molecules under patent protection) developed through innovative technologies, development of analytics, organization and performance of clinical studies. Several SMEs are emerging in the biopharmaceutical sector through the technology transfer process from Croatian universities. The Institute for Immunology must be mentioned for their strong research base and market potential, especially in the development of new vaccines and blood plasma preparation.

5.2.1.2.3. RDI capacity in academia

Historically, Croatia has a good research output and internationally recognized scientists in medicine, life sciences and chemistry. Today, there are several strong public research institutions in this area: research groups at the Faculty of Medicine and Veterinary Faculty, University of Zagreb, Croatian Institute for Brain Research, RBI, Mediterranean Institute for Life Sciences in Split, Institute for Medical Research and Occupational Health and Veterinary Institute in Zagreb, Medical Schools at universities of Rijeka, Split and Osijek. Together with the private sector, all of these institutions account for more than 1000 researchers involved in R&D.

According to SCImago in 2014\textsuperscript{74}, the top ranked subjects in the scientific output of the country are in the fields of medicine (1\textsuperscript{st} - 17,66%) and biochemistry, genetics and molecular biology (7\textsuperscript{th} - 5,79%). In 2013, according to the CBS, the proportion of total R&D expenses in Croatia was very high for life sciences (21,4%), biomedicine and health (16,8%) and biotechnical sciences (8,7%).\textsuperscript{75} Compared to 22 other Eastern European countries, according to the number of research articles, Croatia ranks the best in medicine (5th), pharmacology, toxicology, pharmaceuticals and veterinary medicine (5th), followed by agriculture and biological sciences (6th), immunology and microbiology (9th), biochemistry, genetics and molecular biology (10th) and chemistry (11th).

In overall FP7 funding, Croatian researchers performed the best in health and most of the funds were received by the two medical schools, University of Zagreb and University of Rijeka\textsuperscript{76} in areas of translational medicine, bone regeneration, neurosciences, immunology and microbiology, genetics and

\textsuperscript{72} Azithromycin was patented in 1981. Pliva and Pfizer signed a licensing agreement in 1986, whereby Pfizer received exclusive sales rights in Western Europe and the U.S., while Pliva began marketing the drug in Central and Eastern Europe under the brand name Sumamed in 1988.

\textsuperscript{73} Pliva’s R&D center in Zagreb is today one of the leading R&D centers in the Teva Group.

\textsuperscript{74} http://www.scimagojr.com/countrysearch.php?country=HR&area=1100

\textsuperscript{75} CBS, Research and development, 2013 – Statistical reports, Zagreb, 2015.

\textsuperscript{76} Complete data are in the Chapter on Analysis.
molecular biology and cancer. Outputs of three out of four Croatian ERC grants\textsuperscript{77} could have application in this particular STPA.

Biomedicine has been recognized as one of the priority areas for investment in the Croatian Research and Innovation Infrastructures Roadmap. An indicative list of integrated R&D projects for the ERDF for the period 2014-2020 includes projects related to this priority (one of them is a major project, entitled “Centre of Competence for Translational Medicine” at the Children’s Hospital Srebrnjak).

To foster the development of this STPA, the Croatian Government used IPA funds to invest in the BIO Center in Zagreb, as part of an important bioscience infrastructure expected to open in October 2015. In 2014 and as a result of a strong international peer review evaluation, Croatia also established seven Centers of Research Excellence (CoRE), out of which two are focused on R&D in health and biopharmaceuticals - CoRE for Reproductive and Regenerative Medicine and CoRE for Viral Immunology and the Development of New Vaccines. These two Centres involve close to 60 highly competitive and internationally recognized researchers from both public and private sectors (mostly SMEs) and are in the process of linking with similar European and other international networks. Further investments in both scientific infrastructure and human capital through OP will boost their scientific and innovative excellence.

\textbf{Indicative RDI topics under the defined STPA are:}

- human and animal drug discovery and drug development (new chemical and bio-tech entities, new chemical synthesis processes for generic substances, product or new entities (i.e. molecules under patent protection);
- development of new vaccines and blood plasma preparation;
- development of new medical technology and protocol/procedure (i.e cardiology and radiology);
- new finished dosage forms for generic and patenting drugs, including OTC (over-the counter) products; dermatological cosmetics;
- herbal medicines;
- development of medical (including dental) equipment and devices;
- development of systems, applications and solutions used in research and testing of new medicine, preparations, vaccines and substances for monitoring, healing or control of diseases and illnesses and body rejuvenation.

\textbf{Connected indicative RDI topics under cross-cutting themes KETs and ICT are:}

- KETs for more efficient and less invasive drugs and therapies (implantable devices for medicine and improved surface coatings and coating techniques for drugs);
- KETs for robots, assistive technologies and processes
- process and embedded computer automation and control processes.
- computer vision and machine learning with application in pharmaceuticals, biopharmaceuticals, medical equipment and devices

\textsuperscript{77} Three ERC grants have been awarded to Croatian researchers in the field of medicine: one to the School of Medicine of the University of Rijeka (STADVINN project) and two to the Rudjer Bošković Institute (NewSpindleForce project and MembranesAct project). Both mentioned ERC grants from RBI could well lead to improvements in the development of new drugs and therapies, especially in treatment of degenerative and cancerous diseases.
5.2.1.3. **STPA 2 Health services, new methods of preventive medicine and diagnostics**

5.2.1.3.1. **STPA sector overview**

The 2nd STPA deals with tackling societal challenges in Croatia, such as an ageing population, chronic diseases and an increase of healthcare expenditures through optimization of current health service and processes and development of new health services and new methods of preventive medicine and diagnostics. Also, there is an ultimate need in both public and private sectors for a strategic engagement in solving very important societal problems, while contributing to a reduction of healthcare costs and prevention of the morbidity and mortality rates.

This STPA covers E-solutions in health, new technologies for remote delivery of healthcare and assisted living. These should enhance and broaden the scope of use of eHealth, especially through new opportunities for the integration of mobile health (mHealth) into existing eHealth services. It covers the entire health care industry innovation chain ranging from a better understanding of the diseases, through prevention and recognition, to curing and personalized medicine. This STPA includes E-solutions in health, new technologies for remote delivery of healthcare and assisted living. These should enhance and broaden the scope of use of eHealth, especially through new opportunities for the integration of mobile health (mHealth) into existing eHealth services. It covers the entire health care industry innovation chain ranging from a better understanding of the diseases, through prevention and recognition, to curing and personalized medicine.

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The field of e-Health, together with the services which can be researched and introduced to improve healthcare services has a great potential. According to the EC and the Digital Agenda for Europe, the Research and Innovation in the field of ICT for Health and Wellbeing, the research should be directed towards achieving one of the four goals, which are defined as the actions. Those include secure online access to medical health data, defining the minimal common set of the patient data, define and implement EU-wide standards, testing and certification of e-Health systems as well as providing key cross-border services in the field of the e-Health.

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E-Health in Croatia is facilitated through a custom build information system CEZIH: Due to this project, which has involved both public sector, private companies as well as the academia research groups, Croatia was one of the first European countries, which successfully introduced very well-functioning e-prescriptions, e-referrals, e-appointments, and the data from the system are used for the advanced reports on the health care system (health insurance, public health and patient and health resources administration). Croatian pharmacies are already linked to a primary care doctor’s offices and major hospitals are in the process of being linked.

5.2.1.3.2. **RDI capacity in industry**

An analysis of industry involved in this STPA reveals that, besides in CHIF, there are strong R&D activities in a large number of ICT companies involved in the development of e-health related projects and prevention of chronic diseases in the elderly (large ICT project CareWell). This STPA also involves a smaller number of companies involved in the development of new diagnostic tools and novel methods with applications in the healthcare sector, as well as companies using innovative approaches in disease prevention and novel treatments. With the exception of a few larger companies,

mostly Croatian SMEs are involved in these activities and their performance is documented through scientific publications, patenting activities (from 2005-2014 Croatian ICT companies were granted 25 USPTO patents), exports and new employments.

Companies involved in the development of new diagnostic tools and novel methods present a smaller percentage of the total number of companies in comparison to IT companies involved in e-health. However, due to an appropriate government investment in the development of this sector, it is likely to expand. For the purpose of elaborating this STPA, several examples active in e-Health, modern disease diagnostics and development of new methods important in the health industry, will be described.

Development of CEZIH system has also involved many companies from private sector. More than 50 companies have been involved providing client solutions regarding e-Health services. Primary health care doctors can choose between 8 different application providers (MCS Group, IPT, IN-CON, AdriaSoft, Aplikacija, INMED softver, Vegasoft, PNT), pharmacies have 4 solutions available (Information Systems, Ed Borel, Samson informatika Jadran informatika), dentists can work in one of 7 solutions (IN-CON, PNT, AdriaSoft, MCS Group, Aplikacija, INMED softver, SD Informatika), and gynecologists can choose between 8 different systems (Aplikacija, MCS Group, IPT, PNT, IN-CON, AdriaSoft, INMED software, Vegasoft). There are many solutions available for ambulances (22 approved solutions) taking in consideration the heterogenous nature of their services. Most of Croatian hospitals (around 70%) use hospitals information system of IN2 group, which in last 15 years enable step forward in work efficiency and quality treatment hospital helth system and which in structure of expenditure of helth services hold the largest share (approximately 8.5 billion HRK per year). Further improvement of existing business processes (supported by information technogy of new generations – e.g mobile approach to classical processes) as well as setting up new and innovative health processes, e.g through correlation of large number of facts which hospital information systems are successfully gathering today (through implementing so-called Big Data technology as well as linking the impacts of parallel events e.g nutrition and treatment results), set as a target in majority of leading hospital health institutions in Croatia.

Ericsson Nikola Tesla (ENT) and its partners in the SME sector received several FP7 and Horizon 2020 funded projects for their e-health projects and Ambient Assisted Living (AAL) solutions - software and hardware that improves quality of life for older citizens by increasing their autonomy and mobility. Furthermore, novel applications in e-health and assisted living will be applied in service sectors with high potential (health tourism).

Novel diagnostic tools and treatment methods: The Rudjer Medikol Cyclotron (RMC) is an SME company established as a public-private partnership between the company Medikol and the public institute RBI in Zagreb, with project value estimated to be approximately 7.5 M€. The company is focused to produce 18F-FDG for diagnosis of cancer by using PET/CT technology. The diagnostics of cancer is significantly improved by using PET/CT technology, a medical imaging method established in the world in the last ten years (PET stands for positron emission tomography and CT stands for computed tomography). Until RMC has been established, Croatia imported 18F-FDG, but now it sells the product on the domestic market and recently started to export it to neighboring countries. R&D activity involving both RMC and RBI scientists, along with a unique research infrastructure (cyclotron and GMP production facility) give Croatia a great advantage in this field. Another example is Bellabeat, Croatia’s SME winner of the Pioneers Festival Challenge in 2013. Bellabeat makes products that help expectant moms keep track of their babies’ health and share this information with family and friends. Backed by the YC network, Bellabeat raised $4.5 million in late May 2015.

Market size and future opportunities are very high in these sectors. For example, the e-health market (depending on sub-topics) is expected to grow to $160 billion in 2015 from $96 billion in 2010, at an average growth rate of 12-16 percent.
5.2.1.3.3. **RDI capacity in academia**

Croatian researchers have conducted many studies and projects in the field of medicine and other health related topics (ICT) that can be comprised as development of health services, new methods of preventive medicine and diagnostics.

Analysis of the significant projects implemented through FP7 reveal that in the public sector in Croatia Health and ICT are leading in received funding. The strongest public institutions are at Universities of Zagreb, Split and Rijeka, RBI, Institute for Medical Research and Occupational Health in Zagreb and the Mediterranean Institute in Split. An analysis showed that several fields can be singled out as the most promising ones with great potential for development of new methods and procedures to prevent and treat effectively most common diseases. Conducting basic and clinical research to uncover new insights into human genetics and the molecular basis of disease can thus enable greater precision in diagnosis and more targeted drug development. Collaboration of these institutions with the private sector is reflected in joint publications, projects, patenting and product development. University of Zagreb, School of Electrical Engineering is leading R&D on topics related to e-Health, in which it collaborates with the private sector. This School is the leading single institution in Croatia for FP7 received projects in ICT and it is the main institution for education in ICT in Croatia and regionally. In the field of preventive medicine – apart from one of the global pioneers in this field, the Institute of Public Health Dr. Andrija Štampar – for many Croatian R&D institutions, preventive healthcare is currently regaining momentum thanks to a surge of research in the genomics field and related areas of biology.

RBI is Croatia’s leading life science institution and it is, among other topics, strong in physics and medicine. To further develop the medical diagnostics field, RBI established a **PET/CT Center for preclinical research**, the only one of its kind in the Region. This center will facilitate *in vivo* preclinical research in the fields of tumor biology, degenerative diseases and the monitoring of metabolic processes in living organisms for a wide spectrum of bioactive molecules marked with radioisotopes. The Center offers services to the pharmaceutical and biopharmaceutical industries in Croatia and internationally, and it represents a great research infrastructure asset for contract research, currently an expanding market worldwide. Presently, there are only a few similar centers in Europe.

There is significant potential in clinical research, due to a strong research base with certified clinical researchers and good hospital infrastructure which has drawn many global pharmaceutical companies to conduct clinical research projects in Croatia. Main companies active in this field are Clinres Farmacija, Optimapharm, Altiora CRO, Quintiles Croatia, Parexel International, PPD and inVentive.

The research team of the Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb, in collaboration with the Clinical Hospital Dubrava, and the Institute for Brain Research in Zagreb, developed an innovative dual-arm robotic neurosurgical system that is currently at the stage of preclinical studies – a system called RONNA - Robotic Neurosurgical Navigation. Shortcomings of the previously developed neurosurgical robotic systems have been removed using a number of technical solutions for new technologies available on the market, from light-weight robots with 7 degrees of freedom, an accurate position sensing system, forces and moments, laser and optical devices, as well as newly developed software packages. Knowledge exchange between the RONNA team and companies involved in robotics (DOK-ING and Hypersphere, etc.) is now under planning. This field has a great potential in Croatia.

The **centers for proteomics and Genomics** exist at RBI and Medical Schools in Zagreb and Rijeka. These centers are well equipped with modern infrastructure and besides research activities offer services to the health industry. Genetic testing is commercially available. Researchers at the RBI in the

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79 For example, one of the established CoREs is specialized in research on Viral Immunology and the Development of New Vaccines.

80 [http://www.ronna.fsb.hr/](http://www.ronna.fsb.hr/)
Department of Medicine developed methods for genetic testing, which represent an invaluable step forward in combating malignant and other diseases. Several private companies have been established offering these analyses for Croatian and other patients in neighboring countries, commercially. This significantly contributes to modern molecular diagnostics and personalized therapies.

Researchers in this STPA are amongst the best Croatian researchers publishing in 10% of the best quality scientific journals, they have very competitive FP7 funding from 6 000 000 euro for a single FP7 collaborative project and several ERC grants. Few researchers have a significant number of international patents in biomedicine.

### Indicative RDI topics relevant for this STPA have been selected:

- novel methods of preventive medicine;
- novel diagnostic and therapeutic tools and applications (e.g. advance medical imaging, targeted diagnostics and personalized medicine, pharmacogenomics and technology to identify and validate novel biomarkers, etc.);
- clinical research;
- regenerative medicine and tissue engineering;
- systems, applications and solutions for public health management and monitoring and improvement of quality of health services;
- medical wellness multimodal programs and tools focused on the cornerstones of good health to create fresh, personalized wellness products and services;
- thalassic therapy products and services;
- equipment, systems, applications and solutions used in research and testing of new treatment and diagnostics methods and monitoring disease changes;
- equipment, systems, applications and solutions with purpose of consulting, diagnostics, treatment and remote operations (telemicine)
- equipment, systems, applications and solutions used in sports with purpose of prevention, diagnostics and treatment of wide spectrum and monitoring progress in sport results achievement;
- development of „smart toys“ and applications for mobile and smart devices for children for the purpose of education, prevention and detection of diseases.

### Related indicative RDI topics under cross-cutting themes KETs and ICT are:

- KETs for robots supporting professional care and robot assistive technologies;
- KETs for devices and systems for targeted diagnostics;
- KETs for Connected systems for theranostics
- use of robotics in medicine (e.g. smart systems and robots for healthcare services; new solutions for enhancement of the quality of life of elderly and dependent people)
- e-health solutions and related technologies;
- ICT-based services and applications for improving quality of life for persons with disabilities (such as chronic patients, older population), including solutions for Alternative and Augmentative Communication and video and audio technology for home care assistance;
- GIS solutions for spatial and network analysis (location / allocation, geocoding, time zones in driving, spatial modeling, geostatic analysis — regression analysis and geographic regression)
- ICT solutions for monitoring and statistical analysis of diagnostic devices operations;
- ICT system for geographic analysis and prevention of diseases (GeoHealth);
- ICT systems, applications and solutions which provide support to functioning of particular organs or particular functions of the human body;
- ICT systems for alarming and assistance in urgent medical situations;
- Innovative technologies based on development of health sensors in Internet environment „Internet of things, managing and analysis of Big Data and cloud solutions;
- Computer vision and machine learning with application in healthcare services, new methods of
5.2.1.4. STPA 3 Nutrition

5.2.1.4.1. STPA sector overview

Nutrition\textsuperscript{81} is one of the key environmental factors that contribute to human health but it can also contribute to major diseases. This STPA refers to products derived from food sources that are purported to provide extra health benefits, in addition to the basic nutritional value found in foods: nutraceutical (natural health products, dietary supplements, functional and enriched food). The challenge is to ensure full integration of the Croatian research base and enterprises to enable product development and validation of product claims in order to meet regulatory requirements. Because of nutrition’s multidisciplinary nature, several different stakeholders are involved in policy measures regarding nutrition: Ministry of Agriculture and Ministry of Economy (covering food producers and food industry), agencies covering food safety, consumer associations, Ministry of Health (regulating health/nutrition) and Ministry of Environment (developing environmental policies). The Ministry of Science overlooks R&D in areas related to nutrition and health. Currently, Croatia has different strategic policy documents covering nutrition-related topics; however it does not have its own Nutrition Policy, such as some EU countries. Croatia is following EU and WHO international policy documents.

Croatia has been dealing with a problem of a high number of its citizens experiencing health problems that are related to inappropriate nutrition. The leading causes of death in Croatia are now heart and blood vessel diseases, which have been directly linked to eating habits and nutrition. Diabetes rates in Croatia are 54.7 percent higher than in other new EU Member States (NMS). Data from the Global Nutrition Report indicate that diet and nutrition are linked to many health risk factors such as high blood glucose, raised blood pressure and raised blood cholesterol. The data from the World Health Organization shows that over 60 percent of men and 50 percent of women aged over 18 in Croatia are overweight (with a BMI of more than 25 kilograms per square meter), which places Croatia among those countries with the highest number of overweight citizens in Europe. There are several programs directed towards reduction of body weight and obesity problems in Croatia that the Ministry of Health is implementing. Apart from high body weight and obesity, other nutrition-related factors are linked to the development of major diseases and are a major cause of both morbidity and mortality in a high percentage of Croatian population\textsuperscript{82}. Estimated cost of nutrition-related diseases is also very high and presents a major burden for the Croatian economy. Thus, engaging both public and private sectors in nutrition-related health R&D is of national interest. The most important justification that Croatia has for the selection of this STPA is its direct link to the health of Croatian citizens and its strength in both public and private sectors, i.e. the presence of companies with great market and export potential.

\textsuperscript{81} Nutrition is defined as applied natural science about food and its effects on human organism. Research topics in the field of nutrition, especially last years, play significant role in understanding various processes connected to food habits and appearance of diseases and disorders. Also such researches play important role in understanding the significance of food habits in modulating genetic potential of individual. In that aspect, the role of nutritionists is not only significant as researchers in this specific field, but also as persons that transmit scientific knowledge to general and targeted population in order to preserve health and improve the existing situation. In addition, their skills are also applied in the creation and production of Novel food and other food and dietary products.

\textsuperscript{82} National Health Care Strategy 2012 – 2020, p. 15-17, 27-32.
5.2.1.4.2. RDI capacity in industry

Croatia has a very active private sector in the fields of food and nutrition. The nutraceutical industry (natural health products, dietary supplements and enriched products) has become an important part of the Croatian food and health industry in this decade. In contrast to the natural herbs and spices used as folk medicine, this production has grown alongside the expansion and exploration of modern technology. Croatian enterprises produce nutraceuticals, including herbal products, specific diets and processed foods such as cereals, soups and beverages (JGL Inc.), nutritional supplements for animal feed (Genera, Krka-farma ltd., Labor Test,) dietary supplements (Belupo Inc., JGL Inc., PharmaS ltd.) and functional foods (Atlantic Group Inc., Vindija Inc., Dukat Inc.). New branded food products with explicit health claims have been introduced on the market, including yogurt and fermented drinks with probiotic bacteria, hen eggs with omega-3 and margarines that lower blood cholesterol. One of the R&D collaborative projects realized by Food Bio-technology Faculty in Zagreb in collaboration with the Maraska company, and financed through an IPA fund, was „Višnja Maraska“, the aim of which was to research the nutrition potential of one unique variety of „cherry“ (vitamins, minerals, melatonin), and its potential to be added as a functional ingredient in different food products (ice-cream, chocolate, soft drinks).83

Most of the companies in Croatia engaged in nutraceutical R&D are large entities with R&D departments comprising between 15-50 researchers and exporting to international markets. These companies collaborate on different R&D projects with the public sector and the selection of this STPA will have a positive impact on their collaboration, which needs to be significantly increased.

5.2.1.4.3. RDI capacity in the public sector

Nutrition is a field of science directly impacted by food and medical research. Nutrigenomics, proteomics and metabolomics are three new disciplines that will contribute to the rapid development of functional foods. Bioinformatics is a new tool that uses computer database technology to integrate data from multiple, and sometimes disparate, disciplines. Croatian research institutions have very active research groups in this area (estimated 500-600 researchers) publishing in highly ranked scientific journals with high impact. Medicine is the strongest field of science (Scimago, 1996-2014; May 2015) and when compared with 22 other Eastern European countries, including large countries such as the Russian Federation, based on the number of citable research articles, Croatia ranks 5th and 6th based on the number of citations. It ranks 7th based on the h-index as an indicator of quality of R&D. Similar to medicine, Croatia ranks very high in food science when compared to 22 similar countries. Croatia ranks 4th based on the number of citable articles. It ranks 5th based on the number of citations and 6th based on the h-index. Croatia is planning to invest in these areas of research with a new research infrastructure, and Croatian R&D is therefore expected to significantly improve and provide an excellent basis for nutrition-related research.

R&D in the Croatian food and nutrition sector has moved from identifying and correcting nutritional deficiencies to designing foods that promote optimal health and reduce the risk of disease. Research groups from several public institutes (RBI; Institute for Medical Research and Occupational Health and the Croatian Institute of Public Health, all in Zagreb; Institute of Adriatic Crops and Karst Reclamation in Split) and universities (Faculties of Food technology and Biotechnology at the University of Zagreb, Split and Osijek; Medical Schools in Zagreb Split, Rijeka, Osijek, Veterinary School at the University of Zagreb), and the Croatian Food Agency, as well as several other institutions, are central points for R&D and education of experts in the fields of food technology, biotechnology, nutrition and medicine in the Republic of Croatia. The Croatian Food Agency

83 Through in vivo and clinical research is proved that „višnja maraska“ is anti-oxidans and has potential to be functional food and get health claim.
overlooks and coordinates food safety in the entire country.

All of these public institutions are investigating biological functions of vast numbers of food components and their role in disease prevention and health promotion. Areas for research in Croatia include an improved understanding of the role and optimal levels of traditional nutrients for specific segments of the population, as well as identifying bioactive substances present in foods and medical plants, in order to establish optimal levels. Another relevant R&D institution in this field is KBC Zagreb (Clinical Hospital Centre Zagreb) in Zagreb, which has developed and regularly uses an IT system to follow all segments of dietetics in order to systematically test the latest scientific developments in everyday clinical practice in the field of nutrition and dietetics. This is an important segment because it links clinical practice and basic science in nutrition.

As further evidence about the importance of this area for Croatia, the Croatian Association of Food Technologists, Bio-technologists and Nutritionists, in cooperation with the Croatian Chamber of Commerce and the Ministry of Agriculture since 2008 organizes the annual conference “Functional food in Croatia”, with the aim of promoting a new niche for enterprises, and enabling networking between academia and industry for the development of new products and services in this area. All public institutions are actively involved in national and international research programs such as FP7 and now Horizon 2020. One example of a recently completed FP7 project is PROMISE, a project with the overall goal to improve and strengthen the integration, collaboration and knowledge transfer between the new and old member states of the European Union and its candidate countries. The objective was to tackle common food safety threats and, hence, to protect European consumers.

<table>
<thead>
<tr>
<th>Indicative RDI topics relevant for this STPA</th>
<th>have been selected:</th>
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<tr>
<td>- natural health products;</td>
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<td>- dietary supplements;</td>
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<td>- functional and enriched food.</td>
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Related **indicative RDI topics under cross-cutting themes KETs are:**

- KETs for functional and lifestyle foods to meet diversifying dietary requirements of consumers and embedded computer automation and control processes;
- process and embedded computer automation and control processes;
- ICT systems, solutions and applications for mobile and smart devices for healthy diet per target groups (athletes, pregnant women, persons suffering from diabetes...), prevention and protection from diseases through detection and monitoring of poor or inadequate nutrition;
- innovative technologies based on development of solutions with the function of monitoring quality of nutrition and health in Internet environment “Internet of Things”, management and analysis of Big Data and cloud solutions;
- computer vision and machine learning with application in nutrition.

5.2.1.5. **Expected synergy of economy and RDI and potential for further development of TPA and structural changes**

Health and the quality of life present a thematic priority area with enormous potential in the Croatian context. The Health industry is one of the world's largest and fastest growing industries with predicted world market growth rate of 3-4%, which saves lives and improves the quality of life. The model of structural changes, such as the main outcome of a smart specialization process regarding this TPA, will be related to modernization through the development of specific applications of a general-purpose technology, diversification through commercialization of new products and services and transition through new methods of prevention medicine, as well as care for the elderly that is characterized by a new domain emerging from an existing industrial commons.
Also, the combination of consumer demands, advances in food technology and new evidence-based science linking diet to disease and disease prevention has created an unprecedented opportunity to address public health issues through diet and lifestyle. A growing number of consumers perceive the ability to control their future health by improving their present health and/or hedging against aging and future disease. These consumers create a demand for food products with enhanced characteristics and associated health benefits. Using foods to provide benefits beyond preventing deficiency diseases is a logical extension of traditional nutritional interventions, and the functional food and natural health products industries have become an important part of the global food industry. According to a report by Leatherhead Food Research in 2013, the global market for functional foods was worth an estimated USD 43.27bn; this represents an increase in value terms of 26.7% compared with 2009. Through further specialization and R&D activities in this area, Croatia can find new niches and new markets.

Finally, to make the Health industry in Croatia competitive on the global market, a biotechnology innovation system will be created that can provide favorable conditions to strengthen the value chain and enable new biotechnology processes and products to be developed by securing a conductive environment for biosciences development (including investments into bio education, competitive science base, industrial RTD programs and appropriate technology infrastructure). S3 strategy will provide a great opportunity to stimulate the Croatian National Health, Biotechnology and Pharmaceuticals Initiative. This can be helped through a recently established Health Competitive Cluster. The future BIOCenter in Zagreb and its activities starting by the end of 2015 will help in the successful implementation of a new Croatian Health, Biotechnology and Pharmaceuticals Initiative and it will serve as the great infrastructure needed for further development of these sectors.

The expected synergy of RDI and business in this sector is not strictly limited to domestic collaboration. Moreover, and thanks to a good regional reputation enjoyed by the Croatian health care and education systems, there are good opportunities for cross-border collaboration between RDI and industry.

5.2.2. Energy and sustainable environment

Energy and Sustainable environment in many ways presents and emerges as an important area of specialization in Croatia, on the basis of strong statistics, indicators, analysis and the process of entrepreneurial discovery.


Within this TPA substantial contributions to meet global challenges in relation to secure, clean and efficient energy, climate change, and resource efficiency can be made. Croatia has to secure its own capacity to apply such technologies and equipment as soon as they are economically sound. The installed power capacity in Croatian power system is currently made of app. 45% thermal power plants, 45% large hydro power plants, and 10% renewables. Croatia is increasing investments in R&D projects with primary goal to develop and increase the capabilities of local industry and services, directed towards high-tech solutions and applicative innovations. Given the expertise of the local industry and research community, significant contribution to new technology and operation procedures that involve energy storage and demand response schemes is expected. It is important to emphasize that Croatia tends to interconnect the 2 identified STPAs in “cascade” economy principle that close up the energy circles of various components included under this TPA.
Following strengths are relevant for further investments within this TPA:

- Existence of significant industry capacity related to electrical equipment for power systems, (e.g., power and distribution transformers, rotating machines, wind turbines, photovoltaic panels) and supporting industry for creation of large constructions of metal and concrete (shipyards);
- Existing long tradition and experience in design and construction of power plants, transmission lines, power substations and control systems with very good global export potential;
- Presence of natural resources suitable for production energy from renewable resources (water resources – building and equippinghydro plants, bio plants that can obtain leftovers from Croatian strong agriculture sector, wind to be used for further technological upgrades and investments in field of wind power plants, etc.);
- Numerous educational facilities and programmes within six university centers where students are trained in production, engineering and maintenance;
- Several public and private research organizations with proven capacities in this area which can thus support and enhance the competitiveness of the industry through research and development;
- Existing market that requires upgrading and expansion of production capacities.

Croatia has excellent potential to further develop this TPA due to its strong human potential with tradition and experience of workers in related fields. Particularly strong sectors are: Manufacture of electrical equipment (8,973 employed), Manufacture of machinery and equipment n.e.c. (10,699 employed) and Manufacture of computer, electronic and optical products (5,880 employed)[84]. In terms of the human resource capacities in public R&D institutions, as afore mentioned, there is a proven potential and strength in energy and environment sector with well-established and active cooperation of public and private sector.

According to adopted Industrial strategy 2014-2020, indicators of profitability point out to the sub-industry segment: Manufacture of electric motors, generators, transformers and devices for transfer and distribution of electrical energy as most promising one for future perspective. The state aid and subsidies in total revenue were low (0.05% in the 2012). Labor and capital productivity increased, which makes it one of the higher value productivity in the manufacturing industry.

Entrepreneurial discovery process (EDP) is mainly based on operations and scope of activities of two competitiveness clusters relevant for this TPA: (1) ICT competitiveness cluster and (2) Competitiveness cluster for Electrical and Mechanical Machinery Industry and Technology.

Sub-thematic priority areas under this TPA are based on established strengths and potential and were identified in the framework of conducted EDP. They are presented in the chart below: (1) Energy technologies, systems and equipment; (2) Environmentally friendly technologies and equipment.

Figure 28 Energy and sustainable environment STPAs

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[84] Industrial Strategy of the Republic of Croatia 2014 – 2020
5.2.2.1. **STPA1 Energy technologies, systems and equipment**

The 1st STPA focuses on the development and implementation of modern energy technologies and production of equipment that are expected to be efficient, remotely controlled and monitored, smart grid compatible, environmentally friendly and recyclable at the end of its lifetime. This requires introduction of new optimized technical solutions and often new advanced materials as well as application of various sensors for functionality and condition monitoring based on ICT. Technical and cost optimization is not possible without modern computer tools and knowledge on materials and phenomena in the equipment and its environment.

Strong industrial activities in area of **production of electrical equipment and production of machinery and equipment** present significant support in responding to identified challenges, while at a same time market development will likely positively influence this industry in future having in mind the importance of energy security issue. As already indicated in the analysis, the production of electrical equipment in Croatia has a long tradition and is still highly relevant one. Energy technology is one of the thematic strengths (so called hot-spots) that Croatia possesses in key technologies, indicating the need and justification for stronger support from public sources to the future development of this area.

The users of electric power equipment are mostly industry power plants, electricity producers and transmission and distribution system operators. All of them are facing challenges related to digitalization in the areas of electrical equipment and smart grids. A very important topic in this context is asset management and life cycle of the equipment. There is substantial experience within the private sector in regards to on-line monitoring systems, which detect emerging faults, reduce fault consequences, enable condition based maintenance and residual life assessment. This is supported by Faculty of Electrical Engineering – University of Zagreb, which possess expertise in regards to on-line monitoring systems, and holds international patents in this area (fault-tolerant management for wind turbine generators).

The indispensable part of above mentioned challenges present area of **smart energy systems**. System challenges are related to integration of numerous renewable energy sources (based on wind and solar energy) in the power system and other energy systems (distribution of thermal energy and gas). Smart energy systems will enable mitigation of energy use and reduced cost of integration of renewable energy sources by application of instruments such as ICT infrastructure incorporating management/control algorithms in existing energy system. Effective application of technological

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86 Some of the key companies in this sector were founded in the first half of the 20th century. Data for 2012 indicate that in production of electrical power equipment for power engineering there are 8973 employees in 280 enterprises.
87 Research and Innovation Performance in EU Member States and Associated Countries, Innovation Union Progress at Country Level, 2013, European Commission
88 The systems with larger share of renewables inevitably need to have higher degree of flexibility and capability of storing the surplus energy and utilizing it at the later point in time (i.e. the time arbitrage of energy use).
upgrades and new products, services and equipment will create multiple challenges for the existing electricity grid in terms of integrating the new generation capacities, energy storage and distribution.

It is important to emphasize that these kinds of smart systems require new level of maintenance and monitoring of system using advanced technologies such as smart sensors and autonomous robotic technologies which are able to independently perform monitoring and maintenance and thus reduce costs. One of the examples is an FP7 project „BladeHunters – System for remote inspection of wind turbine” implemented by Faculty of Electrical Engineering and Computing at University of Zagreb.

5.2.2.1.1. RDI capacity in industry

The prevailing companies from the sector are large and medium companies which produce specific equipment and are mostly export oriented, intensively investing in R&D. Their main drawback is the lack of infrastructure for industrial research and experimental development as well as infrastructure for conformity testing of products and equipment in line with EU norms and directives.

The company Brodariski institut ltd. performs activitites in the area of smart grids, hydro energy and biomass is one of the relevant and competent companies in the area. Furthermore, referent SMEs investing in RDI in this STPA are gathered around cluster “Inteligentna Energija” (Intelligent Energy), a business network (counting 32 members), mostly export oriented (62 % of their activities were export activities in 2014), intensively investing in R&D and innovation (11 patents). The cluster is focused on energy technologies in areas of energy efficiency, energy management, HVAC and energy systems, smart grids, hydro-energy (small hydro power plants), solar-energy (PV and thermal systems) and biomass. Some of leading SMEs, investing in RDI in this field are: Prointegris ltd., Veski ltd., Helb ltd., EnergoControl Zagreb ltd., Solvis ltd. and RITEH ltd.. Some of EU projects, in which cluster participates are: Building European energy community Mediterranean Energy Clusters (SMARTinMED) 90, Transferring European VET Structures to cover skill needs in Energy Efficiency Sector (EFFIVET) 91, Transferring European VET Structures to cover biomass skill needs (BIOMASS EUVET) 92.

In this STPA there are active companies in design, production and maintenance of equipment for efficient heating/cooling in buildings and industrial facilities. According to the total revenue, the top five companies in the energy technology area in 2012 generated 49% of total revenue of analyzed industrial activities (KONČAR Group, Siemens Inc. and others). This activity is profitable, while the trend of change in profitability is positive. Profit per employee increased, and the loss per employee is reduced. KONČAR - Electrical Engineering Institute Inc. is a leading private research organization for industrial research and experimental development in the area of energy and transport.

KONČAR - Electrical Industry Inc. is regional producer of Smart Grid and Smart Metering solutions, intensively working on Digital transformer stations and producing research results on international level regarding emerging communication protocols and standards. State-of-the-art Distribution management system portfolio recognizes following: SCADA, Market Management Systems, wireless communication systems and sensor technology, heading towards ICT solutions, etc. In connection to smart energy systems worth mentioning are R&D investments to several smart grid solutions from one of the top Croatian companies Ericsson Nikola Tesla Inc. R&D investments in renewable energy (described in STPA 2) and Smart energy utilization present important connection point in processes identified under this TPA.

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90 http://www.inteligentnaenergija.hr/?cat=3
91 SMARTinMED
92 BIOMASS EUVET
When it comes to **manufacture of machinery and equipment**, Croatian industry has tradition and capacities in building complex integrated machinery (e.g. Đuro Đaković ltd. that can assemble energy bio plants components, Elektro kontakt Inc., PRO Integris ltd. that offers full service engineering providing services in energy automation, etc.). These are the capacities that Croatian industry has to upgrade through proposed RDI thematic of this STPA. Top five companies gained 32% of total revenues.

The manufacturing sector in the field of biomass energy mainly consists of recently formed small and medium companies, together with Lesaffre - a large European producer of yeast biomass. There is an increasing interest for biomass production present among Croatian entrepreneurs who require significant RDI contribution to the optimal use of resources that may provide significant competitive advantages for Croatia. Agrokor, one of the largest Croatian companies, is investing significantly in bio-production facilities and will certainly create demand for next-generation management systems for this type of investments. Croatian producers of complete projects in the area of renewable energy sources, such as Đuro Đaković ltd. (one of the largest industrial groups in Croatia and the region) have capacity for production integrated bio-production facilities which together with KONČAR generators and control systems, can establish unique manufacturing and create potential for large number of RDI investments.

5.2.2.1.2. **RDI capacity in academia**

When it comes to relevant R&D stakeholders quite a few public research institutions in Croatia have already established a strong position in this field: Faculty of Electrical Engineering and Computing, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Faculty of Electrical Engineering Mechanical Engineering and Naval Architecture, University of Split and Energy Institute Hrvoje Požar from Zagreb have strong expertise and well established track record in publications, patents, industrial applications and joint research activities with a private sector.

In Energy field in period from 1996-2014 Croatian researchers published total of 1403 citable documents with 5203 citation and overall h-index 31. The most scientific articles were published under topic Energy Engineering and Power Technology followed by fuel technology. When Croatia was compared with 22 countries in Southeastern Europe using Energy publication record, based on citable document it ranks 9th, number of citations 10th and h-index 10th indicating a quality of science. 93

Energy related research area was included in identified research topics with notably high 9.2% of total budget dedicated to FP7 Cooperation programme. 94 Most of the projects deal with smart grids, transition planning and Systemic Energy Planning and biomass energy. Among H2020, several are in field of energy efficiency and energy planning, especially concerning smart cities. 97 Other HEIs and PROs relevant for research within this priority are Faculty of Electrical Engineering, University of Osijek, Faculty of Engineering University of Rijeka, Brodarski Institute and RBI Zagreb. Private R&D Institute for Nuclear Technology (INETEC) has achieved distinguished results in development of technologies for nuclear power plant examination and repair, inspection and repair services.

Scientific community can significantly contribute to the development of new methods of supervision and inspection of energy systems using robotic technologies and autonomous systems. An example of a FP7 project within which autonomous aircraft is used for inspection of wind turbines is

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93 Indicated by analysis using Scimago, September 2015
94 Stairway to Excellence, 2015, p.12.
95 http://cordis.europa.eu/project/rcn/92467_en.html
96 http://cordis.europa.eu/project/rcn/194623_en.html
97 http://cordis.europa.eu/project/rcn/194631_en.html
“BladeHunters – System for remote inspection of wind turbines“ implemented by Faculty of Electrical Engineering and Computing at University of Zagreb.

On the infrastructural level, an indicative list of ERDF projects (2014-2020) shows that one important project relevant for this STPA: CEKONET project - Center of competence for smart energy and clean transport.

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<tr>
<th>Indicative RDI topics relevant for this STPA</th>
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<tr>
<td>Development of new and improvement of existing primary and secondary equipment for electrical energy systems (primary equipment: turbines, generators, motors, transformers, switchgears, transmission lines and cables, secondary energy equipment: management, measurement, protection, supervision, guidance);</td>
<td></td>
</tr>
<tr>
<td>New technologies and improvements related to power plants, substations, components and systems connected to renewable energy sources;</td>
<td></td>
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<tr>
<td>New researches connected to increasing efficiency and production capabilities of industrial, agriculture and forestry plants and machines;</td>
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<tr>
<td>Advanced energy storage systems;</td>
<td></td>
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<tr>
<td>Diagnostic and better management of energy equipment;</td>
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<tr>
<td>Energy management systems for planning, investment, real time management and monitoring of energy efficiency and CO2 reduction;</td>
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<tr>
<td>Process and embedded computer automation and control processes;</td>
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<tr>
<td>Systems for energy management and support for the functioning of energy markets at levels of microgrids, smart grids and smart cities;</td>
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<tr>
<td>Advanced conventional energy solutions;</td>
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<tr>
<td>Application of smart grids and complex energy systems;</td>
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<tr>
<td>Energy-efficient interconnected and universal lighting;</td>
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<tr>
<td>Sustainable conversion of biomass into energy;</td>
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<tr>
<td>Biogas technology for production of electricity and heat;</td>
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</table>

Related indicative RDI topics under cross-cutting themes KETs and ICT are:

- Energy-to-gas and gas-to-energy conversion technologies;
- Process and embedded computer automation and control processes;
- Robot technologies as systems for autonomic supervision of energy infrastructures;
- KET – fotonics
- Micro and nano electronics for high efficiency power control and conversion electronics.
- Solutions for Smart Metering and Internet of Things;
- ICT solutions connected to energy sector (Smart Cities and regions, Utilities, Smart Mobility and Smart Living, inventory of power plants, systems and equipment in the environment and connected process of management and supervision of energy assets, Physical and logical network inventory, Service inventory, energetic dimensioning when designing supply networks)
- Energy Efficient Appliances;
- Efficient grid and energy systems;
- Innovative ICT Solutions for increasing energy efficiency consumption and solutions for production forecasting for support to energy management and market operations in microgrids and smart grids;
- Advanced solutions for increasing energy efficiency in buildings (architectural, construction, engineering, electrical, control and their synergic combinations);

Computer vision and machine learning with application in energy technologies, systems and equipment;
5.2.2.2. **STPA 2 Environment friendly technologies, equipment and advanced materials**

Sustainable environment in Croatia has strengths in energy related areas while also being very strong in other environmental areas important for sustainable growth: tackling climate change (affects food production and bio-economy, quality of life, tourism, etc.); water resource management (drinking water, waste waters); clean air protection (health and quality of life); control of other environmental conditions (rivers, Adriatic sea, soil). Croatian Environment and nature Agency (CENA) as an independent public institution controls environment by monitoring water, sea, rivers, air, climate changes, soil, nature, sector impacts, waste and general issues. The Agency is a focal institution in charge for collecting, integrating, and processing all environmental data.\(^{98}\)

Primary focus for this STPA is to tackle challenges of climate change and development of economy with decreased emission of carbon dioxide in Croatia. EU Renewable Energy Directive has set targets for increasing the average share of renewable energies in final energy consumption. Solar Photovoltaics (PV), Concentrating Solar Power (CSP), and Wind Energy Technologies (wind) will play a key-role in achieving these targets. Climate change will have major and unpredictable effects on the water systems, including an increase in floods and droughts. This presents strong drive and determination for future research initiatives in this area, supported by the adequate government measures and industry stakeholders capable for investing in R&D, connected to mentioned initiatives and measures.

**Advanced materials**, as an interdisciplinary field applying the properties of matter to various areas of science and engineering, present one of the thematic strengths that Croatia possess in key technologies\(^{99}\), and shows the potential for economic growth. The selection of advanced materials in the hotspots of the key technologies in Croatia is significantly supported by the scientific output by Croatian scientists in materials science and other related fields, such as condensed matter physics, physics in general, chemistry, engineering and chemical engineering. The impacts of advanced materials and nanotechnology are expected to increase in the foreseeable future and are likely to deliver substantial growth opportunities especially for environment friendly technologies and equipment.

Opportunity related to challenge of decreasing emission of carbon dioxide relates to potentials in exploring possibilities in using animal and vegetable waste in production of bio fuels. **Biomass and Bio-based products** are related to the applications of life sciences and biotechnology in a broad variety of sectors as the main innovation drivers of the knowledge-based bio-economy (KBBE), leading to new growth and competitiveness in traditional chemical sector, and the creation of emerging sectors based on renewable raw materials, such as bio-based products and bio fuels. Once developed and fully integrated, this area will form good supplement to the energy systems mentioned in STPA 1. The potential of biomass comprising plant (mainly wood but also several other fast growing plants) and single cell biomass, originating from agriculture, industrial wastes, or cultivation, is in Croatia explored both for the conversion to energy, as well as for the production of chemicals (mainly pharmaceuticals). One of the Croatian strategic objectives is the production of 26 PJ of biomass energy by the year 2020 with total power of about 85 MW. (CIT). To achieve this goal Croatia has to encourage further development of forest management and use of forest biomass, forestation and cultivation of short rotation crops, as well as to explore alternative sources of biomass of plant and microbial origin. Plants producing electricity and heat in a joint process can increase the energy efficiency as an added value. Moreover, RDI that includes processing of different renewable biomass sources available regionally may be tested and novel value chains and industrial or economical routes can be discovered. The area of Biomass provides opportunities to certain industry sectors that will need

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\(^{98}\) CENA runs the database of documents on sustainable development and environmental protection.

\(^{99}\) Research and Innovation Performance in EU Member States and Associated Countries, Innovation Union Progress at Country Level, 2013, European Commission
to orient towards different niches and new technological directions. For example, chemical industry - the relative importance of the sector is significant with 278 companies employing 7,280 people according to data from 2012\textsuperscript{100}, together with 1,270 companies with around 10,000 people in plastic fabrication, and provides excellent basis for implementation of bioprocesses, as is already the case in companies like Hospira, Jadran Galenski Laboratorij, or Fidelta.

Important prerequisite for above mentioned bio potential and part of this “cascade” economy circle will be to provide solutions and products for efficient collecting, compacting and discharge of municipal and selected waste. The need for environmental friendly equipment and machinery largely depends on overall industrial activity, mentioned policy framework that is changing due to the EU accepted norms and goals, as well as the state of agriculture, construction, production, exploration and exploitation of oil and gas, and the production of electricity.

As for other environmental areas important for sustainable growth, like control of pollution, the inclusion of regional countries into Global Earth Observation (GEO) and their contribution to GEO System of Systems (GEOSS) is of great importance in the EU, since comprehensive EO framework can lead to a better understanding and more intelligent utilization of environmental resources, increased quality of life and faster economic development. The importance and benefits of participation in global EO initiatives have already been recognized by Croatia, in order to create conditions for sustainable economic development through the increased use of Earth observation products and services for environmental applications. This purpose serves the higher goal of effective use of Earth observation for decision making and management of economic and sustainable development processes.

An important area to mention is environmental monitoring using robotic technologies and autonomous systems. One of the first projects dealing with underwater supervision is FP7-REGPOT 2CURE - Development of Croatian potentials in area of underwater robotics” implemented by Electrical Engineering and Computing, Zagreb. Ensuring sustainable environment by using robotic technology and autonomous systems is of great importance for Croatia. Special emphasis should be placed on technology for exploration of marine and underwater environment. Those research activities were continued through H2020- TWINNING project “EXCELLABUST - LAPOST excellence in underwater robotics” aimed at expanding capacities of Laboratory for Underwater Systems and Technologies of Faculty of Electrical Engineering and Computing Zagreb in order to improve the use of underwater robotic technologies, among other, in the area of environmental protection.

Last important area for this STPA is related to the field of Solar Photovoltaics (PV), Concentrating Solar Power (CSP), and Wind Energy Technologies (wind). Croatian industry has capacities to operate and develop certain solutions in relation to this areas of renewable energy. An example is a highly sophisticated product developed by Končar group - wind turbine of 1 MW and 2,5 MW. However, in terms of profitability, it can be noted that Croatian companies aim at upgrading of existing technologies soon to be outdated.e. improvement of existing technologies for conversion, generators and related equipment, transformers, solutions for control and energy storage and micro networks.

5.2.2.2.1. RDI capacity in industry

Croatian Center of renewable energy sources (CCRES) formed back in 1988, is one positive example of larger association of companies with main intention to excel applied research and development center with an international reputation, focusing on the optimal use of the nation's energy resources.

\textsuperscript{100} Industrial strategy of Republic of Croatia 2014-2020. (OJ 126/2014)
Cluster “Inteligentna Energija”, a business network mentioned as relevant in STPA1, gathers SMEs investing in RDI in the framework of this STPA, as well.

Examples of successfully translated R&D into manufactured goods and products in biochemical and bio plastic production and in development of environmentally friendly new materials and substances can be found in Croatian relatively large companies like Pliva, Belupo, or JGL, and in smaller producers like Genera, PharmaS, BioPharm etc. In the recent years also small knowledge-based companies providing biotechnology services like Genos, SemGen, etc. have emerged. Larger companies are all exporters with already established position in the market. Currently, there are several large companies focused on materials science and nanotechnology relevant to energy sector in Croatia, including the following: Applied Ceramics (semiconductors), Solaris(solar cells), Solvis Ltd. (solar cells), Končar (nanotechnology in the production of transformers), Systemcom (nano chips), Odašiljači i Veze.

Numerous Croatian companies operate within the waste treatment field. Some of them are global players - e.g. TEHNIX ltd.is the leader in the production of EKOMUNAL special utility vehicles for collecting, compacting and discharge of municipal and selected waste, high flow rate separators, wastewater treatment and purification plant. This company is the Croatian leader in this area and innovation trendsetter with numerous export markets (Russia, Iran, Romania, Germany, etc). In Wind technologies – mentioned KONČAR Group with numerous sub-contractors - offers solutions in developing and producing almost every component of wind energy plants (except of wind blades) and wind turbine as whole. The development of the wind turbine system was accompanied by intensive cooperation with Faculty of Electrical Engineering and Computing and Faculty of Mechanical Engineering and Naval Architecture at University of Zagreb in last 15 years. Several companies are utilizing innovative methodologies to further develop their services focusing on the Earth Observation (EO) data, such as; ECOINA Ltd.(air quality monitoring, landfill design, wastewater treatment); EKONERG Ltd. (power plant performance testing, air emission measurements, developing air quality monitoring stations); Geodata Ltd. (geo-information systems, digital terrain modelling, urban planning), Geofoto Ltd. (3D city modelling, LIDAR, UAV); GEOSAT Ltd. (environmental monitoring, CORINE programme, geo-hazard mapping, remote sensing); GISDATA Ltd.; GDI CONVIVO Ltd. (cloud services).

5.2.2.2. RDI capacity in academia

In addition to major Croatian universities, there are several research institutions in Croatia with significant human resources working in environmental science. RBI is by far the largest and most prolific among them, covering greatest diversity of key research disciplines (environmental chemistry, biology, informatics, modeling, oceanography, geology, physics and radiology). Only marine and environmental science includes over 150 researchers. Therefore, there is more than 400 researchers in Croatia working in the field of environmental research and protection, comprising the development of environment friendly technologies and equipment. Another good example of a research institute with a focus on sustainable resources is already mentioned Energy Institute Hrvoje Požar, Energy Institute Hrvoje Požar (EIHP) contributes significantly to the development of sustainable energy, through analysis of potentials and possibilities of construction and operation capacities for production of energy from renewable sources, analysis related to construction and development photovoltaic systems and solar systems for production of thermal energy and CPS systems, analysis of market models and their impact on business, feasibility studies related to conventional and renewable energy sources in market conditions, development of sustainable market of heating energy from biogas plants, analysis and simulations of electric energy network occurrences related to integration of renewable energy sources, and forecasting production and the uncertainty related to forecast production errors for renewable energy. EIHP Exerts have interdisciplinary and long time international experience in planning, analysis, simulations and optimizations of energy
systems. Specific knowledge of EIHP experts is of great importance for the feasibility of sustainable development integration in the energy sector in Croatia.

In terms of the human resource capacities, there is a proven potential in this sector as a valid area for enhancement of skills of researchers and for a more stable and active academia-industry collaboration. It is also important to mention new Center of Research Excellence established at University of Split, where one of main fields is related to renewable energy sources.

Significant number of researchers (more than 500), mostly in public sector located in Zagreb, perform research activities in material sciences and advanced materials relevant to energy and sustainable environment. Public institutions performing R&D in materials (advanced materials with applications in the environment) science and nanotechnology are as follows: University of Zagreb, University of Split, University of Rijeka, University of Osijek, Rudjer Boskovic Institute (RBI) and Institute of Physics (IP).

As for the scientific production, Croatia ranks with h-index 57 for environmental sciences in the period 1996-2014. In field of environmental science in general, Croatian scientists published 3806 research articles which were cited 27,833 times. Global benchmarking of Croatia on key research output indicators in materials science and related fields shows that out of 189 countries worldwide, Croatia ranks 51st as measured by the number of citable research articles and 53rd as measured by the number of citations and 49th as measured by h-index in this period (SCImago, Journal and Country Rank, May 2014).

Environment related research has a high score of absorption with 7.6% of total budget dedicated to FP7 Cooperation programme. The strong research capabilities in the area of environmental science and water resources stem from the 23 FP7 projects, 3 UNECE projects with key players coming from the University of Zagreb, University of Split and Institute of Oceanography and Fisheries in Split as well as The Institute for Medical Research and Occupational Health. Public institutions in Croatia collaborate with private sector on different projects in environmental sector directly contributing to economic development and smart growth. Some of project examples are: Sea and environment research platform “Maritime experimental centre of biodiversity- MORExpo” (planned in cooperation with Croatian Academy of Sciences and Arts); FP7-ICT Intelligent Urban Water Management System (2012-2015); ENHEMS-Buildings (IPA IIIc); Appearance and interaction of biologically important organic molecules and micronutrient metals in marine ecosystem under environmental stress; Assessment of Carrying Capacity for Tourists in Nature Protected Areas (ACCTA); Assessment of hazardous chemical contamination in the Sava River basin NATO Science for Peace (SARIB); Determination of ecotoxic metals in water environment of Rijeka harbor using passive samplers.

Ministry of Environmental and Nature Protection and the national Environmental Protection and Energy Efficiency Fund in collaboration with the Ministry of Science, Education and Sports are launching initiative - a new project line for funding applied and basic research directed to monitoring and mitigation effects of climate change, resource efficiency and green-house gases. The funds will be ensured out of selling greenhouse gases emission units fund as well as from ESIF. Almost 10 million EUR will be invested in RDI activities within this field, starting from 2016. The focus of projects will be set on innovative products and technologies related to above-mentioned challenges.

Croatian public and private stakeholders participated in number of projects focusing on the Earth Observation (EO) data innovation methods and its inclusion in the wider regional context. Some of them are: Balkan GEONet (FP7), IASON (FP7), Building the Link between Flood Risk Management...

\[101\] SCImago Journal
\[102\] Stairway to Excellence, 2015, p. 12.
\[103\] In different environment related fields, as for example: Climate change and Carbon cycle research, Economic Aspects, Environmental Protection, Medical biotechnology, Medicine and Health, Meteorology, Network technologies, Radioactive Waste, Social Aspects, Sustainable development and Water resources and management.
Planning and Climate Change Assessment in the Sava River Basin\textsuperscript{104}. Project IMPACTMIN developed new methods and a corresponding toolset for the environmental impact monitoring of mining operations using EO with particular focus on hyperspectral imaging technique, and was declared as a FP7 “success story”. A broad analysis of gaps and complementarities of EO activities within the Croatia and the region has been performed within these projects. Most of the developed innovations and new methodologies will be utilized by public and private sector in implementing provisions stemming from INSPIRE directive.

In connection to Biotechnology, this field is throughout the whole S3 document presented as one of the most perspective areas. Also, agricultural and biological sciences are second most notable field regarding published scientific papers\textsuperscript{105}. Several research groups are led by scientists with over 1,000 citations (Web of Science) and they have achieved good results in obtaining projects and performing international research through pre-accession funds mainly at the, University of Zagreb and the Josip Juraj Strossmayer University of Osijek, as well as at the Agricultural Institute in Osijek. An important boost in the field of Green-Biotechnology is also expected with the soon opening of the BIOCentre. University of Rijeka (in particular it’s Department of Biotechnology and Centre for high-throughput technologies) has been granted the first infrastructural project funded by Cohesion EU funding that is partly dedicated to the field of white biotechnology. In addition, there is strong research capacity devoted to problems of environmental pollution. Numerous national and international projects have been performed by the various research organizations in e.g. the field of agriculture to monitor and analyse effects of fertilization and other chemical treatments in agriculture to pollution of soils and waters (salinization, nitrates, heavy metals, etc.). These projects were conducted in collaboration with industry in the food sector, state companies (Croatian Waters) and public authorities (Croatian Environment Agency), City of Zagreb, etc.) in order to ensure environmental sustainability and improve the health status of food products. Also, there are projects dealing with non-food problems\textsuperscript{106}.

<table>
<thead>
<tr>
<th>Indicative RDI topics relevant for this STPA have been selected:</th>
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<tbody>
<tr>
<td>- environmental sustainability of manufacturing;</td>
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<td>- technologies and solutions connected to reducing resource consumption and waste generation;</td>
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<tr>
<td>- optimization of use of resources by including new or advanced materials in view of producing more with less;</td>
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<tr>
<td>- laboratory utilization of waste streams; techniques and protection of biodiversity;</td>
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<tr>
<td>- energy saving technologies combined with effective usage of renewable energy capacities;</td>
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<tr>
<td>- technologies reducing harmful industry emissions of CO2 through applying innovative new technologies and solutions;</td>
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<tr>
<td>- development of technologies and equipment for protection of sea;Technologies for energy saving combined with efficient use of renewable energy capacities;</td>
</tr>
<tr>
<td>- integrated water management aimed at water use minimization, reuse or recycling in industry plants, “end of life” activities and researches for obsolete production capacities, “through life” engineering, ICT-supported management of the entire water-use chain including the connection between water and energy systems;</td>
</tr>
<tr>
<td>- researching biopolymers and bio-plastic of 1st and 2nd generation, bioreactors, atmospheric biotechnology;</td>
</tr>
<tr>
<td>- novel sources of biomass and bio-based products;</td>
</tr>
<tr>
<td>- added-value bio-based chemical products and environmentally friendly biomaterials;</td>
</tr>
<tr>
<td>- Waste waters monitoring, foresight and mitigation innovations for environmental pollution</td>
</tr>
<tr>
<td>- Technologies and use of autonomous unmanned vehicles for monitoring of the environment</td>
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</table>

\textsuperscript{104} Financed by UNECE through the International Sava River Basin Commission.
\textsuperscript{105} SCImago Journal and Country Rank
\textsuperscript{106} Data Flow System and Indicators to Enhance Integrated Management of Global Environmental Issues in Croatia. (Univ. Of Zagreb, Faculty of Agriculture, LETA ltd. and Croatian Environment Agency)
Related indicative RDI topics under cross-cutting themes ICT are:

- Energy Efficient Appliances;
- Process and embedded computer automation and control processes;
- Environmental monitoring based on Internet of Things and Big Data analysis;
- Energy management systems for planning, investment and monitoring of energy efficiency and CO2 reduction.
- KET – advanced materials with application in green construction;
- ICT solutions for spatially-enabled monitoring of emissions of pollutants and greenhouse gases in the environment
- Solutions for measurement and modeling of light pollution and the preparation and maintenance of the light pollution maps;
- Smart grid of public lighting, combination of the powering of public lighting and charging batteries for electric vehicles;
- Innovative technologies based on the development of advanced sensor networks in internet environment
- Computer vision and machine learning with application in environmentally friendly technologies and equipment and advanced materials.

5.2.2.3. Expected synergy of economy and RDI and potential for TPA further development and structural changes

As an EU member, and the member of international community, Croatia will be obliged to reduce GHG emissions by at least 50% by 2050. Realization of this goal is possible but it is necessary to design a new strategy which will evaluate more realistically economic impacts of environmental protection and climate change and create assumptions for technology and industrial development, improvement of energy efficiency in all economic activities. Furthermore, use of renewable energy sources and technologies that reduce harmful effects on the environment will affect the improvement of the general and personal living standards. General trend is a more effective use of energy, use of renewable energy sources, use of energy sources that do not produce greenhouse gases and more efficient transport system with greater use of CO2 neutral fuels and the internalization of external costs of environmental pollution by establishing a price of carbon dioxide emission. The global demand for environmental technologies, eco-friendly products and services is expected to gather speed in the coming years. The global market, currently estimated at 1.15 trillion EUR a year, could almost double, with the average estimate for 2020 being around 2 trillion EUR a year. For Croatia, like the rest of Europe and the World, the main challenge will be to capture and store CO2 emission that are product of usage of fossil fuels in existing power plants. Energy efficiency in industry is closely linked to technology development and pace of renewal of existing production capacity. Market opening, competition and technology advancements will have positive impact on continuous improvement of energy efficiency in industry. It is expected that the demand for electric energy will grow considerably as a result of trends in industrial products market and higher level of automation and even robotisation of processes. It is also expected that costs of power plants, and consequently energy costs, will be significantly reduced through introduction of advanced autonomous robotic technologies in the area of supervision and maintenance of energy infrastructures. Croatian industry’s share in total energy consumption is around 20 percent. This is the sector with the highest long-term decline of energy consumption, which is partly the result of technology improvements (improved energy efficiency) and decreased industrial output. Use of renewables in Croatia, like biogas, wood residue or residues in food industry or agriculture, will also grow, particularly the use of biomass.

Management of energy consumption by smart grids offers new potentials for improving energy efficiency in Croatia. Development of ICT technology opens up great opportunities for the development of energy market and entrepreneurship in energy sector. In addition, smart grids can
Contribute to higher energy conservation, optimisation of appliance use and their energy consumption on the level of each household, changed concept in the development of energy infrastructure, lower costs and improvement of many other functions and business activities.

New initiatives and improvements of energy efficiency in all segments of value chain from energy generation, transport/transmission, distribution to consumption, use of new technologies and renewable resources will be developed.

5.2.3. Transport and mobility

5.2.3.1. Sector overview

Transport sector is one of the key factors of the economic and social development, both from the aspect of revenues in GDP, as well as from the aspect of the basic needs of living in a modern society - the need for mobility. Transport affects directly the expansion of industrial market, consequently implying the economic growth, improvement of the living standard, competition among regions and local communities and physical expansion and infrastructure integration.

Transport and mobility are important areas for Croatia that can make substantial contributions to meet global challenges in relation to smart, green and integrated transport. Strategy for Transport Development 2014 – 2030 presents a vision of upgrading Croatian economy and development through intermodal, sustainable, effective and safe transport system. A set of goals and measures to achieve it will be further elaborated through the National Transport Model107.

In a broader context, Croatian transport sector is relevant for the macro regional strategic framework set-up through the EU Strategy for the Danube Region (EUSDR)108. Croatia participates in EUSDR Priority Areas 1A "To improve mobility and intermodality of inland waterways" and 1B "To improve mobility and intermodality - rail, road and air". Furthermore, Croatia is also involved in the EU Strategy for the Adriatic and Ionian Region (EUSAIR)109. Croatian transport sector is relevant for ensuring coordination and actions in the scope of EUSAIR Thematic Pillar 2. Connecting the region (transport and energy networks), focusing on three topics of the Pillar: maritime transport, intermodal connections to the hinterland and energy networks.

This TPA is characterized by long tradition in production and is made of export-oriented sectors (metal, plastic, electrical and ICT sector for automotive, rail vehicle and maritime applications) and knowledge intensive service sector (logistics).

There is a proven R&D capacity in this TPA which also has important impact and high potential in the development of new products and services and upgrading in global value chain. FP7 Transport thematic area is one of the most active FP7 research priorities in which Croatian stakeholders participate, according to 6,47 M€ granted, which present 7.23% of total EC contribution to HR within FP7 (right after Health and ICT priorities, if horizontal activities like Marie-Curie Actions are excluded).110 Based on current data from CORDIS111, out of 608 Framework programme projects (FP5, FP6 and FP7) in which Croatian researchers and entrepreneurs participate as partners, 62 project fall under Transport thematic area. Majority of these projects are collaborative R&D projects with several specific support actions. Participation in FP7 transport thematic area is characterized by a

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107 expected to be developed in 2016.
108 EUSDR aims to establish synergy and coordination between existing policies and initiatives present in the Danube region.
109 EUSAIR aims to promote economic and social prosperity and growth in the region by improving its attractiveness, competitiveness and connectivity.
110 Seventh (the last) FP7 monitoring report, European Commission, March 2015.
relatively low number of applications made by mostly large companies (ULJANIK shipyard participates in 7 FP7 projects) and by large research institutions (University of Zagreb participates in 11 FP7 projects). There is also significant contribution of research oriented SMEs (Alveus l.l.c; Rimac Automobili Ltd.). So far, Croatian stakeholders participate in three Horizon 2020 projects in this field, as partners in three projects.

Most evident opportunities raising within this TPA lie in: (i) moving from 2nd and 3rd Tier supplier of automotive parts to 1st Tier supplier, (ii) new added value in rail vehicles production (iii) efficient transport that respects the environment by making vehicles and vessels cleaner and quieter to minimize transport’s system’s impact on climate and the environment, (iv) developing smart equipment, and services to improve transport and mobility in urban areas, that produce less congestion and make usage of transport infrastructure more effective (e.g. highways), (v) improving safety and security of citizens and infrastructure by developing new concepts of transport and logistics in order to reduce accident rates, fatalities and casualties, (vi) further development in design, production and operation of waterborne assets.

These opportunities for the sector development were confirmed through the Entrepreneurial Discovery Process, in which several CCCs had a key role. The four CCCs which were crucial for the EDP and whose members are expected to contribute further to raising competitiveness of this TPA in the period to come are (1) ICT CCC, (2) Automotive CCC (3) Maritime CCC and (4) CCC for Electrical and Mechanical Machinery Industry and Technology. Automotive CCC has prepared five project proposals which the cluster labelled as being projects of national interest. Two of these projects received assistance for technical documentation preparation: National reference laboratory for emissions from IC engines and motor vehicles at Zagreb University and The Centre of Competence for development of parts for automotive industry.

The selected sub-thematic priority areas under this TPA are presented in the chart below.

**Figure 29 Transport and mobility sub-thematic priority areas**

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| Added value manufacturing of road and rail vehicles parts and systems |
| Environment friendly transport solutions |
| Intelligent transport systems and logistics |
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5.2.3.2. **STPA 1. Added value manufacturing of road and rail vehicles parts and systems**

Representing the first pillar of this STPA, the automotive industry is a very competitive industrial sector as it is stated in Analysis. It is almost entirely composed of the parts suppliers. Since real competition in all automotive sub-sectors is global rather than local, Croatian automotive component parts producers face tough competition and are greatly dependent on global developments. The development of the Croatian automotive industry was based on a very diversified range of products and on inherited expertise and a strong tradition in the sectors that provided support to the automotive industry.

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112 „Preparation of Future Programming Documents and Accompanying Project Pipelines (EuropeAid/131491/D/SER/HR)“
components manufacturing such as metal processing and metal tool production, plastic product manufacturing, glass product manufacturing and textiles. Advantages of the automotive industry in Croatia include highly educated work force, excellent infrastructure, as well as proximity of market and facilities for the production of vehicles of West and Central Europe.

Croatian companies dealing with the production of automotive parts (AD Plastik inc., LTH Metal Cast lijev ltd., Lipik Glas ltd., Boxmark Leather ltd., etc.) have a tradition in high-precision manufacturing with zero tolerance for breakdowns and the main competitive advantage is the excellent quality of their products. Over three quarters, the added value in the automotive industry is realized in the production of components for installation and activities related to the development of vehicles and related processes.

As for the Croatian industry of rail vehicles, significant production potential exists in several firmly established companies: Končar Electric Vehicles Inc., Gredelj Rolling Stock Factory, Đuro Đaković Transport and Altpro Ltd which, together, employ approximately 1100 employees. These companies are involved in the development, production, modernization and maintenance of various (mostly electric) rail vehicles, such as: low-floor trams; electric trains; electric multiple units and rail freight wagons. In addition, these companies are involved in various activities supporting equipment and components for electric and other vehicles.

5.2.3.2.1. RDI capacity in industry

Many companies in this field conduct R&D activities (e.g. AVL ltd., ALTPRO ltd.) such as development of instrumentation and test systems, powertrain engineering and advanced numerical simulations in the field of state-of-the-art internal combustion systems. Significant levels of innovation were introduced to Croatia by foreign companies (e.g. Yazaki, Saint-Jean Industries, Cimos, TDK-EPC, Boxmark ltd.) and domestic 1st Tier suppliers since they are active in the product commercialization process, jointly with innovation drivers. Very successful medium innovative company is HSTEC inc.in the area of robotic automation and drive technology development with the aim to improve the competitiveness of the production of parts for automotive industry.

At the moment, the private sector is leading the way regarding R&D, being the partner in over 50% of granted projects in this area, in the recent years. Producers in these niches very well know their interest and are willing to invest in specialized R&D activities primarily oriented to industrial research and experimental development.

Trend of switching investments in R&D from original car manufacturers to their suppliers directly affects automotive industry in Croatia (being almost entirely composed of the parts supplier). Compared to the original manufacturers of cars, the share of parts suppliers in the cost of R&D since 2007 amounted 30%, while it is expected that in 2020 this share will rise over 60%.

5.2.3.2.2. RDI capacity in academia

It is notable that very promising initiatives in the area of electric and mechanical engineering are conducted between universities and international global players through collaborative R&D projects. This refers to projects of Faculty of Mechanical Engineering and Naval Architecture, at University of Zagreb, conducted at several departments such as Department of IC Engines and Mechanical Handling Equipment and Department of Robotics and Production System Automation, resulting in industrial research projects with Jaguar and Ford. Another important institution that is quite active in this STPA is Faculty of Electrical Engineering and Computing whose project MAGEF \[113\] deals with permanent

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\[113\] Project is financed through ERDF (OPRC 2007-2013, SIIF2). http://magef.eu
magnet machine technology for boosting the energy efficiency in traction and marine applications. FLEXCHEV\textsuperscript{114} is yet another collaborative project of the Faculty (collaboration with Danish and Norwegian research institutions) designed to find solutions for flexible electric vehicle charging infrastructure. As Croatian project partners from the industrial RDI sector, KONČAR-Engineering and Transport Inc. and HEP Inc. also participated in the project. Furthermore, as a result of cooperation with universities and the position of Croatian suppliers within the automotive value chain, R&D initiatives are visible in the other selected fields of the automotive industry (navigation, telemetry, fleet management, ICT-based manufacturing). R&D related to rail vehicles is also conducted in academia (Faculty of Mechanical Engineering and Naval Architecture, Faculty of transport and traffic Sciences, University of Zagreb) and Končar Electrical Engineering Institute and already cited Faculty of Electrical Engineering and Computing). The last two mentioned institutions collaborate on a project Advanced technologies in electrical power plants and rail vehicles\textsuperscript{115} (project financed via ERDF, within OPRC 2007-2013), which aims at finding new knowledge and technologies with commercial application in power facilities and in rail vehicles.

Some of the emerging and expanding niches in this STPA being moderately high in complexity are related to vehicle accessories production and supply of automotive engineering services as a high value added activity. Resulting from exceptional competency levels within dedicated Croatian faculties, such engineering services are being sold abroad to OEM and Tier 1st operators with high quality cost ratios. Similarly, new and innovative auto related engineering services (e.g. navigation, fleet management and traffic control and energy systems) have the same characteristics in terms of demand and profitability. When it comes to automotive components suppliers, the potential for growth lies in the area of developing and investing in R&D fields related to products made of new lightweight materials as well as developing electronic components (carbon-fibre chassis and auto parts) and production of 1st Tier automotive components.

<table>
<thead>
<tr>
<th>Indicative RDI topics within this STPA are as follows:</th>
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<tbody>
<tr>
<td>- higher value-added automotive and railway components,</td>
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<tr>
<td>- reduction of impact to the environment, noise reduction</td>
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<tr>
<td>- increase safety and comfort,</td>
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<tr>
<td>- technology assisted driving (“drive by wire”)</td>
</tr>
<tr>
<td>- new technologies and equipment related to reducing CO2 emissions and more rational energy consumption vehicle accessories,</td>
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<tr>
<td>- new materials for automobile and railway industry needs,</td>
</tr>
<tr>
<td>- automotive engineering services, modelling and simulation of applications focusing on inclusion of next-generation materials into production processes and development of advanced manufacturing processes and system and technologies,</td>
</tr>
<tr>
<td>- propulsion, auxiliary power supplies, technologies related to railway</td>
</tr>
<tr>
<td>- development of modelling and simulation of applications focusing inclusion of next generation materials into production processes and development of added value products in automotive, railway and maritime sector</td>
</tr>
<tr>
<td>- advanced trams and trains and their components</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Connected indicative RDI topics under cross-cutting themes KETs and ICT are:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Advanced materials for high-strength/low-weight fiber-reinforced polymer composite materials and technical textiles and textile products for specialized industrial applications;</td>
</tr>
<tr>
<td>- Micro and nanoelectronics for solutions for adapting infrastructures to innovative transport means and lightweight vehicle embedded circuits and systems;</td>
</tr>
<tr>
<td>- Smart citizen solutions for environmentally friendly multimodal transport;</td>
</tr>
<tr>
<td>- Sustainable platforms for embedded HW/SW systems and components;</td>
</tr>
<tr>
<td>- Solutions for the planning and design of systems for contact or non-contact charging of batteries of</td>
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</tbody>
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\textsuperscript{114} http://flexchev.com/flexchev.htm|
\textsuperscript{115} http://fer-kiet.fer.hr/
5.2.3.3. STPA 2. Environment friendly transport solutions

The 2nd STPA provides a clear opportunity for Croatian science and research sector, as well as traditional and declining automotive and maritime industry, to turn to developing innovative solutions with strong commercial potential in this field and transform these sectors and bring a totally new competitive edge as green vehicles and vessels.

Specialized vehicle producers (e.g. Rimac Automobili ltd., Greyp Bikes ltd., DOK-ING ltd.), especially ones dealing with electric propulsion and mobility, are ones that Croatia tends to focus throughout this TPA. In that sense, projects already mentioned under first STPA, have some elements “belonging” to this one, especially in the field of energy efficiency in traction applications. Taking in the consideration the shifts on global markets and global value chains, Croatian specialized vehicle producers show potential in positioning Croatia as important player in future development of the automotive sector in electric mobility. Specialized vehicle producers are very much dependent on their creativity and ability to innovate. Their success comes from operational excellence in identifying and successfully filling niches that the market needs. Along with necessary investments and partnerships with foreign companies in developing and participating in establishment of regulatory framework for electro mobility, even more important will be to recognize and support this niche of automotive sector as most promising one. The importance of these companies is not only in their innovativeness and application of high-technology, but also in the fact that they produce finished products\textsuperscript{116}, concurrently supporting ecological and security aspects of the sectors and the economy in general.

Other pillar of the STPA relates to waterborne sector. Maritime (shipbuilding) industry is a key driver of sustainable economic development based on traditional knowledge, high-added value and complex production, export orientation with the positive trade balance, high employment and application of R&D and innovation. The production program of Croatian shipyards includes designing and building

\textsuperscript{116} Electrical vehicles such as XD from DOK-ING and Concept One from Rimac Automobili, de-mining vehicles from DOK-ING
all types of merchant ships, floating docks, cranes, special and naval vessels and generally all vessels according to customer requirements. Maritime sectors have focused on innovation not only in their own production but also by stimulating R&D and design activities among the entire chain of suppliers, hence playing an important role as integrators of innovative technology.

One of the key institutions in Croatian shipbuilding, Croatian Shipbuilding Corporation – Jadranbrod inc. (CSC) is corporative organization covering the coordination of the Croatian Shipbuilding Industry on the international shipbuilding market. Croatian Shipbuilding Corporation-Jadranbrod is a member of SEA Europe\(^{117}\), former CESA\(^{118}\), which among other activities, works on identification of thematic areas relevant for EU through European Technology Platform WATERBORNE.\(^{119}\) However, the main activities in EDP process were covered through Maritime CCC, established by the Ministry of Economy in 2013. This CCC gives clear directions and R&D investment inputs for Maritime (shipbuilding) industry. Besides CCC, there is as well active Pro Rail Alliance, a non-profit and independent organization that promotes environment-friendly and safe rail transport, consisting of 15 non-profit organizations (mostly trade unions, professional associations, organizations that are helping to protect the environment) and 31 company in the railway sector\(^{120}\).

Furthermore, it is important to mention development of autonomous vehicles (underwater and surface), a new area in which Faculty of Electrical Engineering and Computing Zagreb is active. This interdisciplinary area, combining the above mentioned manufacturers of specialized vehicles, the maritime industry and shipbuilding, is experiencing a major global boom.

5.2.3.3.1. **RDI capacity in industry**

Companies already mentioned in STPA1, involved in production of specialized vehicle producers, with their innovativeness and application of high-technology, participate in EU funded projects (e.g. DOK-ING ltd. in the field of optimised and systematic energy management in electric vehicles\(^{121}\), or Rimac Automobili ltd. in Hybrid Battery Pack project\(^{122}\)). In the waterborne sector, the concentration of the RDI activities lies within the largest companies whose products are the result of their own R&D capacity. Among them, the most successful in terms of granted FP projects, is Uljanik Inc. It is participating in various projects in fields ranging from energy efficiency of ships to productivity improvement of shipyards. some of these projects are for example GRIP (green and innovative propulsion), SMARTYARDS (smart technologies for advanced productivity of European small shipyards), SHOPERA (energy efficient ship navigation), DE-LIGHT TRANSPORT (development of light modules for transport systems).

Among the most prominent research oriented SME’s in this sector is SME like Alveus Ltd which was one of the partners in 5 EU R&D projects: CO-PATCH (composite material repairs and patching), ULYSSSES (ultra slow ships), MOSAIC (naval materials), ADAM4EVE (smart adaptive materials and ship constructions), and SAFEWIN (safety in winter navigation and dynamic ice).\(^{123}\)

5.2.3.3.2. **RDI capacity in academia**

The top ranking public research organizations in this STPA are Faculty of Mechanical Engineering and Naval Architecture - University of Zagreb, Faculty of Engineering – University of Rijeka, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture – University of Split and

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\(^{117}\) Ships and Marine Equipment Association  
\(^{118}\) Community of European Shipbuilding Associations  
\(^{119}\) http://www.waterborne-tp.org  
\(^{120}\) Participates in FP7 project LivingRAIL  
Brodarski Institute with numerous FP6 and FP7 and national technological projects in this field. Based on the data from CORDIS\(^{124}\), they participate in 11 shipbuilding R&D projects financed within FP5, FP6 and FP7 programs: Composite Patch Repair for Marine and Civil Engineering Infrastructure Applications, Tools for Ultra Large Container Ships, Ultra Slow Ships, Green Retrofitting through Improved Propulsion, Materials Onboard: Steel Advancements and Integrated Composites, Adaptive and smart materials and structures for more efficient vessels, Developing Smart Technologies for Productivity Improvement of European Small and Medium Sized Shipyards”, Energy Efficient Safe Ship Operation, Safety Of Winter Navigation In Dynamic Ice, Design of improved and competitive products using an integrated decision support system for ship production and operation, Developing lightweight modules for transport systems featuring efficient production and lifecycle benefits at structural and functional integrity using risk based design production and lifecycle benefits at structural and functional integrity using risk based design”. National reference laboratory for emissions works closely with the sector of automotive industry in efforts to support implementation of EU environmental and protection legislatives and enable better research studies and prototypes in designing engines and sub systems with internal combustion (future Centre of Competence for internal combustion engines and motor vehicles).

Furthermore, major research achievements of Faculty of Electrical Engineering and Computing in the area of autonomous vessels (surface and underwater) should also be mentioned, as well as the related navigation, management and control systems. In last 10 years Faculty of Electrical Engineering and Computing participated in implementation of more than 13 international projects related to the subject, mostly within Laboratory for underwater systems and technologies (LAPOST). Some of these projects include development of autonomous waterway system for boats towing (FP7 SME project CART), development of advanced systems for management of autonomous vessels etc.

Based on listed projects, it is evident that current R&D activities mostly cover innovative design procedures, technologies and materials on specialized and high value ships. Most FP7 projects with Croatian participants in the field of transport were related to technologies and solutions for maritime and inland waterways transportation. Also, this field has proven collaboration between research organizations and shipyards. In the past, Brodarski Institute ltd. was leading institute for development of special purpose vessels including frigates, missile corvettes, new mine countermeasures vessel landing crafts and patrol boats. Lately, research organizations conduct R&D projects important for development of more sophisticated technologies providing new directions for development for Croatian shipyards, in order to increase their competitiveness on global market.

5.2.3.4. **STPA 3. Intelligent transport systems and logistics**

5.2.3.4.1. **Sector overview**

Several major challenges (road traffic congestion, road transport related CO2 emissions, road fatalities) have to be overcome for Europe’s transport system to play its full role in satisfying the mobility needs of the European economy and society, making the main policy objectives for transport and travel cleaner, more efficient, including energy efficient, safer and more secure. These challenges are, as well, applicable to Croatia. Response to those major challenges cannot be limited to traditional measures and innovation will have a major role to play in finding appropriate solutions for the Union.

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Intelligent Transport Systems (ITS) integrate telecommunications, electronics and information technologies with transport engineering in order to plan, design, operate, maintain and manage transport systems. The application of information and communication technologies to the road transport sector and its interfaces with other modes of transport will make a significant contribution to improving environmental performance, efficiency, including energy efficiency, safety and security of road transport, including the transport of dangerous goods, public security and passenger and freight mobility, whilst at the same time ensuring the functioning of the EU internal market as well as increased levels of competitiveness and employment. Advances in the field of the application of ICT to other modes of transport should now be reflected in developments in the road transport sector, in particular with a view to ensuring higher levels of integration between road transport and other modes of transport. The challenge is to come up with new, efficient, affordable, safe, secure and accessible solutions taking advantage of the ever growing connectivity of people and objects, the availability of European GNSS based location, the advances in cloud computing, big, linked and open data and the propagation of Internet and social media, that will help solve the mobility problems European citizens and businesses are facing today. Indeed, 'Big Data' management (availability, collection, storage, distribution and use) will progressively become a major challenge in intelligent transport communications as will the wider issues related to data ownership, user acceptance and privacy concerns.

In recent period, motorway construction programme was especially significant for the development and implementation of ITS in the Republic of Croatia. However, one must recognize a certain lack of systematic approach at the state level (lack of legislative framework, lack of appropriate guidelines, failure to use appropriate cost/benefit analysis and other „tools“) causing reduced system interoperability (Electronic Toll Collection), increased maintenance costs (surveillance), poor coordination on the entire road network in Croatia and coordination towards neighboring countries (the absence of a national Centre for traffic management), lack of intermodal solutions, etc. Unfortunately, the situation is much worse on the level of state and other roads, as well as in urban traffic.

Croatian Standards Institute Technical Committee - HZN/TO 524 (Road transport and transport telematics) is responsible for standardisation in the field of road telematics, information, communication and control in urban and rural road transport, and for setting standards in the field of ITS. Work of the Committee includes especially intermodal and multimodal aspects, passenger information, traffic management, public transport, commercial transport, emergency services and commercial services in the field of transport information and control systems.

Another significant changes in ITS development after the accession of the Republic of Croatia to the EU is due to mandatory harmonization of Croatian legislation with that of the EU. Introduction of ITS in the Roads Act and especially the foundation of the National Council for development and implementation of ITS in the Republic of Croatia established for the first time the real "infrastructural organisational basis" for efficient development of all ITS aspects. Recognition of interests of Croatian economy, particularly of corresponding industries, is certainly of special importance. ITS development fits very well into a recently popular syntagma of "reindustrialization of Croatia". The domain of ITS offers a possibility of involvement of Croatian industry providing products and services of high added value.

126 The priority areas for the development and use of specifications and standards set by the Directive 2010/40/EU are Optimal use of road, traffic and travel data, Continuity of traffic and freight management ITS services, ITS road safety and security applications, Linking the vehicle with the transport infrastructure.

127 So far, the Committee has adopted a large number of documents from this area of standardisation, which provide basic information for the road sector and economy from this area, e.g. National Programme for the development and deployment of Intelligent Transport Systems in road transport for the 2014-2018 period.
The latest breakthroughs in building and modernisation of motorways and other segments of transport infrastructure put the Republic of Croatia at the top position in the region in terms of traffic management systems on high-speed and other roads, safety systems and protection on roads and road structures (especially tunnels), etc. Modern ICT technologies implemented on all Croatian motorways and some more important high-speed roads (Rijeka and Split region) enable further progress towards integration of road infrastructure as a significant step in development of harmonised traffic management in the country, region and wider. Given that the implemented technology is to a large extent a product of domestic industry, effects of building and modernisation of motorways and other transport infrastructure is a respectable increase of SMEs active in the field of road telematics equipment, through the following: research and development, design, production, installation, and maintenance of telematics systems of different functionalities. Certain Croatian companies have specialised in delivery of fully integrated technological solutions for advanced traffic management on motorways, in tunnels and in cities. Numerous projects were successfully completed in Croatia, but also in more than 30 countries in the region and worldwide (Austria, Russia, Ukraine, USA, etc.).

In close future, it is necessary to develop a concept of a public-private partnership through joint, co-operative activities of public and private sectors in development and implementation of different systems, as well as in provision of various services in the field of Intelligent transport systems. The result of a public private partnership in this area should be a faster, more economical and more effective application of ITS and its services in the Republic of Croatia. In doing so, it is especially important to establish a system of traffic data management (primarily real-time data), in order to enable particular providers of traffic and transport information exchange services the development of their services and applications in this area.

5.2.3.4.2. RDI capacity in industry

The most notable examples of subjects in the field of ITS include several companies which are internationally recognized. Telegra Ltd. as global company (Europe, USA, Asia, Africa) provides complete ITS solutions (advanced traffic management systems and tolling systems) for highways and tunnels based on their own software components and core equipment. TEB Engineering Inc. Zagreb – consisted of several companies: TEB Automatika ltd. offers equipment and solutions for process control and monitoring (process instrumentation, low voltage distribution and motor control centers, PLC and HMI), communication networks, SCADA systems. LED Elektronika offers systems of road weather stations – fixed and portable, automatic traffic counters – fixed and portable, variable light signs, road traffic stations. TEB Informatika ltd. has a long experience and references in the establishment of a modern, efficient, computer-supported system of road network management in the Republic of Croatia. ZG Projekt ltd. and Promel ltd. are companies specialized in projects in the area of traffic control, organization of traffic, traffic signalization and engineering, traffic-information systems, systems of remote management and control, light signaling (traffic lights), construction projects, architecture of road toll passages and related facilities, electrical installation and toll collection systems. Ericsson Nikola Tesla was a member of the pan European project HeERO (Harmonised eCall EuRopean pilOts), which has successfully evaluated and validated the eCall service set norms and specifications within the national pilot-projects framework.

Company ORYX has developed “Travel Angel”, first innovative smartphone application in Europe, which automatically detects if a vehicle had an accident and automatically dials the emergency services number (ambulance, roadside assistance, police and firefighters), based on changes in speed, noise in the vehicle and other parameters. “Travel Angel”, as well, shortens the waiting time for emergency interventions to a minimum by providing to emergency services the exact location of the vehicle.

128 National Programme for the development and deployment of Intelligent Transport Systems in road transport for the 2014-2018 period
When it comes to public research institutions, the Department of ITS at the University's Faculty of Traffic and Transport Sciences carries out research in the field of architectures, technologies, services and tools for advanced traffic and transportation management. The most significant part of research activities in the last period was financed within the programme of the Ministry of Science, Education and Sports, covering various themes (general ITS models and their modal mapping, methods of development of integrated Intelligent transport systems and of integrated adaptive transportation logistics systems. This Faculty is a partner in the few FP7 projects aiming to build a new ITS architecture that is less centralized than its predecessors, like Intelligent Cooperative Sensing for Improved traffic efficiency (ICSI), or to optimize the range and energy efficiency of 'fully electric vehicles' (FEVs) through an integrated ICT system which uses information from drivers, vehicles and transport or energy infrastructures to provide trip planning and routing that optimizes energy charging and discharging opportunities. Projects of Faculty of Mechanical Engineering and Naval Architecture and Faculty of Electrical Engineering and Computing, University of Zagreb and Faculty of Maritime Studies, Faculty of Rijeka are also contributing to development of intelligent transport systems, as well as Faculty of Civil Engineering or IGH with two projects related to road infrastructure maintenance, monitoring and management. Other projects, like VISTA aiming at developing computer vision innovation for safe traffic, or SORDITO, dealing with system for route optimization in dynamic transport environment, were financed through IPA-ERDF. Some were implemented through SEE TCP, like SEE ITS, or through COST, like project “Towards Autonomic Road Transport Support Systems” , “Scientific and technical innovations for safer Powered TwoWheelers” and “Social Network and Travel Behavior”.

Indicative RDI topics are as follows:
- smart and secure mobility and logistics;
- innovative transport and logistics services;
- cooperative systems;
- intelligent urban mobility;
- Equipment, systems and applications for traffic monitoring, management and control incident management systems;
- multimodal all cargo logistic chain;
- advanced embedded positioning and navigation;
- surveying graphics systems with wide range of applications (LIDAR technologies);
- integrated electric transport systems and infrastructure;
- Development of systems, applications and products for early warning in traffic, logistics and transport

Related indicative RDI topic under cross-cutting themes  KETs and ICT are:
- KETs for E-propulsion and widespread E-mobility;
- KETs for advanced broadband wireless communication;
- micro and nano electronics for multimodal all cargo logistic chains;
- process and embedded computer automation and control processes;

130 http://www.ict-icsi.eu/
131 http://siif2.com/siif/eng/vista/
132 Aim of this project is to develop algorithm for optimization of routes distribution plan which will be, respecting the time component, more precise and avoid congestion and deal with real economic issue: delays in delivery services that have impact on business and stability of the company. It is estimated that companies that provide delivery services with use of this algorithm will cut down their costs for transportation up to 30%. Additional benefits: less congestion, increased security of traffic participants, saving fuels, less exhaust emission.
133 Intelligent Transport Systems in South East Europe,
134 http://www.cost.eu/COST_Actions/tud/Actions/TU1102
5.2.3.5. Expected synergy of economy and RDI and potential for TPA further development and structural changes

With its geographic position, Croatia has a tremendous potential regarding development of transport and mobility for its growth and development. Due to favourable and to some extent developed transport infrastructure and expected future investments in this sector, in terms of modernizing infrastructure and traffic safety (demand side), it is expected for new products and services coming out of scope of this TPA to be relevant generators of economic development.

Transport and mobility as a smart specialization TPA can provide growth opportunities and support to transformation of traditional and declining automotive and maritime industry through diversification and transition changes to new domains, such as Tier 1 supplier and OEM (electric car) and green boats production. Additionally, Croatia in this TPA has potential to support certain R&D niches that concern developing smart equipment, services to improve transport and mobility and improving safety and security by developing new concepts of freight transport.

Current ship and port security EU standards, together with other relevant legislation, provide an opportunity for Croatian transport sector to find new specialization niches (e.g. incorporation of security standards and new ship design to respond to piracy incidents) and for the use of autonomous waterway systems, underwater and on surface). Furthermore, RDI topics under this TPA relate to few of the societal challenges - Smart Cities and Communities, Mobility for Growth, Green Vehicles and deal with different problems that Croatian cities are facing, like fast motorisation, capacity problems in public transport, infrastructure renewal and rapidly changing cityscapes. ICT applications and services will be used as support the development in this and other areas that have substantial potential, like ITS, which integrates various sectors. The application of ICT to the road transport sector and its interfaces with other modes of transport will make a significant contribution to improving environmental performance, efficiency, including energy efficiency, safety and security of transport. The use of robotic technology in the field of autonomous marine vehicles will significantly contribute to positioning Croatian in this rapidly growing development area.

5.2.4. Security

This thematic priority area is in line with several key strategic documents: Long-term plan for the development of Croatian Armed Forces, National mine action strategy (2009-2019), National Security Strategy and National Strategy for Cyber Security (currently in the process of adoption). Security emerged as one of the TPAs for smart specialization in Croatia through the well guided and focused process of entrepreneurial discovery. While rising security issues present in both EU and Croatia create demand and favourable conditions for the development of products, services and solutions, verifiable statistical data in the Analysis chapter clearly show Croatian capacities in that field and justify the intention to further strengthen this specific area. Existence of few global players (such as company HS Product ltd.) indicates potential of this priority area in Croatia.

This TPA is based on widely ranged industrial sectors – mainly focused around defence related producers, mine action companies and ICT companies intending to invest and develop cyber security related fields. Its competitiveness is based on focus to produce and integrate high-tech innovative

| - fixed and mobile broadband infrastructure and high-bandwidth optical network |
| - Multimodal routing and optimization, monitoring and planning of transport;  |
| - embedded broadband communication payload and high bandwidth optical networks;  |
| - Internet of Things and Big Data and cloud solutions in transport;  |
| - Computer vision and machine learning with application in the field of Intelligent Transport Systems and Logistics. |
products and/or associated services of high added value. This orientation results from the very nature of this thematic area (Security), which does not tolerate unreliable products and services for the market.

Emerging new technologies in the aerospace and defence industries significantly contribute to the development of novel products for civil markets. Despite this fact, clear methodical classification of the Security industry on EU level\textsuperscript{137} is lacking for the following reasons: the security industry is not covered as such by the main statistical nomenclatures (NACE, Prodcom, etc.); the production of security-related items is hidden under a wide range of headings; statistics for these headings does not distinguish between security and non-security related activities; there is no statistical data source available at European level from the industry itself. These reasons apply to Croatia as well.

Two CCCs and one business cluster relevant for this thematic area have been established: (1) CCC for defence industry\textsuperscript{138}, (2) ICT cCCC (3) Cluster for humanitarian demining ltd\textsuperscript{139}. Competitiveness cluster for defence industry was the main tool in the entrepreneurial discovery process related to this TPA. The aim of this cluster is to upgrade current technological capabilities of its members and to foster future innovation development in Security related R&D\textsuperscript{140}.

An important feature of TPA Security is that it links implementation areas for products/services arising from numerous industrial branches and sectors such as: energy (SCADA systems Security – KONČAR Group); tourism (ICT applications related to Security of people – Security cards for banks – COMBIS ltd.); traffic (ICT traffic applications for highway control of traffic density – Projektura ltd.) and transport (Port security, Aquamarine protection of seaports), etc.

Product portfolio for this TPA covers areas of production and industry sectors organized around the following market niches: (1) protective clothing and equipment, (2) complete integrated ICT systems and sub systems, (3) mine action solutions and products and (4) integrated security related products, services, applications.

Selected sub-thematic priority areas (STPAs) under this TPA emerged as a result of the entrepreneurial discovery process (EDP). During EDP, more than 100 key players gathered around the Competitiveness cluster for defence industry identified sub-thematic priority areas of mutual interest to both the business sector and the science community. Identified STPAs are presented in the chart below:

\textbf{Figure 30 Security sub-thematic priority areas}

\textsuperscript{137} source: EU Security Industrial Policy- Action Plan for an innovative and competitive Security Industry
\textsuperscript{138}http://www.aid-invest.hr/wp-content/uploads/2013/12/Obrambena-industrija-Analiza-PRIKAZ-I-MOGU%C4%86I-SMIEROVI-RAZVOJA.pdf
\textsuperscript{139}http://www.cluster-demining.hr/home/index.php
\textsuperscript{140}http://www.aid-invest.hr/wp-content/uploads/2013/12/Obrambene-industrija-Strate%C5%A1%2C-1ke-smjernice.pdf
5.2.4.1. STPA 1. Cyber security

The 1st STPA Cyber security is mainly focused on development and research investments in several areas/niches where Croatia intends to upgrade its current level of technological capacity, human resources and expertise.

Cyber security is a fast growing field worldwide due to great and ever increasing reliance of society on networking and information systems. Croatian Government recognized this area as important and has set up a strategic framework for cyber security within the National Strategy for Cyber Security with Action plan (OJ 108/15). The Draft Strategy identifies the following fields of importance: public electronic communications; e-government; financial electronic services; critical infrastructure and crisis management; cyber-crime; data protection; technical coordination; international cooperation and education; R&D and awareness campaigns in relation to cyber and information security.

ICT is, without a doubt, the basic support service for cyber security. Since information security is a very broad area and companies in the ICT sector cover only certain parts of security services (as part of their overall market operations), it is hard to present the exact number of ICT companies covering security related R&D and services.\(^\text{141}\)

During the S3 entrepreneurial discovery process, entrepreneurs already working in the field of cyber security started networking to exchange ideas, establish testing facilities, identify industry needs, etc. In order to strengthen their initiative, University of Zagreb, with the support of MIPRO Croatian Society encouraged other institutions to join in and gathered around 150 ICT companies and different institutions (research organizations, government agencies, financial institutions). This is a continuous process and new companies interested in the cyber security field are being detected, mostly smaller enterprises with very few larger companies. Some of them recently established departments dedicated to cyber security research, services and/or products development. This reflects their strategic direction towards development in this field. It is evident from the data presented in the analysis\(^\text{142}\) that there are companies in Croatia already operating in the cyber security field, which are economically healthy and are investing in expanding their cyber security business.

Potential for development of the cyber security industry in Croatia lies on the demand side, as well. The main driver of its growth in the past 10 years has been the financial sector that has strict information security requirements, imposed by the Croatian National Bank. Other drivers are security

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141 In 2012 ICT sector in Croatia employed 31.388 employees in 4215 companies; it is anticipated it will grow by 10% annually (Croatian Industrial Strategy).
142 Analysis chapter, subchapter 2.2.7.
sensitive government institutions (like intelligence services, military and police), as well as health services, telecommunications industry, insurance industry, etc. There is a heavy push for different services provided by the Government to become accessible via the Internet, thus creating huge risks for their misuse. Furthermore, for the last several years, Croatia experienced a number of cyber-criminal incidents that made society more aware of cyber threats as an important societal issue. All of this has generated demand for cyber security solutions for quite some time, with this trend accelerating and spreading into other areas.

5.2.4.1.1. RDI capacities in industry

Companies producing highly technological products and services, such as those involved in cyber security R&D, are not sustainable without research and development support. While some companies are large enough to have their own R&D labs (like Combis), the majority are too small and must outsource those activities. This creates great potential for synergy with public research organizations. Reversing Labs ltd is an SME operating mainly on US and EU markets, specializing in malware reverse engineering. It also develops markets and sells a product created for the protection of networks. InSig2 ltd, which successfully operates on EU and Middle East markets is specialized in digital forensics, with emphasis on educational and consulting services in this field. InSig2 ltd. won a NATO international tender for the education of police forces in digital forensics. Končar KET is an internationally renowned large company operating in the power industry that heavily uses SCADA systems.

5.2.4.1.2. RDI capacities in academia

Research capacities in the field of cyber security are scattered between several faculties and research institutes: Laboratory for information security and Privacy at the Faculty of Electrical Engineering and Computing, and Laboratory for Open Systems and Security, Faculty of Organization and Informatics, both of the University of Zagreb. These laboratories grouped and unified research resources of both faculties and now act as a catalyst for further research in the field of cyber security. Furthermore, several groups performing R&D in cyber security related research areas are working at the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, at the University of Split, and several more at the University Josip Juraj Strossmayer in Osijek and the RBI (e.g. random number generator). A number of other institutions are performing R&D, such as the National CERT (Croatian Computer Emergency Response Team) as a subdivision of CARNet, or Information Systems Security Bureau (it has a primary role of a CERT for government institutions), as well as SRCE as a central infrastructure for scientific and education community of Croatia.

Different aspects of cyber security are covered by following universities: technical (Faculty of electrical engineering and computing or Faculty of Organization and Informatics, both of University of Zagreb, or Faculty of Mechanical Engineering and Naval Architecture, University of Split), mathematical i.e. cryptography (previously mentioned faculties as well as studying mathematics on

143 Analysis chapter, subchapter 2.2.7.
144 http://reversinglabs.com/
145 http://www.insig2.hr/
146 http://www.koncar-ket.hr/en/
147 lisp.fer.unizg.hr
148 http://www.foi.unizg.hr/lab/foioss
149 http://www.cert.hr/en/start
150 Croatian Academic and Research Network plays a crucial role in the area of national cyber security providing spam, virus and malware detection and cleaning, while also raising general security knowledge in the academic community and the general population. Furthermore, they contribute to ACDC (Advanced Cyber Defence Centre) European project for antbot detection. CARNet is also a member of the large-scale Géant project.
151 https://www.zsis.hr/default.aspx?id=30
152 Through its role of AAI@EduHr coordinator, SRCE plays a key role in trust and identity area. SRCE is the main computing centre and the architect of the e-infrastructure, covering both the University of Zagreb and the whole research and higher education system.
Faculty of Science, University of Zagreb) or legal or economics aspects of cyber security (Law faculty and Faculty of Economics, respectively) as well as several specialists studies offered by University of Zagreb: Specialist study of Information security\(^{153}\) on Faculty of Electrical Engineering and Computing and Specialist study of management of Information Security and Audit\(^{154}\) on Faculty of Organization and Informatics.

According to the SCIMAGO analysis (2015), in the period 1996-2014 Croatian researchers published 5449 citable documents in all scientific disciplines involving Computer Science, ranking Croatia at 9\(^{th}\) place out of 22 other Eastern European countries, involving large countries like the Russian Federation. Quality of those articles has been evaluated based on the number of citations and h-index, ranking Croatia at 10\(^{th}\) place.

Croatia received 7 research projects through the FP7 Cooperation scheme, related to the Security topic. Those projects were mostly related to physical security related topics. Some of them are: National Advanced Cyber Defence Centre project\(^{155}\) (CERT); New methods for verification of security and privacy mechanisms in e-commerce and e-government systems (Faculty of Electrical Engineering and Computing); Open Systems for Energy Series (KONČAR-KET ltd.). According to a summed report for Croatia listing the participation of Croatian science R&D projects, it is notable that the Security area was included in identified research topics with a notably high 4.6\% of total budget dedicated to FP7 projects (5th place among overall sector overview of FP7 funds withdrawn).\(^{156}\)

<table>
<thead>
<tr>
<th>Indicative RDI topics under this STPA ((^{153}))</th>
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<tbody>
<tr>
<td>- cyber space monitoring systems;</td>
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<tr>
<td>- Security of IT systems;</td>
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<tr>
<td>- crypto security communications systems – tailored to EU/NATO standards;</td>
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<tr>
<td>- Security of SCADA systems;</td>
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<tr>
<td>- digital forensics;</td>
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<tr>
<td>- development of tailor made systems for security education.</td>
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<tr>
<td>- Cloud computing security</td>
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</table>

Associated **indicative RDI topics under cross-cutting themes KETs and ICT are:**

- KETs for tools and techniques for the cyber security including wireless security, cloud security and privacy, and autonomic network defence;
- KET’s - Micro and nano electronics for embedded circuits and systems for severe operational conditions and high autonomy and communicating devices and secure and dependable communication platforms and IT infrastructures and services, relying on cryptography, authentication, authorization and accounting methods;
- Computer vision and machine learning with application in the field of cyber security

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\(^{153}\) [www.fer.unizg.hr/infosig](http://www.fer.unizg.hr/infosig)

\(^{154}\) [http://www.foi.unizg.hr/studiji/spec/usris](http://www.foi.unizg.hr/studiji/spec/usris)

\(^{155}\) [http://acdc-project.eu/](http://acdc-project.eu/)

The 2nd STPA Defence “dual use” is especially represented through one of the most important segments for this TPA, defence industry (producers and suppliers of special purpose products). Croatian defence industry represents a very important part of this TPA, since the producers under this industry sector represent a very strong industrial base oriented towards high tech products with high added values. Export orientation of highly sophisticated products and services is the main interest for companies operating within the defence sector\textsuperscript{157}. This base is supported by skilled and experienced human resources in technical sciences and fields of expertise related to technology development. Some of the referent examples are: Armored vehicles of various applications – e.g. military, police, robotic platforms in demining, border surveillance through drones, autonomous vessels (surface and underwater) for surveillance of maritime borders, CBRN solutions and shipbuilding (Police force border security ships, small anti-terrorist naval ships, submarines).

Numerous companies that fall under the category of defence suppliers are coming from various industry sectors. Very few of these companies are oriented strictly towards production of only military goods and services. Most of them are oriented towards production of dual-use products/services/technologies\textsuperscript{158}. This STPA represents the connector and implementation areas for products/services arising from various Croatian industrial branches and sectors.

Due to the constant decreases in defence expenditures across the EU (Croatia especially), rising technology costs and difficulties for sustainable investments in the defence sector, companies that include both defence and commercial arms, are recognizing the necessity to invest in commercial R&D (connected to their defence program). Numerous examples support good practices in which military technologies find their applications in civil purposes and other way around (e.g. carbon fibres started in military purposes and ended in multiple civilian purposes). Through investments in “dual-use” technologies and exploitation of its strong defence industry sector Croatia wishes to invest in all technologies and production capabilities that are essential to maintain and foster its competitiveness. Europe still suffers from legal and psychological barriers between civilian and military research – barriers that our competitors do not have (for example USA and BRIC countries)\textsuperscript{159}. These limitations seriously hamper our capability to “cross-fertilise” developments from both worlds. This is something that Croatia is willing to test and bet on in further investments.

In such perspective, enterprises providing dual-use technologies are driving a strong impact on economic, social and environmental development of Croatia. Since technology is increasingly becoming dual in nature, there is identified considerable potential for synergies between civil and defence research.

A very important additional benefit for this STPA is that it provides solutions and new strategic directions for declining industry sectors (e.g. textile industry orientation towards products and solutions in protective clothing and anti-riot program – certain companies in Croatia already specialize in various solutions for Anti-riot program: CROSHIELD ltd., KROKO International ltd. and MADLERD ltd., while shipbuilding turns towards investments in segments of developing and incorporating advanced automated production in current business processes).

The Competitiveness cluster for defence industry adopted “Development directions of defence related industry in context of RDI”\textsuperscript{160}. This Analysis and presentation serve as the key documents in the EDP process and provide clear goals and directions for RDI investment in this STPA.

\textsuperscript{157} Analysis chapter, subchapter 2.3.5.
\textsuperscript{158} http://www.morh.hr/hr/zakoni-i-strategije/cromil/book/25-croatian-defence-industry-catalogue-2015/1-publikacije.html
\textsuperscript{159} The issue has been acknowledged at the highest level: in December 2013, the European Council itself tasked the European Defence Agency and other bodies to better exploit civil-military synergies.
\textsuperscript{160} http://www.ainvest.hr/konkurentnost/obrambena-industrija/upravni-odbor/
5.2.4.2.1. RDI capacities industry

In this STPA Croatia has some strong and global leaders: HS Produkt ltd., Šestan-Busch ltd. (world leader in production of protective gear – mainly helmets and anti-riot program for police forces), DOK-ING ltd.(robotics and unmanned vehicles), Adria-Mar ltd. (project engineering, production, repair and related services in special purpose ship building – e.g. submarines, small anti-terrorist forces naval ships). These companies present a significant opportunity since they strive to integrate various components into their final products, hence providing a window for companies entering their future supply chain to develop complementary products and services.

Existence of strong companies presents a powerful push effect for investments in business R&D since they are used to investments in new products and solutions, presenting market trend setters with capacities to the direct sector and setting new value chains in completely new directions. Some of these companies have their own development departments (HS Produkt, DOK-ING. ltd., Brodaraki institute ltd., etc.), which gives additional potential for synergies and collaboration for this STPA.

A good indicator for the right selection in specialization in “dual use” technologies represent the EDA 2014 (European Defence Agency) call for R&D projects connected to “dual-use” technologies. In 2014, a total of 9 projects from Croatia applied. This is a 900% increase in comparison to 2013. According to a report published by the Ministry of Defence (which was National contact point and 1st round evaluation for the mentioned EDA call) all projects showed connection to public research institutions and involvement of SME’s as partners. This proved very high preparedness levels of a sector for the next level of specialization in various technologies, products, and services.

5.2.4.2.2. RDI capacities academia

RDI capacities in academia in this field are well covered by the most prominent research organizations mainly in the category of technical sciences. Most notable examples that can support certain identified R&D topics for future development are: Faculty of Electrical Engineering and Computing Zagreb in the field of in the area of autonomous vehicles and process and embedded computer automation and control processes (microcontrollers, sensors, lasers for positioning the object, PLC's, HMI's, SCADA systems), Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in multiple fields, but especially – (1) materials engineering (protective clothing and equipment); (2) automated advanced production (e.g. robotics, automated devices for dimensional control of static and dynamic measures), both at the University of Zagreb.

Several other research institutions are engaged in RDI identified topics: Faculty of textile technology (University of Zagreb), RBI, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (FESB), University of Split, Faculty of Chemical Engineering and Technology – Zagreb, Private institute – KONČAR ltd. Zagreb, Polytechnic of Zagreb, Institute of Physics, research centre for metals in the Region of Istria – METRIS and numerous others. All listed here will provide support to industry stakeholders in identified development goals and R&D topics. It is important to mention that strategic guidance and additional support will be given through collaboration with the Croatian Defence Academy „Petar Zrinski“ – Centre for Defence and Strategic Studies.

Chair for polymer processing (CPP) as a part of the UNIZAG FSB (Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb) is oriented on research and projects from the field of polymer processing and equipment for polymer processing. In those projects the main tasks are usually the development of new polymeric products as well as appropriate tools for their production (moulds). This targets and involves defence oriented companies which strive to solutions in recycling (namely – new advanced materials that are currently using e.g. Aramid polymers), reactive armours for de mining vehicles and special purpose vehicles, new materials for coatings (graphene and/or nano coatings). The topic of EUREKA project E! 2819 – FACTORY ECOPLAST (2002-2005) was the development of wood-plastic composite (WPC) suitable for injection moulding. This field is of particular interest to companies operating with polymers (like Šestan Busch; DOK-ING; Đuro
Another CPP Project was "Innovative Collecting and Recycling Scheme for Plastic and Advanced Polymeric Materials" with the main objective to enable economically viable recycling of advanced polymeric materials all over Europe (Finding Global Solution for Defence related industry obtaining massive production wastes out of Aramid polymers).

University of Zagreb Faculty of Textile Technology (TTF) and its Textile Science Research Centre (TSRC) have strength and knowledge to support industrial development of advanced textile materials (ATM) for security purposes, in particular for dual-use purposes. TTF was in charge of introducing novel and durable eco-driven surface modification processes in textile production, complemented by the risk analysis and sustainability issues, together with the recyclability of newly developed product without significant environmental burden. Developed innovative textile products are directed towards the needs of the following industries: textile/clothing/leather/footwear, defence (protective clothing/footwear), medical (medical textiles), wood (textiles/leather for furniture) and automotive (bio-composites and leather). TTF participated in the following projects: 1. FP7-REGPOT-2008-1-229801: T-Pot – Unlocking of Croatian Textile Research Potentials, 2. FP7-SME-2007-2-217809: SMILES – Sustainable Measures for Industrial Laundry Expansion Strategies: SMART Laundry-2015, 3. NMP-FP7-2010-3-4-1: MAPPIC 3D - One-shot Manufacturing on large scale of 3D upgraded panels and stiffeners for lightweight thermoplastic textile composite structures, 4. E!5785 FLAMEBLEND: Improvement in the flame retardant properties of cotton and wool blends, 5. COST Action MP1105: FLARETEX: Sustainable flame retardancy for textiles and related materials based on nanoparticles substituting, 6. COST Action TU 1011: Towards safer bicycling through optimization of bicycle helmets and usage.

### Indicative RDI topics under STPA Defence “dual-use” were identified:

- Materials engineering (protective clothing and equipment);
- Automated advanced production (e.g. robotics, automated devices for dimensional control of static and dynamic measures);
- Real-time aerial multispectral imaging solutions in connection to laser technologies (LIDAR);
- Advanced digital and communication technologies;
- Unmanned and automated remotely controlled systems for CBRN responses (EOD/IOD), natural disasters and technological catastrophes;
- Unmanned vessel (underwater and surface), kao Systems for surveillance of the maritime border and maritime traffic, as well as the prevention of ecological disasters;
- Process and embedded computer automation and control processes (microcontrollers, sensors, lasers for positioning the object, PLC’s, HMI’s, SCADA systems);
- Technological solutions for control and protection against the use of biological agents in terrorist purposes;
- Medical counter measures against CBRN & CW agents;
- Anti-riot program.

### Related indicative RDI topics under cross-cutting theme KETs are:

- ICT - Systems common management and control of resources and property in crisis situations;
- ICT - Solutions for the integration and interpretation of data from social networks and other mass data sources (Big Data) in geospace context;
- The integration of different sensor platforms in real-time into a single operating system image command;
- Inventory of the physical computer communications networks in the area along with the analysis of access, threats and needed protection;
- Computer vision and machine learning with application in the area of defence “dual-use”;
- KETs for wearable active textiles and clothing for improved human performance aimed at human safety and protection;
- KETs for active textiles with embedded sensing capabilities;
- KETs for satellite or drone-based wide area surveillance in air, land and water;
5.2.4.3. STPA 3. – MINE ACTION PROGRAM

The 3rd STPA is a specific emerging industry sub-segment Mine action program. In Croatia, it is very much supported through activities of SMEs, with very highly developed technological level of sophistication and capacities (human and material).

National Mine Action Strategy (2009-2019) gives clear prospects to the development of this area and future prospects in terms of real test polygon for future developed products and services. Current status of mine suspected areas in the Republic of Croatia amounts to 507,60 km2 and it is a result of humanitarian demining and general survey operations. Mine suspected area (MSA) covers 10 counties, i.e. 78 towns and municipalities contaminated with mines and unexploded ordinances. It is assumed that the MSA is contaminated with 61,254 mines.

Through years of active participation in the mine action program, due to the mines left over from the recent Homeland War, Croatia developed one of the most organized international demining systems that became a regional model. Croatia achieved widespread international recognition and reputation as a prestigious, well established and successful partner. Acquired knowledge, skills, competencies, capacities and contacts can therefore be transferred and used in countries facing mine problems, primarily due to the geographical position of Croatia in the wider Mediterranean area. Croatian enterprises operating within this scope of operations have developed world-class expertise and technological capacities for this type of operations. With activities in mine action Croatia is successfully present on all continents. Through the realization of cooperation, primarily through training activities, i.e. educational activities in the field of mine action, HCR-CTRO has opened further political and economic space in various countries.

5.2.4.3.1. RDI capacities industry

The most representative company operating within the Mine action program is DOK-ING Ltd. This is a Croatian global player in area of counter-mine activities. DOK-ING, in a few words, integrates its own innovations and new technologies, develops and manufactures special purpose systems to protect human lives in the most dangerous environments, primarily in demining, mining and fire-fighting. With numerous subcontractors involved in constant design of new products and innovation oriented management this company is the true leader in this area.

In addition to the usual services offered to resolve the specific mine threats, Croatian companies within this specific segment of the industry are developing technologically very demanding services and end products:

- KET (Photonics) - R&D theme: optical R&T&I capacities;
- KET Unmanned vehicle controls;
- KET – advanced composite materials and new material architectures with added functionalities;
- KET – coatings and surfaces with high scratch resistance/weatherability/self-repairing capabilities;
- KET - Embedded circuits and systems for severe operational conditions;
- KET - High resolution integrable 3D displays;
- KET - User-friendly human-machine interfaces;
- KET - High autonomy communicating devices;
- KET - Small scale embedded energy systems;
- KET - Process and embedded computer automation and control processes
- GIS, geo-physical analysis i geoprocessing,
- KET – technology for Physical and logical network inventory and for the spatial representation of the network and environment.
- Multi-purpose, integrated programs, systems, services and equipment for counter mine, explosive ordnance disposal (EOD), counter natural disaster resilience (prevention, reaction and restoration after disasters), and engineering;
- Remotely piloted aerial systems (RPAS), light manned helicopters, for multi-sensor, hyperspectral, thermal survey for mine action, natural disasters;
- Services of the aerial civil reconnaissance, surveillance, monitoring, survey for humanitarian mine action, in case of natural disasters (floods, landslides, torrents, forest fires);
- Deployment of new technologies (developed in research and technology development programs) into operations;
- Testing, evaluation and operational validation of new technologies for counter mine action, EOD, survey in natural disaster;
- Specialized training for new technologies in mentioned domains is continuous export service;
- Development of electronic learning at distance (e-learning) for EOD training.

5.2.4.3.2. RDI capacities academia

Croatian Mine Action Centre - Centre for Testing Development and Training ltd. (HCR-CTRO ltd.) is conducting activities of testing, training and R&D in the field of humanitarian demining.

Within the framework of R&D activities in mine action, Croatia is an example of successful co-operation between the scientific community and industry. HCR-CTRO, in co-operation with scientists (particularly through its Scientific Council as an advisory authority) has generated innovations of world significance in the sphere of general airborne survey, as well as the initiation and gradual improvement of methods of training honeybees to investigate the application of these techniques in demining operations, which represents an exceptional scientific contribution to the global mine action community.

HCR-CTRO participated in the following R&D projects related to the Mine action program: Space and Airborne Mined Area Reduction Tools – SMART\(^\text{161}\) (FP5); Airborne Minefield Area Reduction - ARC\(^\text{162}\) (FP5). Another successful collaboration is the TIRAMISU (FP7) research project\(^\text{163}\), which aims to provide the Mine Action community with a toolbox to assist in addressing the many issues related to Humanitarian Demining. Apart from HCR-CTRO ltd., Croatian partner in this huge European project is Faculty of Geology, University of Zagreb.

There are as well projects funded by the US State Department through ITF – "Application of the advanced intelligence decision support system for mine action in Croatia", and "Application of the advanced intelligence decision support system for mine action in Bosnia and Herzegovina" (mine-action technology to successfully combine remote sensing with advanced intelligence methodology); and a project conducted with the Croatian Ministry of Science, Education and Sports, "System for the multisensory airborne reconnaissance and surveillance in crisis situations and protection of the environment”.

The transfer of methods and technologies (e.g. Airborne Survey) related to mine action can be applied in other spheres outside the mine action, for example in relation to the risk assessment of areas that are affected by natural disasters, such as floods (survey, acquisition of images and development of models showing movement of mines due to flooding, torrents and landslides), and potentially can be used for surveillance and detection of coca fields and other opiates that are often also the indicators of mine presence, because the fields are surrounded by mines (e.g. Colombia), as well as in fires and marine pollution, and in border surveillance systems (in particular for illegal border crossing).

\(^{161}\) http://cordis.europa.eu/project/rcn/55431_en.html
\(^{162}\) http://cordis.europa.eu/project/rcn/54367_en.html
\(^{163}\) Toolbox Implementation for Removal of Anti-personnel Mines, Submunitions and UXO http://www.fp7-tiramisu.eu/
Underwater mining is also an area of great interest for Croatia due to its geostrategic position. Faculty of Electrical Engineering and Computing in cooperation with NATO-CMRE (Centre for Maritime Research and Experimentation) developed a system for Underwater mining within the NATO project „Autonomous Naval MCM Neutralization“ The system consists of an autonomous underwater vehicle pushed from an autonomous catamaran and by using sonar images is autonomously navigated towards an underwater object that needs to be investigated and eventually neutralized. The project was implemented by a team from LAPOST on Faculty of Electrical Engineering and Computing Zagreb

**Indicative RDI topics of interest under this STPA:**

- ICT: development of mine-information and geo-information systems (e.g. systems for multi-criteria decision making based on geo-information system, development of E-learning for EOD training);
- KET: optoelectronic (hyperspectral, thermal), 3D mapping;
- Advanced Production: solutions in applying robotics to special ground/mobile platforms; UAV systems integrating multi-sensor, hyperspectral, thermal survey for mine action, natural disasters;
- Development of Technology Convergences: e.g. biotechnology + ICT, ICT + sensor and digital technology, ICT + airborne and ground platforms for countering large scale natural disasters
- Evolution of Applications: natural disasters, multidiscipline detection capabilities and border security, land systems of control and scanning, new explosive materials – testing, research on usage and equipment, identification methods, services of the aerial civil reconnaissance
- The development of autonomous vehicles (underwater, land and air) for the timely detection and neutralization of dangerous objects.

**Related indicative RDI topics under cross-cutting themes KETs and ICT are:**

- ICT - development of solutions for the establishment of spatial database on mine clearance and movement in a cleared area on the principles of crowdsourcing,
- ICT – tracking of vehicles and persons (devices) on the demined areas and in the vicinity of mine suspected areas
- Computer vision and machine learning with application in the field of mine action programme;
- KETs for satellite or drone-based wide area surveillance in air, land and water;
- KET – Unmanned vehicle controls;
- GIS, Geospatial analysis and geoprocessing, Geostatistical Analysis;
- KET - tracking of vehicles and persons / fleet management u demined areas and in the vicinity of mine suspected areas.

**5.2.4.4. Expected economical structural changes with this TPA**

The goal of RDI in the Security area is making Croatia more secure for its citizens and critical infrastructure, while strengthening its SMEs and industrial competitiveness. Problems that Croatia is facing in relation to growing challenges related to security are the same as in the EU and across the world. This makes solutions and expertise that Croatian companies are developing applicable globally, offering a big business opportunity. By fostering specialization within this TPA Croatia can, inter alia, significantly contribute towards overall European security.

The future of the TPA can be connected to tackling societal challenge “Secure societies – Protecting freedom and security of Europe and its citizens” in the fields of enhancing the resilience of society against natural and man-made disasters, ranging from the development of new crisis management
tools to communication interoperability, and to develop novel solutions for the protection of critical infrastructure; fighting against crime and terrorism ranging from new forensic tools to protection against explosives and illicit trafficking; improving border security, ranging from improved maritime border protection to supply chain security and supporting the EU's external security policies including through conflict prevention and peace building and providing enhanced cyber-security, ranging from secure information sharing to new assurance models. For this purpose, autonomous vehicles and robotics technologies will play a major role, contributing to achievement of social challenge „safe society“ in the safest possible manner.

The model of structural changes, as the main outcome of a smart specialization process regarding this TPA, includes modernization through an upgrade of already existing technologies, which produces a significant impact on the efficiency and production results, diversification through commercialization of new high performance products, platforms and services and transition to new processes and higher position in value chain targeting integration of components and future products.

5.2.5. Food and Bioeconomy

5.2.5.1. Thematic priority area rationale

Food and Bioeconomy were selected as a thematic priority area for several reasons. First, Croatia has great available natural resources in this sector: plenty of good quality arable land and sea\textsuperscript{164}, natural forests\textsuperscript{165} and water resources that enable their conversion into food, feed, wood and bio-based products. Second, there are numerous companies of various size within this sector (some of them being regional leaders) that play an important role in the GDP and employ a significant portion of the working population (agriculture accounts for 12.4\% of total employment, forestry 1\%, food production and food processing industry 3.4\%), which is traditionally hardworking, highly skilled and well educated. Third, there is an appropriate research and education system in place, along with an adequate research infrastructure.

There are several strategic documents, prepared by the Ministry of Agriculture, Fisheries and Rural Development regulating food and bioeconomy policies: (i) The Rural Development Programme 2014 - 2020 emphasizes the need for development of ICT infrastructure to support rural development; (ii) The Maritime Development and Integral Maritime Policy Strategy 2014 - 2020 recognizes the importance of the development of electronic public services as a precondition for increasing the efficiency of maritime administration and strengthening the competitiveness of the entire economy; (iii) the National Strategic Plan for Aquaculture Development 2014 - 2020 states the need to maintain the geographic information system in fisheries. In recent decades, the Croatian Government has placed the development of the agriculture, fishery, food and wood processing industry sectors high on its agenda, recognizing their potential impact on the country’s economic development, and this was reflected in several key policy documents, besides those above mentioned: (i.e., the Strategic Development Framework, National strategy for Education, Science and Technology). Similarly, recent policy documents issued by the Ministry of Science, Education and Sports, Strategic Plan 2016 – 2018\textsuperscript{166}, describe the overall Croatian strategic short-term measures in education and science. The plan of the Ministry of Agriculture, Fisheries and Rural Regions for the period (2012 – 2014)\textsuperscript{4} describes the overall Croatian short-term measures in the fields of Agriculture and Fishery. This area has already been recognized as highly important and of national interest in both the National Industrial Strategy\textsuperscript{167}. 

\textsuperscript{164} The surface of the Republic Croatia is 87,661 km\textsuperscript{2} and it comprises 56,594 km\textsuperscript{2} (64.5\%) of land area and 31,067 km\textsuperscript{2} (35.5\%) of territorial sea.

\textsuperscript{165} The total area of forests and forestland in Croatia amounts to 2,688.688 ha, accounting for 48\% of the total land area.

\textsuperscript{166} http://public.mzos.hr/Default.aspx?art=10679&sec=3331

\textsuperscript{167} Industrial Strategy, p.163-171.
and the Croatian Research and Innovation Infrastructure Roadmap\textsuperscript{168} (especially, forestry and wood technology, sustainable agriculture, fisheries and aquaculture).

In the near past, capacities and income out of this sector were much higher but unfavourable transition factors affected significant reductions. However, effective linking of industry and RDI sector, as well as natural and human resources through smart specialization should enable fast growth and new employment.

Regarding the level of cluster development, CCCs that contribute to raising competitive value of this thematic area are: (1) Food processing CCC and (2) Wood processing CCC. Further development of relevant CCCs (Food, Wood and Chemical, Plastic and Rubber CCC) will contribute to raising competitiveness of this thematic area and to promoting cooperation between the public, private and science sector with the aim to create bioeconomy value chains, which produce goods, services and solutions sustainably, with more efficient use of resources and through clean technologies.

TPA Food and Bioeconomy is a very complex area and it encompasses a wide range of science disciplines and economy sectors. However, an applied approach of prioritization and elimination through the process of entrepreneurial discovery that is conducted through several workshops with representatives of business and the public research sector, followed by efforts of an interministerial working group, has shed light on two sub-priority areas containing the most promising thematic fields. They have been selected based on significant natural resources, successful companies, including large companies with their own R&D institutes or departments, and most progressive SMEs, combined with proven research excellence in the public sector.

Food and Bioeconomy as a priority area has logical and functional links with other TPAs such as Health and Quality of Life, Energy and Sustainable Environment and cross-cutting sub-thematic priority areas KETs and ICT, providing space for cross-sectorial cooperation and the development of new emerging niches through research and product development.

The selected sub-thematic priority areas (STPA) under this TPA are presented in the chart below.

\textbf{Figure 31 Food and bioeconomy sub-thematic priority areas}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{food_bioeconomy_stpa.png}
\caption{Food and bioeconomy sub-thematic priority areas}
\end{figure}

\textbf{5.2.5.2. STPA 1 Sustainable food production and processing}

\textbf{5.2.5.2.1. STPA sector rationale}

Sustainable food production and processing covers three very important and dynamic sectors for the Croatian economy: Agriculture, Fishery and Aquaculture, and the Food processing industry, which are based on traditional production, strong R&D, rich and diverse resources for the development of

\textsuperscript{168} Croatian Research and Innovation Infrastructure Roadmap, p. 18.
primary production as well as educated and trained people. Activity is characterized by a high degree of product completion and as such, the activity is capable of attracting investment and capital needed for development. Main economic indicators of the Croatian food sector are already presented in Chapter II - Analysis.

**Agriculture** is historically an important sector in Croatia and it represents a relatively significant proportion of the labour force. In a relatively narrow agricultural area, due to diverse climatic conditions, relief and soil, a large number of agricultural crops, starting from wheat and industrial crops to wine grapes, olive growing and fruits and vegetables, are successfully cultivated. However, the largest share of market production is focused on large farms, which are also the ones that have been growing at a fastest rate in the past years. With the application of the latest technologies and extensive investments and knowledge, extraordinary production results have been achieved on some of these farms from a global perspective and production is characterized by high-quality products and a large number of registered products with quality marks applying for EU registration. Also, agricultural activities are characterized by a limited and uneven application of research knowledge, low-level inclusion of agricultural holdings into higher level organizational forms and other types of cooperation; uncompetitive agricultural production and low productivity, outdated and neglected systems for the improvement of drainage and underdeveloped infrastructure for irrigation systems.

**Fishery** (both marine and freshwater), represents the main source of income of the coastal and especially island communities. The fishing industry includes sea fishing, fish farming and producers of fish feed - the entire value chain from ‘sea to table’. The Fishing Fleet Register of Croatia includes 4,039 vessels. The total catch in Croatia in 2013 amounted to 75,267 tons. One of the major companies is Adris Group, which produces feed for fresh water farming, marine farming and recirculation. The industry also includes a few medium companies such as Sardina, Pelagos and a large number of small businesses working primarily with fishing. A fisheries company significantly participates in the export of the Republic of Croatia’s food products with the value of total exports in 2011 amounting to USD 178,503,695 (38,493 tons).

As an economic activity with a long tradition, **aquaculture** is playing an important role in Croatian fisheries. Based on data presented in the Analysis chapter, there is obvious capacity and potential for growth. There has been a constant growth in the production, due to the increase in domestic consumption and the stabilisation of prices on the EU market. However, innovative solutions in production, a higher level of organisation and more effective distribution are essential in order to overcome identified problems (available resources, limited fishing infrastructure and inadequate port facilities, limited knowledge on the capacity of the environment and the assessment of stocks, lack of processing capacities and production of products with a higher added value, inadequate disposal of waste generated in the production process) and to maximise the existing strengths (variety of species and diversity of fishing techniques, favourable environmental conditions, production of food of high nutritive values).

**Croatian food processing** companies mainly rely on domestic plant and animal and fishery production and are relatively competitive. Compared to the other branches of the processing industry in Croatia, the main strengths of the food industry (food and beverage) can be found in the highest total revenue (30% of total manufacturing revenue) and employ the most people (19.53%, i.e. more than 65,000 employees in more than 3,000 registered companies). Apart from half a dozen large companies (Agrokor Group, Podravka, Atlantic Group, Kraš, Cromaris and others), there are many developed and

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169 The agriculture sector accounts for 5.5% of GDP and 13.8 % of total labour force.
170 Consolidated trend leads to a more viable farm structure evidenced by the increase in number of agricultural holdings registered in the categories from 20 to 100 ha (2007-2011, increase of 36.24%) and from 100 to 750 ha (2007-2011 increase of 62.5%).
171 97.4% of holdings function as family agricultural holdings and only 0.2 % as cooperatives due to the negative historical connotations of former cooperatives.
172 The productivity of Croatian agriculture (2010-2012) was 58.2 % less than the EU average.
growing SMEs and private farms that are creating a network of successful food producers within the Croatian food sector. The most profitable businesses in this sector are the production and processing of confectionery products such as milk and cheese, baked goods, beer production, processing of tea and coffee and the production of soft drinks. The most important export products of the food industry are food additives, biscuits and wafers, filled chocolate, canned fish, instant soups, olive oil, beer and other alcoholic beverages. Apart from the production of basic food ingredients, Croatia has a rich tradition, experience and reasonably good technology in the production of very distinctive (some being world-renowned) products such as wine, cheese and meat products.

However, as discussed in the entrepreneurial discovery process, Croatian food industry (CFI) technology level and investments in RDI are significantly lower than in other EU member states. The main CFI issues that were recognized by key companies and research organizations are: generally outdated technologies (low efficiency, high energy consumption, low quality products, high final product price), low level of investments in research and development (new product development, production of trendy products e.g. functional food), weak connection between primary producers (of raw materials) and food industry. It is worth noting that this STPA was widely recognized within the entrepreneurial discovery process and the main challenge was to narrow it down to the most prospective topics.

5.2.5.2.2. RDI capacity in industry

RDI capacity in the business sector is mainly concentrated in the largest companies such as Agrokor Group, Podravka, Atlantic Group and Heineken with the focus on RDI topics that are determined by European Technology Platform “Food for Life”, Strategic Research and Innovation Agenda, (2013-2020 and Beyond), Horizon 2020, and company strategies, policies and plans. R&D activities within the business sector are realized through research and development centres, units and R&D teams according to specialized fields. Product development strategies are based on the recognition of benefits important to customers and are offering solutions through improved ingredients and flavours, their health and functionality, as well as improved packaging for the purpose of extending product freshness, shelf life and convenience. The main areas for R&D in industry are: agriculture and the production of oil, margarine, ice cream, frozen food, bottled water, soft drinks, wine and meat and meat-based products. The aim of R&D laboratories for product development is to ensure the highest quality of products and building trusting relations with the consumers. Companies are connected with Croatian and international scientific and research colleges, institutes, small and mid-size entrepreneurs, suppliers and consumers, and build a platform for open innovations, aiming towards a faster development of innovative solutions for the creation of new and competitive products.

The R&D capacity of the business sector is evident from investment in RDI projects from 2006 to 2014 by BICRO and HIT. In total, 33 RDI projects were related to Food and Agriculture with total investment of 3,870,434 EUR (9.6% of total investment by BICRO and HIT).

5.2.5.2.3. RDI capacities in academia

The current food production and food processing sector mostly relies on R&D in agriculture, biological sciences and biotechnology. Research related to this field points to good performance in comparison with 22 other Eastern European countries, showing that Croatia ranks high in the number of publications in agriculture and biological sciences (miscellaneous) (4th), agronomy and crop science (4th), aquatic science (4th) and food science (4th). Moreover, Croatian publications in agronomy and crop science (5th), aquatic science (5th), food science (5th) and horticulture (5th) are in the top category among the 23 Eastern European countries considered. The best $h$-indices were

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174 The food processing industry has also attracted considerable foreign investment and many international companies are successfully operating in Croatia, such as Meggle, Axereal, Coca-Cola, Lactalis, Carlsberg, Heineken, Nestle and others.
reported for Croatia in agronomy and crop science (5th), aquatic science (5th) and horticulture (5th). Based on this data, Croatia has good potential for the development of green and blue biotechnology.

Several research institutions have achieved quite positive results related to research projects financed through EU funds: Faculty of Agriculture and Faculty of Food Technology and Biotechnology, University of Zagreb; and the Faculty of Agronomy and Faculty of Food technology, Josip Juraj Strossmayer University of Osijek, as well as agriculture related research institutes from Osijek, Split and Poreč (CORDIS database). Based on the existing research infrastructure as seen from the volume and quality of scientific projects and publications (“Food, agro, fish and biotech” as one of the top three thematic areas in which Croatia has participated within FP7175 and with an h-index of 66 for Agricultural and biological Sciences in the period 1996-2014176) it is obvious that Croatia has a very good potential to contribute with patents and innovations in various research fields such as: plant, animal and microbial biotechnology, physiology and biology of integrated and organic agriculture, soil and water science, plant and animal health protection, horticulture (viticulture and fruit growing), meat and milk quality, as well as in research related to food processing and food technology. It is worth noting that Croatia has particular strength in the plant breeding (applied genetics) and seed production sector lead by the Agricultural Institute in Osijek, BC Institute Zagreb and the University of Zagreb - Faculty of Agriculture. As a result of their RDI programs, Croatia is largely self-sufficient in seed production of the basic crops (such as wheat (88%), soybean (80%), maize (53%), barley (50%), etc.), which is of strategic significance. Intellectual property over domestic seed, planting material, stock animals and microbial strains has significant potential to ensure a strategic basis for agriculture and food industry, especially through the development of new cultivars tolerant towards environmental stresses caused by climate changes.

In the field of fishery and aquaculture the key scientific institution is the Institute of Oceanography and Fisheries in Split. From 2009 to 2014 the employees of the Institute published over 300 scientific papers related to fisheries and oceanography and were cited in WoS database. The Institute is a member of a number of eminent international organizations, such as EFARO, EMBO, EUROMARINE, EUROMARINE and it participates actively in the work of STECF, GFCM, FAO, ICCAT, being also the responsible institution for collecting data on the fisheries in the Republic of Croatia (EU DCF). Apart from this institute, research related to fisheries and aquaculture is also conducted by smaller research organisations or departments, e.g. the Institute for Marine and Coastal Research, as well as the Faculty of Agriculture in Zagreb (Department for Fisheries), Faculty of Natural Science in Zagreb and the Centre of Marine Research in Rovinj, department of RBI.177

Above mentioned research institutions have an array of well-equipped laboratories and experimental units (experimental fields, germplasm collections, cold storage units, green houses, etc.) that serve high quality research. Several other infrastructures (Centres of research excellence and competences, technological parks, innovation centres) are currently under establishment/construction. This is accompanied by higher education programs that ensure the provision of relevant professionals within the sector. There are more than 50 bachelor and master level study programs with more than 5,000 students, who are acquiring university level knowledge relevant for the food production and processing sector.

The Croatian success rate in recent FP7 projects is quite good, especially in biotechnology178. Also, agricultural and biological sciences are the second most notable field regarding published scientific

175 Eurada (2014), Mirris Scoping Paper.
177 The most important recent projects in which scientists are involved are: Horizon 2020 (PARASITE), FP7 (CREAM, EUROFLEETS, PERSEUS, SEADATANET, ARAMACC), FP6 (SUSTAINQU, SESAME, AQUAMED), UKF (NEURAL), DEFISHGEAR, NOAA (TMEWS), COST (Emboss), DG MARE (SEDAF, Marea, EMODNET), FAO (ADRIAMED, SOLEMON, DEEPSSEA, UWTV
just after medicine. By linking science and business in one of the most propulsive technologies, the brand new BIO Centre (Bioscience Technology Commercialisation and Incubation Centre) has been constructed through an IPA project, with the purpose of enabling a technology transfer and commercialization facility in the field of biotechnology and life sciences.

**Indicative RDI topics relevant for this STPA have been selected:**

- biotechnology and applied genetics of plants, animals and microbes;
- physiology-based innovative solutions to increase productivity and sustainability;
- agricultural land and water resource management in order to increase agricultural yields;
- integrated and organic agriculture innovations including plant protection;
- climate change adaptation mechanisms of plants and animals;
- cropping systems adapted to biotic and abiotic stresses; conservation and sustainable use of agro biodiversity including valorisation and exploration of authentic local products;
- innovative technologies and processes for high quality food production;
- food safety;
- preservation of products;
- functional feeds and feed additives;
- integrated supply and value chain solutions;
- innovative processing of by-products;
- ecosystem based approach in the fisheries instead of single stock approach;
- regional approach in the assessment and management of shared stocks;
- smart fishing gears and protection of critical habitats; protection of marine areas;
- impact of climate change and invasive species to the ecosystem and fisheries;
- post harvesting methods to maintain the value of catch and diversification of fishing activities;
- introduction of new species and use of environmentally friendly technology;
- development of added value aquaculture products;
- development of innovative uses for undesired catches and new breeding technologies;
- Aquaponics

**Related indicative RDI topics under cross-cutting themes KETs and ICT are:**

- Biotechnology (White, Grey, Blue and Green Bio Tech) for Environment sustainability;
- KETs for food packaging systems for preserving food from microbial contamination and for improving shelf life and cost-efficient consumer food packaging with increased environmental sustainability;
- e-services for managing agricultural and food production operations and distribution management;
- Innovative cloud solutions in the Cloud, the Internet of Things and big data analysis of large amounts of data ("Big Data");
- Process and embedded computer automation and control processes;
- ICT systems, applications and solutions for the management and monitoring of agricultural land;
- ICT systems, applications and solutions for the control and monitoring of organic farming of food and geographical origin of food products;
- GIS Systems and network services for precision in agriculture;
- Robotic systems for growing food and control in aquaculture
- Computer vision and machine learning with application in sustainable food production and processing.

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5.2.5.3. **STPA 2 Sustainable wood production and processing**

The forestry sector has a significant economic role in relation to wood-processing and furniture production. Sustainable wood production and processing has big export-oriented subsections (furniture production, industrial sawn timber, etc.) that create positive EBITDA and employ a significant number of workers. Its strengths lie in several factors: availability of high quality raw material, export orientation (in the past 3 years a surplus in foreign trade has been achieved) and existence of more than 500 companies specialized in furniture production. Also, it is important to mention, more than 150 wood processing companies have obtained the FSC-CoC certificate. As a result of more proactive involvement of the public sector in the strategic management of the wood-processing sector, the last ten years have been marked by relatively high export sales (value of exports has doubled in comparison to ten years ago).

The wood processing sector in Croatia numbers more than 1300 companies that employ over 21,000 workers, generating total revenues of approximately 1 billion EUR. Export figures show that the wood-processing sector represents almost 7% of Croatian manufacturing exports. Nevertheless, this sector is lagging behind in terms of technological capabilities and usage of innovative and value added solutions in production. This is especially related to the finalization process, which should clearly be the main orientation of the Croatian Wood industry (finalization of wood products, especially furniture). Manufacture of furniture has a relatively high share of employed persons in the manufacturing industry (4.03%), but has a successful performance in terms of export orientation, with more than double the value of exports compared to imports and more than a third of its revenue being generated through exports in 2012 (39.77%). The largest companies, such as Tvin, Pan parket, Parketi Požgaj, Spačva, PPS Galeković, Exportdrvo and Spin Valis for the production of furniture, sawn timber and elements and parquets have developed their own supply chain and are in cooperation with other wood-processing companies constantly investing resources and efforts in the production of healthy and environmentally-friendly furniture, and the realization of a cogeneration plant in order to produce electricity and heat from biomass. The potential of biomass comprises plant (mainly wood, but also several other fast growing plants) and single cell biomass originating from agriculture, industrial waste, or cultivation, and it is being explored in Croatia both for the conversion to energy, as well as for the production of chemicals (mainly pharmaceuticals). To achieve this goal Croatia has to encourage further development of forest management and enable utilization of forest biomass, forestation and cultivation of short rotation crops, as well as explore alternative sources of biomass of plant and microbial origin.

The main problems of this sector are: lack of specialization of producers, large logistics costs, inadequate distribution channels, lack of trend-following, poor technological equipment and unfavorable exchange rate policy. The majority of Croatian furniture manufacturers do not invest in design and innovation, which is, along with uncompetitive prices— with which Croatia is not able to compete with China and similar countries with low labor costs— the main factor of competitiveness on the foreign markets.

During the entrepreneurial discovery process it has been stated that although the Croatian wood processing industry technology level and investments in RDI are significantly lower than in other EU member states, given their growth in recent years and very high export potential, this STPA will profit from the joint efforts from both public and private companies, as well as the research sector, especially with investments in new products, knowledge and technology.

5.2.5.3.1. **RDI capacity in industry**

180 Forest Stewardship Council – Chain of Custody certification.
181 Strategic guidelines for the development of the wood processing industry.
As far as wood production is concerned, since 78% of forests and forestland are owned by the state, most of the Croatian forests are managed by the public company Hrvatske šume. Consequently, RDI in forestry is mainly in the domain of public research institutions, which have very good connections with the business sector and apply their results in the production process. They have a long tradition of sustainable forest management with valuable and well preserved close-to-nature forests and quality raw wood material, as well as sustainable use and valorisation of non-wood forest products.

In the wood processing industry, RDI capacity is mainly concentrated in larger companies whose departments are mostly concerned with finding innovative solutions for the modernisation of production (mostly through application of robotic devices and new ICT solutions, i.e. 3D printers), automation of the production processes, application of new materials for surface treatment (coating, oil, etc.) and sustainable wood production. The wood processing industry closely cooperates and exchanges knowledge about Innovation Policy with other CE European countries, primarily Italy (Wood Technological Institutes Cosmo Pesaro and Cates Udine) and the German wood sector (particularly in the Federal State of Bavaria). The importance of this process is recognized at the strategic level, and now it is important to establish closer cooperation with their official bodies and organizations in order to continue the process of know-how transfer.

### 5.2.5.3.2. RDI capacity in academia

The key scientific institution in this sector in Croatia is the Faculty of Forestry of the University of Zagreb. From 2009 to 2015 the Faculty employees have published over 400 scientific papers cited in WoS and Scopus databases. The Faculty is an active partner in a number of projects, of which the most important recent ones are: FP7 (BEE, BENWOOD), EC (EurRedHab), IPA (CroWoodFlooring, HKO, BBio), ESF (FGErerbur), CSF (Fraxinpro, PerdaQuercus). The Faculty is a member of a number of eminent international organizations, such as IUFRO, FORMEC, INNOVA WOOD, WOODEMA, Pro Silva Europe, Silva Network and EFI. An important institution in this sector is the Croatian Forest Research Institute, which played a key role in the establishment of the joint EFISEE-EFICEEC regional office of the European Forest Institute (EFI) for South-East Europe.\(^\text{182}\) Employees of the Institute published 69 scientific papers cited in the WoS database. Based on the existing research infrastructure, and as seen from the volume and quality of scientific projects and publications, it is obvious that Croatia has very good potential to develop patents and innovations in the wood production and processing field.

\(^{182}\) The Institute is an active partner in a number of projects of which the most important recent ones are, as follows: FP7 (INFORMED), FP6 (CarbonPro), IPA (HOLISTIC, AMF), COST (STReESS, ClimMani, CAPABAL, EuroCoppe, FACESMAP, ORCHESTRA, GreeninUrbs, NWFPs Network, Global Warning, EISA5), EFI (IMACFORD, MEDFOREX), ICP Forests
Indicative RDI topics relevant for this STPA have been selected:

- physiology and applied genetics of forest trees to ensure climate change adaptations;
- forest management innovations including plant protection to increase productivity and sustainability;
- conservation and sustainable use of forests, including valorization of non-wood forest products (forest based bioenergy);
- innovative technologies and processes for high quality and added value wood production;
- new dry processing technologies for wood manufactures, new eco-coating in final production of wood furniture and parquets: „eco“ based glues, water paints;
- new materials and wooden construction;
- new technologies for manufacturing of wooden objects and sustainable constructions (low energy and passive buildings).

Related indicative RDI topics under cross-cutting themes KETs and ICT are:

- AMT - Processes for the cost-efficient conversion of various biomasses to biofuels;
- Advance material for coatings and surfaces with high scratch resistance and/or weather ability and/or with self-repairing capabilities;
- process and embedded computer automation and control processes;
- ICT-solutions in wood furniture production;
- ICT systems, applications and solutions for inventory of forest resources and prevention and protection against fire and other natural disasters
- Innovative solutions with drones and remotely controlled systems for forestry, nature protection and environmental monitoring
- Innovative cloud solutions in the cloud, the Internet of things and big data analysis; of large amounts of data (“Big Data”)
- Computer vision and machine learning with application in the field of sustainable wood production and processing

5.2.5.4. Expected potential for TPA further development and structural changes

The Croatian food and wood production and processing sector will face major opportunities for global growth in the coming decades. Food demand is expected to increase by 70% by 2050 and many of today's food production systems already compromise the capacity of the planet to produce sufficient future food supplies. Through the application of smart technologies, the primary focus will be on producing high quality and safe agriculture and food processing products, products from organic farming and traditional, branded products. The perspectives and the main challenges for the future development will improve the product portfolio in such a way that it adapts to the customer's wishes and needs, it will optimize the supply chains, increase the efficiency and sustainability of production processes, while improving technological levels, management of logistics, etc. This will require modernisation and diversification of production through investment in technology development, RDI and commercialization of innovations. The extent of the cooperation between food industry players and research institutions will be further strengthened through cluster cooperation and open innovation and strategic initiatives. Large companies - through integration of SMEs in their own value and supply chain and performance of collaborative RDI activities - will secure access to larger markets for small, innovative growth companies, which, in return, supplement the large companies through their innovative power. All this will be in the function of increasing self-sufficiency and supply of a fast growing tourism industry through the development of a local production food system.

The main objective of R&D activities in the fisheries and aquaculture sectors will be to strengthen sustainable fisheries management and application of an ecosystem-approach as well as to promote the sustainable and competitive development of aquaculture products with a strategic focus on the
expansion and diversification of products from marine and freshwater farms. R&D activities will lead to innovative solutions for the "greening" of the fisheries sector through the modernization and resource efficiency of farms. At the same time, the new robotic technologies in the field of aquaculture will lead to increased production efficiency as well as progress in environmental protection.

In relation to wood sector production and processing, it is worth noting that Croatia has particular strength in the long tradition of sustainable forest management with valuable and well preserved close-to-nature forests and quality raw wood material. Projected climatic changes will challenge this sector to explore innovative forest management solutions, to maintain sustainable forests production. It is necessary to find solutions to increase productivity and efficiency of the wood supply pre-processing and processing phase through R&D and branding, to give added value to wood products, while at the same time ensuring the protection of nature and maintaining high biodiversity. The potentials of this STPA can be seen in the increased demand for eco-products and materials on the EU and global market and trends of increasing the usage of wood products for eco and sustainable constructions and interior design. The further increase in competitiveness of the wood sector can be facilitated through ICT and creative services as well as advanced engineering, investments in development and implementation of product design and inclusion of advanced manufacturing technologies in manufacturing capacities, with an aim to develop and promote safe, healthy and new value-added wood products, bio-based paints and eco-surface treatments.

5.3. Cross-cutting themes and their link with priority thematic areas

The capabilities of the business sector for innovation are highly influenced via so-called growth-relevant „cross-cutting themes“. Cross-cutting themes are cross-industry technologies and processes which are important for Croatian development because they are the additional source of innovation in all thematic priority areas, supporting them in a value-added manner. They indirectly lead to product and process innovations in the respective industries, i.e. they are only turned into market-ready services and products in the context of the business potential (see Annex 2). Cross-cutting themes are acceleration factors and growth drivers within the thematic priority areas. They provide support for the formation of innovations and for the dynamics in the industries, and therewith significantly contribute to value creation. The relevant cross-cutting themes for the identified 5 TPAs and 13 STPAs are KETs and ICT.

Cross cutting themes’ areas of application are within the framework of 5 defined TPAs and 13 STPAs. Special attention will be given to those projects under the 13 STPAs which incorporate elements of KETs and ICT, meaning that during the selection they will have priority. Furthermore, in order to fully use the cross-cutting themes as growth drivers and innovation spurs, it is envisaged to support the projects mainly based on cross-cutting themes that will have impact on several thematic priority areas and sub-thematic priority area(s), hence enabling a wide range of possible applications. Special attention will be given to KETs and ICT as cross-cutting areas within strategic projects - Establishment of Innovation Network for Industry and development of Thematic Innovation Platforms and Support to competitiveness cluster initiatives.

It is important to note that the listed KET and ICT RDI topics are indicative and other KET/ICT topics could in principle be supported on the S3 basis, if their scope of application is in accordance with at least one of defined STPA identified under S3.

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183 This principle will be applied for following delivery instruments: Support to business investment in RDI; Centers of Competence; Support to SMEs capacities to innovate.
184 This principle will be applied for following delivery instruments: Development of new and the improvement of existing RDI infrastructure in Croatia.
Table 18 Cross-cutting themes link with selected TPAs and STPAs

<table>
<thead>
<tr>
<th>Thematic Priority Area (TPA)</th>
<th>Sub-thematic Priority Area (STPA)</th>
<th>ICT</th>
<th>KETs</th>
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</table>
| **Pharmaceuticals, biopharmaceuticals, medical equipment and devices** | - Process and embedded computer automation and control processes.  
- Computer vision and machine learning with application in pharmaceuticals, biopharmaceuticals, medical equipment and devices | - KETs for more efficient and less invasive drugs and therapies (implantable devices for medicine and improved surface coatings and coating techniques for drugs);  
- KETs for robots, assistive technologies and processes | |
| **Health services and new methods of preventive medicine and diagnostics** | - use of robotics in medicine (e.g. smart systems and robots for healthcare services; new solutions for enhancement of the quality of life of elderly and dependent people)  
- e-health solutions and related technologies;  
- ICT-based services and applications for improving quality of life for persons with disabilities (such as chronic patients, older population), including solutions for Alternative and Augmentative Communication and video and audio technology for home care assistance;  
- GIS solutions for spatial and network analysis (location / allocation, geocoding, time zones in driving, spatial modeling, geostatic analysis – regression analysis i geographic regression)  
- ICT solutions for monitoring and statistical analysis of diagnostic devices operations;  
- ICT system for geographic analysis and prevention of diseases (GeoHealth);  
- ICT systems, applications and solutions which provide support to functioning of particular organs or particular functions of the human body;  
- ICT systems for alarming and assistance in urgent medical situations;  
- Innovative technologies based on development of health sensors in Internet environment „Internet of Things”, managing and analysis of Big Data and cloud solutions;  
- Computer vision and machine learning with application in healthcare services, new methods of preventive medicine and diagnostics. | - KETs for robots supporting professional care and robot assistive technologies;  
- KETs for devices and systems for targeted diagnostics;  
- KETs for Connected systems for theranostics | |
| **Nutrition** | - Process and embedded computer automation and control processes;  
- ICT systems, solutions and applications for mobile and smart devices for healthy diet per target groups (athletes, pregnant women, persons suffering from diabetes…), prevention and protection from diseases trough detection and monitoring of poor or inadequate nutrition;  
- Innovative technologies based on development of solutions with the fuction of monitoring quality of nutrition and health in Internet environment “Internet of Things”, management and analysis of Big Data and cloud solutions;  
- Computer vision and machine learning with application in nutrition. | - KETs for functional and lifestyle foods to meet diversifying dietary requirements of consumers and embedded computer automation and control processes. | |
| **Energy and sustainable environment** | **Energy technologies, systems and equipment** | - Energy-to-gas and gas-to-energy conversion technologies;  
- Process and embedded computer automation | - KET – photonics  
- Micro and nano electronics for high efficiency power control and conversion electronics. |
<table>
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<tr>
<th>Environment friendly technologies, equipment and advanced materials</th>
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<tr>
<td>- Energy Efficient Appliances;</td>
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<td>- Process and embedded computer automation and control processes;</td>
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<td>- Environmental monitoring based on Internet of Things and Big Data analysis;</td>
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<td>- Energy management systems for planning, investment and monitoring of energy efficiency and CO2 reduction;</td>
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<td>- ICT solutions for spatially-enabled monitoring of emissions of pollutants and greenhouse gases in the environment;</td>
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<tr>
<td>- Solutions for measurement and modeling of light pollution and the preparation and maintenance of the light pollution maps;</td>
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<tr>
<td>- Smart grid of public lighting, combination of the powering of public lighting and charging batteries for electric vehicles;</td>
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<tr>
<td>- Innovative technologies based on the development of advanced sensor networks in internet environment „Internet of things“, management and analysis of Big Data and cloud solutions;</td>
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<tr>
<td>- Computer vision and machine learning with application in environmentally friendly technologies and equipment and advanced materials.</td>
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<th>Added value manufacturing of road and rail vehicles parts and systems</th>
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<tr>
<td>- Smart citizen solutions for environmentally friendly multimodal transport;</td>
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<td>- Sustainable platforms for embedded HW/SW systems and components;</td>
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<tr>
<td>- Solutions for the planning and design of systems for contact or non-contact charging of batteries of electric vehicles driving on smart roads;</td>
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<tr>
<td>- Computer vision and machine learning with application in the added value manufacturing of road and rail vehicles parts and systems.</td>
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<th>Transport and mobility</th>
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<td>- Environment friendly transport solutions;</td>
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<td>- the Port of the future;</td>
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<tr>
<td>- Equipment, systems, solutions and applications for planning, organization and monitoring of multimodal transport and results in the reduction of emissions.</td>
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<tr>
<th>Environment friendly transport solutions</th>
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<tr>
<td>- KET – advanced materials with application in green construction;</td>
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<tr>
<td>- Advanced materials for high-strength/low-weight fiber-reinforced polymer composite materials and technical textiles and textile products for specialized industrial applications;</td>
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<tr>
<td>- Micro and nanoelectronics for solutions for adapting infrastructures to innovative transport means and lightweight vehicle embedded circuits and systems;</td>
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<tr>
<td>- KETs for more sustainable and green vehicles and greener combustion based vehicle propulsion.</td>
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<tr>
<td>Intelligent transport systems and logistics</td>
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<td>Cyber security</td>
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<td>Security</td>
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<td>Defense dual-use</td>
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<td><strong>Mine action program</strong></td>
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<tr>
<td>- ICT - development of solutions for the establishment of spatial database on mine clearance and movement in a cleared area on the principles of crowdsourcing.</td>
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<td>- ICT – tracking of vehicles and persons (devices) on the demined areas and in the vicinity of mine suspected areas</td>
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<tr>
<td>- Computer vision and machine learning with application in the field of mine action programme;</td>
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<tr>
<td>- GIS, Geospatial analysis and geoprocessing, Geostatistical Analysis.</td>
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### 5.3.1. Key Enabling Technologies (KETs)

Key Enabling Technologies (KETs), as the technologies of the future\(^\text{185}\), will provide the technological building blocks and key source of innovation in Croatia that will enable a wide range of product applications in S3 Thematic and Sub-thematic Priority Areas including those required for developing low carbon energy technologies, improving energy and resource efficiency, boosting the fight against climate change or allowing for healthy ageing. They will create added value along different industrial chains and sectors - from materials through equipment and devices, to products and services. Due to their cross-cutting nature and systemic relevance, KETs will be instrumental for modernizing Croatia's industrial base as well as driving the development of entirely new industries.

\(^{185}\) Micro- and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics and advanced manufacturing technologies
The scientific base is apparent from the increasingly successful track record in KET related FP7 and Horizon 2020 projects, particularly in biotechnology and in advanced materials. The main research institutions responsible for these achievements are the RBI, the faculties of Medicine at the University of Zagreb and the University of Rijeka, and the Faculty of Electrical engineering and Computing at the University of Zagreb as well as Faculty of Chemical Engineering and Technology. Because of their spill-over effects on industry users from various industrial value chains, including suppliers and downstream sectors, KETs can spur innovation, increase productivity, give rise to new applications and help tackle societal challenges.

In order to enhance the potential to deploy KETs, it is therefore essential to enhance the critical mass in KETs in Croatia and to make specific choices on research themes to support according industry and academic strengths. Smart choices and a focus on particular KET will well align the concept of smart specialization.

**Biotechnology** is one of the most important and most widespread KETs, in public ROs as well as in business sector, and containing several categories: Blue, White, Green, Grey and Red Biotech. Blue and Green biotechnology are especially important in activities focused on food production, biodiversity protection and use of by-products. White biotechnology (Industrial biotech) is particularly important in the processes for the cost-efficient conversion of various biomass to biofuels and to basic chemicals and intermediates, due to the prominence of biomass in Croatia. Indicative research themes for White, Grey, Blue and Green Bio Tech are: environment sustainability – plants & soil and water management; food security; food processing; healthy food ingredients and food packaging systems for preserving food from microbial contamination and for improving shelf life and cost-efficient consumer food packaging with increased environmental sustainability. The use of Red biotechnology is mostly present in health care and pharmaceutical industry which is recognized as one of the quickest growing industrial sectors in Croatia. Indicative research themes related to Red Biotech are: more efficient and less invasive drugs and therapies; devices and systems for targeted diagnostics and personalized medicines and functional and lifestyle foods to meet diversifying dietary requirements of consumers.

The use of **advanced materials and nanotechnologies** has its application in improvement of existing products and in development of the new ones in numerous industries. Some examples would be in the automotive (batteries, sensors, coatings) and health (bio-implants and devices) industry. There is also realistic potential with biocompatible and biodegradable materials in food industry, with renewable energy technologies (solar cells, hydrogen and lithium based batteries), with functional coatings and metamaterials in industries such as textile or defence, and with specialized sensors for radiation detection in the defence industry. Indicative research themes are: advance material and nano technology for functional (para-) medical textiles and functionalized textile products for better health, wellbeing, comfort and aesthetics; advanced and/or functional construction and building materials and components for Energy Efficiency (advanced composite materials and new material architectures with added functionalities, ceramics; intermetallic, alloys and metal/ceramic-based composite materials for high-performance applications; insulating materials and components for the energetic improvement of the building envelope; construction materials and components with low lifecycle carbon footprint; lightweight structural beams and components); competitive more sustainable alternatives to conventional materials (bio-based products, as well as specialty, chemicals, bio-polymers and other bio-based derivatives); advanced materials for high-strength / low-weight fibre-reinforced polymer composite materials and technical textiles and textile products for specialized industrial applications; advance materials an nano technology for wearable active textiles and clothing for improved human performance aimed at human safety and protection; advance material for coatings and surfaces with high scratch resistance and/or weather ability and/or with self-repairing capabilities.

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186 With a recent H2020 project- Sustainable industrial processes based on a C-C bond-forming enzyme platform.
Micro- and nano-electronics, including semiconductors, are mostly applicable in smart industrial control systems as they permit more efficient management of electricity generation, storage, transport and consumption through intelligent electrical grids and devices. Indicative research themes are micro and nano-electronics for connected systems for: theranostics, high potential renewable energy systems, advance non-renewable energy solutions, smart grid enforcement and embedded energy systems; satellite or drone-based Earth observation for meteorology, environment monitoring and other wide area services; autonomous vehicles (underwater, land and air) with purpose of monitoring and increasing safety and security in / at sea, on land and in the air; highly efficient energy management and conversion electronics, eco-friendly and green transport propulsion solutions with cleaner and greener fuel combustion; solutions for adapting infrastructures to innovative transport means and lightweight vehicle embedded circuits and systems; E-propulsion and widespread E-mobility; advanced broadband wireless communication, embedded broadband communication payload and high bandwidth optical networks; multimodal all cargo logistic chains; satellite or drone-based wide area surveillance in air, land and water; embedded circuits and systems for severe operational conditions and high autonomy and communicating devices and secure and dependable communication platforms and IT infrastructures and services, relying on cryptography, authentication, authorization and computing methods, deperimeterized firewalling, pro-active STDP (security, trust, dependability and privacy) solutions, physical hardening, etc.

Photonics, among other things, provides the technological basis for the economical conversion of sunlight to electricity which is important for the production of renewable energy, and a variety of electronic components and equipment such as photodiodes, LEDs and lasers. One of the indicative research themes is photonics for energy-efficient interconnected and versatile lighting.

Since there is a strong indication of the re-emergence of the EU manufacturing sector as part of the new sustainable economy – in technical, environmental and social terms, research into production processes is therefore a key issue. Thus advanced manufacturing and processing technologies and photonics have potential applications in all TPAs. There is in fact a significant input of these technologies in the successful Croatian defense industries (mine detection vehicles), as well as in the automotive industry (batteries). Some of the indicative research themes are: AMT for robots supporting professional care and robot assistive technologies and processes for the cost-efficient conversion of various biomasses to biofuels.

The integration of different KETs represents a vital activity in S3. The key question for Croatia is how to focus the knowledge investments and to take advantage of technologies whose potential is to drive innovation and to stimulate Croatia’s competitiveness and manufacturing renaissance. There is a need to prepare Methodology, work plan and roadmap for KETs activities and to create KET platforms involving public and private actors to foster collaboration with the aim to increase productivity and competitiveness in Thematic and Sub-thematic Priority Areas.

Industry is an important actor in deploying KETs, hence the culture of doing business between academia and industry has an influence on the deployment of KETs. A good insight into the strengths and weaknesses of a regional and/or national KETs innovation system is essential to stimulate collaboration among the appropriate actors in the KETs areas of interest. The Ministry of Economy will emphasize the role of KET in thematic innovation platforms under Innovation Network for Industry. The purpose is to transfer Croatian KET-related activities from individual actions towards a coordinated approach across different policy fields, and to boost the deployment of KETs into KETs based products. This will include: (1) mapping of the technological know-how and production capacities related to cross-KET activities; (2) developing the methodology that will identify potential areas of industrial interest relevant for cross-cutting KETs and Key Nodes, representing promising areas of converging industrial interest for more than one KET with high potential for future development and demonstration activities; (3) developing the roadmap and work plan; (4) creating a KETs web platform, as a part of each of 5 web innovation platforms, to be established per 5 S3 TPAs; (5) developing a specific chapter for KET applications in thematic business sector RDI strategies with aim to identify the most promising areas of converging industrial interest for KETs and cross-cutting
KET application and creating a Teaching factory for industry to raise the awareness of the importance of using KET in technology.

Furthermore, it is envisaged to give support to RDI projects of CoREs, some of them being directly in several KETs with the main objectives of the strengthening of application-oriented basic research, knowledge and technology transfer. This particularly concerns CoRE for Advances Materials and Sensors – CEMS where researchers from RBI, Institute of Physics’ and Končar Institute collaborate in few co-related fields. This CoRE will promote interdisciplinary research in that field through four key research units: Photonics and Quantum Optics, Graphene and Related 2D structures, New Functional Materials and Physics and Ion Beams Technology. Several other CoREs are partially in KET areas, as STIM with its unit Interdisciplinary Centre for Advanced Science and Technology at University of Split (new generation of nanostructured biosensing materials, optical detection of biological aging and inflammatory diseases, new materials for solar cells, new catalytic materials for fuel cell etc.).

Additionally, further development of KETs is foreseen through infrastructural investments and capacity building of public RO that have shown the most success in FP and Horizon2020 projects and possess the greatest potential to commercialize their KET know-how. The most relevant projects for this investment are indicated in the Operational Programme Competitiveness and Cohesion 2014 – 2020. One of the projects is O-ZIP (Open scientific infrastructural platforms for innovative applications in economy and society). The goal of the project is to bridge a series of gaps between the RBI and the ERA, business sector, scientific communities as well as society as a whole, by modernization, strengthening and organizational reform of the research infrastructure at the RBI. More specifically, within the O-ZIP project, four “research infrastructural platforms” will be created - functional units organized within the multidisciplinary environment of the RBI, with the aim of supporting selected S3 thematic and sub-thematic priority areas and cross-cutting themes: 1) The Biological and Medical Sciences platform will enhance activities in the areas of Red, Green, White and Blue Biotechnology and nano-medicine; 2) the Advanced Technologies and Materials platform will support the development of the Croatian defence industry, the food- and wood-processing industries as well as the production of pharmaceuticals, medical equipment, electrical and mechanical machines; 3) the Marine and Environmental Sciences platform will contribute to sustainable development, ecosystem protection and human health; 4) the Information and Communication Science and Technology (ICST) Platform is an e-Science technology-based platform for development of novel technologies and services for the biotechnological and pharmaceutical industries, the food industry and the health sector. The RBI has just recently received a H2020 grant for project “Expanding Potential in Particle and Radiation Detectors, Sensors and Electronics in Croatia”, which also falls within KETs cross-cutting theme.

Other investment plans in the KET include Institute for Physics (IPZ) project CALT (Centre for Advanced Laser Techniques). Given the importance of lasers and their applications in all areas of science and industry, CALT’s main objectives will be to provide state-of-the-art laser-based infrastructure for competitive interdisciplinary research, to strengthen the IPZg’s leading role in laser-based research in Croatia by opening up new applications/fields in research and innovation in several areas: environment (laser spectroscopy for detecting and tracking ozone formation/chemistry), energy (graphene-based devices, light sources), food safety (plasma diagnostics/treatment), health (bio-imaging and diagnostics, laser and plasma treatment, magnetometry) and security (optical sensors).

Recent investments in R&D infrastructure were made in order to address and support next technological readiness level phases, especially when it comes to biotechnology (BIOCentre in Zagreb), as well as nanotechnologies (Research Infrastructure for “Campus-based Laboratories” at the University of Rijeka) which will not only enhance research capacity and excellence but both will play

188 http://cems.irb.hr/hr/
189 http://cordis.europa.eu/project/rcn/197321_en.html
an important role in transfer of knowledge and technology, especially the former which is one of the first real “open” research infrastructures in the country and an important tool to support the biotechnology sector and to increase the deployment of Industrial biotechnology\textsuperscript{190}.

Additional measures related to the need to cover multiple stages of technology development and deployment and need to strengthen the demand side support\textsuperscript{191} will be carried out by developed delivery instruments (for example by Centre of Competences and Clusters initiative). Further development and deployment of KETs are envisaged through different policy measures, which tackle further technological readiness levels. This will be developed in compliance with recent EU documents and initiatives pleading integrated approach providing increased and adequate support to cross the KETs “valley of death”\textsuperscript{192}.

5.3.2. Information and Communication Technologies (ICT)

ICT sector in Croatia represents one of the key factors of the economic and social development, taking into consideration employees' skills, high share of the overall active population employed in this sector, technology level, value added, business performance, high BERD values, share in GDP, increasing export orientation and growth potential\textsuperscript{193}. It is impossible to envisage further technological advancement of particular industry segments, research areas and niches without integrating ICT solutions within their operation. ICT sector integration within many economic activities can be particularly used across large number of industries. It is also a source of dramatic change in business practices of other industrial activities. Characteristics of the ICT industry are innovation, support to higher added values of industry segments and high dependence on continuous technological progress. Because of these characteristics and its role in further technological development, ICT was selected as S3 cross-cutting theme with the aim to further develop particular areas of application that can support development of all 5 identified TPAs.

The strategic foundation of ICT is strengthened by national documents in the field of education, science, technology, innovation and industrial development in which ICT was given a prominent role: Croatian Industrial Strategy 2014 – 2020 stated that this industry has great potential of growth and employment (especially engineers)\textsuperscript{194}; e-Croatia 2020 Strategy; National Cyber Security Strategy (NCSS) and the Strategy for Broadband Development in the Republic of Croatia 2016-2020. Recently founded \textit{National Council for Digital Economy}\textsuperscript{195} aims to establish an active partnership of all relevant stakeholders in the development of the digital economy, through defining the objectives and priorities for the creation of a single digital market. The Council has a role of an advisory body of the Croatian Government in the transformation processes of the economy of the development of digital technologies. The Council is chaired by representative of Ministry of Economy and consisted of representatives of entrepreneurs, educational institutions, professional associations, non-governmental organizations and public authorities. Presented council can provide support in process of continuous entrepreneurial discovery for this specific area, particularly in case of further development of in depth RDI strategies that will focus only certain selected segments and applications areas of this STPA.

The majority of R&D investments in Croatia generally, and ICT specifically, is done by large and medium-sized enterprises, whereas small enterprises comprise only 6.6% of total R&D investment in

\textsuperscript{190} http://www.biocentre.hr/
\textsuperscript{191} Exchange of good policy practices promoting the industrial uptake and deployment of Key Enabling Technologies, Brussels, 2012, p. 22 et passim.
\textsuperscript{193} Analysiy, sub-chapter 2.2.7.
\textsuperscript{194} The highest potential of growth and employment has been detected in Computer programming, consultancy and related activities.
\textsuperscript{195} Croatian Government adopted a Decision on Establishment of National Council for Digital Economy on 3rd June 2015 (OG 62/15)
the business sector, and microenterprises additional 1.1%\textsuperscript{196}. **There are several large enterprises in Croatia that are active in R&D in the field of ICT** (APIS IT, Combis, Ericsson Nikola Tesla, Končar Group, IN2 Group), a greater number of medium-sized enterprises (ATOS IT Solutions and Services, CROZ, CS Computer Systems, Degordian, Kapsch Hrvatska, King ICT, Nokia Solutions and Networks, Siemens Hrvatska, Span, S&T, Poslovna analitika, INFODOM, Sedam IT, Telegra) and a lot of small enterprises. Two of the large enterprises have private research institutes and strong R&D resources: Ericsson Nikola Tesla (800 employees, all in ICT in Zagreb and Split) and Končar Group (200 employees, partly in ICT in Zagreb). SMEs mostly have R&D departments or organized teams dedicated to development of products and services in ICT segment due to very nature of their work. Appropriate policies could open space for action in R&D for branch offices of large foreign enterprises that don’t have their own R&D resources, such as Cisco Systems Croatia, IBM Croatia, HP Croatia, Microsoft Croatia, Oracle Croatia, SAP Croatia. Some of ICT medium-sized, small and microenterprises are most frequent tenants of technological parks and centres: Osijek BIOS (Betaware, ICT media, ZL Media et al.), Split (Studio Piksel, Intech et al.), Rijeka (Infobip et al.), Varaždin (Abit, Ekobit, Maxcom, MediaTrend, Microsoft Innovation Centre, Modus NTH Media, Orion, Trending et al.), Zagreb (Alfabit, Citus, DeCode Agency, Digitalbit, Live Good, Mag informatika, MBIT Studio, Mobendo, Pinecone et al.). Several large enterprises and SMEs, are cooperating in ICT with universities and research institutes via cooperation agreements and contracts: Ericsson Nikola Tesla, Končar Group, HT – Hrvatski telekom, VIPnet, HRT – Croatian Radiotelevision, Agrokor, Konzum, Kron, HSM Informatika, Degordian, Diversitas IT sustavi, Infodom, Mrežne tehnologije Verso, Siemens, Osijek Software City.

Next to public funding, (Croatian Science Foundation, HAMAG BICRO) and IPA programmes (Instrument for Pre-Accession Assistance), participation in FP7 is of utmost importance for R&D in the ICT sector\textsuperscript{197}. **The ICT sector is second largest area of participation for Croatia in FP7, with EU contribution of 8.76 M€.** Three biggest FP7 beneficiaries are higher education institutions (University of Zagreb, Faculty of Electrical Engineering and Computing: 12 projects), research institutes (Ruđer Bošković Institute: 5 projects) and private business sector (Ericsson Nikola Tesla: 5 projects). Some of these projects are: ACROSS – Centre of Research Excellence for Advanced Cooperative Systems (Faculty of Electrical Engineering and Computing at University of Zagreb in partnership with Ericsson Nikola Tesla, Končar Group and DOK-ING), Q-ImPrESS – Quality Impact Prediction for Evolving Service-Oriented Software (Ericsson Nikola Tesla), UNIVERSAL – UNIVERSal Open Platform and Reference Specification for Ambient Assisted Living (Ericsson Nikola Tesla), S-CASE – Scaffolding Scalable Software Services (Ericsson Nikola Tesla), CloudScale – Scalability Management for Cloud Computing (Ericsson Nikola Tesla), eWall for Active Long Living (Ericsson Nikola Tesla), MOBINCITY – Smart Mobility in Smart City (HT – Hrvatski telekom), FERARI – Flexible Event processing for big data architectures (Poslovna inteligencija, HT – Hrvatski telekom). ECSAFEMOBIL – Estimation and management in secure wireless industrial plants with a high degree of mobility and cooperation”, „SafeLog – Safe human-robot interaction in logistic applications for highly flexible warehouses and CADDY – Cognitive autonomous diving buddy (Faculty of Electrical Engineering and Computing, University of Zagreb).

CCC for the ICT sector was established for the purpose of strategic direction of ICT sector and support in defining specific target niches for Croatia. In that aspect they have issued the Strategic ICT Sector Framework 2013 – 2020\textsuperscript{198}. The Cluster includes 37 members from the business sector, universities and research institutes.

Since ICT became inevitable asset in development of RDI capacities of ROs, it is necessary to mention the current state of ICT resources of Croatian research system. Coordinating, developing and

\textsuperscript{196} Data for 2012 (Entrepreneurship and Investment Strategy in the Republic of Croatia 2013 – 2020, Ministry of Entrepreneurship and Crafts, 2013)
\textsuperscript{197} European Commission, JRC-IPTS (2015), Stairway to Excellence Facts and Figures: Croatia, Update: 01/07/2015
\textsuperscript{198} Strategic ICT Sector Framework 2013 – 2020, Competitiveness Cluster for the ICT sector, Ministry of Economy, 2013
maintenance of the e-infrastructure layers is conducted by the Croatian Academic and Research Network and the University Computing Centre – Srce (including other e-infrastructure layers: CRO NGI – National Grid Infrastructure, the Isabella Computer Cluster etc.). The role of Ruđer Bošković Institute has to be mentioned due to significant contribution to the data infrastructure. These key parts of joint e-infrastructure aim at empowering researchers with an easy and controlled online access to facilities, advance computing resources (HPC, HTC), storage resources, network connectivity and various collaboration tools, as well as foster the emergence of e-Science, i.e. new working methods based on the shared use of ICT tools and resources across different disciplines and technology domains. Due to the lack of funds, only minimum operation and maintenance of existing hardware is being done which could bring into question the viability of the entire system in the very near future. Therefore, one of the strategic project is the planned HR ZOO project (the Croatian scientific and educational cloud) that will consists of modernization, upgrading and equipping of current CRO NGI which is a common resource of the scientific community representing the basic infrastructure for the scientific research, the application of new technologies. This project, which is one of the most important identified in the Croatian Research and Innovation Infrastructures Roadmap, will enhance and upgrade the whole Croatian research community, allowing multipurpose use of e-resources. Croatian research organisations have participated in several multinational networks and infrastructures: Trans-national cooperation among ICT National Contact Points, Multi-Gigabit European Research and Education Network and Associated Services (GN3plus), European Grid Initiative: Integrated Sustainable Pan-European Infrastructure for Researchers in Europe (EGI-inSPIRE), SEE-GRID e-infrastructure for regional e-Science (SEE GRID SCI) and Common language resources and technology infrastructure (CLARIN).

Identified potentials and areas to strengthen implementation of ICT in TPAs and STPAs of Croatian Smart specialization strategy:

1. Robotics and automatization

Robotics has initial potential for the development of elements that, together with the elements listed in the communication software, can be integrated in complex systems for the development of new industrial plants (Industry 4.0) or with the full application of the IoT ensure the creation of “cyber-physical systems”. So far, the most robotics projects were oriented towards health, security and transport application. It is notable that one RDI topic particularly emerges throughout every identified TPA’s RDI topics of Croatian Smart specialization strategy: Process and embedded computer automation and control processes. This field of investment is of most interest to various industry branches identified under TPA’s and it can be said that this particular ICT application area is needed link for improving current level of technological development for Croatian industries.

In order to develop competitive industry (industry 4.0. and lean manufacturing capacities), important prerequisite will be to develop capacities in area of Process and embedded computer automation and control processes (microcontrollers, sensors, lasers for positioning the object, PLC’s, HMI’s, SCADA systems) for which Croatian ICT sector has capacities, has potential demand and future prospects. Academic community is very active in R&D in this area (especially the University of Zagreb, Faculty of Electrical Engineering and Computing, and the Faculty of Mechanical Engineering and Naval Architecture), but also a certain number of medium-sized and small enterprises that develop their own robots and automatization systems (e.g. DOKING that manufactures demining robots) and components, especially software for controlling the robots and application of embedded systems. Notable achievement in R&D in robotics is RONNA - Robotic Neurosurgical Navigation (a new application of robotics in neurosurgery based on a dual-arm configuration with coordinated navigation and a new localization method. The use of robots is not limited only to the replacement of stereotactic frames, but robots can also be used as an assisting technology) ASSISI_BF- Animal and robot Societies self-organize and by Integrate Social Interaction (FP7-ICT) project.

2. Internet of Things, Big Data and Internet-based services
R&D activities in Croatia related to Future Networks and Future Internet cover three related segments of the global value chain: Internet of Things (communication software and platforms for interconnected objects), Big Data (acquisition, processing and analysis of data originating from physical and virtual world) and Internet-based services, all for application domains defined by TPAs. Croatia tends to focus its investments for the purpose of supporting identified TPAs in following specific areas: e-health solutions and related technologies; ICT-based services and applications for improving quality of life for persons with disabilities, including solutions for Alternative and Augmentative Communication; Solutions for Smart Metering and Internet of Things; ICT solutions connected to energy sector (Smart Cities and Utilities, Smart Mobility and Smart Living); Environmental monitoring based on Internet of Things and Big Data analysis; Smart citizen solutions for environmentally friendly multimodal transport; Internet of Things and Big Data in transport; mine-information and geo-information systems (e.g. systems for multi-criteria decision making based on geo-information system, development of E-learning for EOD training); Internet-based services for managing agricultural and food production operations; ICT solutions in wood furniture production; all RDI topics in STPA Cyber Security are related to ICT.

Communication software and platforms for interconnected objects encompass components of existing and Future Networks and existing and Future Internet, specifically Internet of Things (IoT) and Machine-to-Machine communications (M2M) converging to the unique concept of interconnected objects by linking and networking various objects in the physical and/or virtual world (machines, things, devices, sensors, actuators) for different application domains. Such a pervasive communication and computing environment generates enormous quantities of data. It is closely related to Big Data processing and analysis, and usage of Internet-based services.

Respectable results are achieved in the area of Internet of Things, including M2M, where RDI activities resulted in open source platform OpenIoT (Open Source blueprint for large scale self-organizing cloud environments for IoT applications” (FP7-ICT))199. Contribution of Croatian researchers is an IoT cloud-based publish/subscribe middleware experimentally verified by urban air quality crowdsensing based on mobile sensors. Research and international co-operation in IoT is continuing in a new project symbIoTe – Symbiosis of smart objects across IoT environments (H2020-ICT), in which the University of Zagreb takes the role of technical coordination. RDI in the area of M2M resulted in a new M2M products consisting of Device Connection Platform and Multiservice Delivery Platform (Company Ericsson Nikola Tesla). Cooperative networked embedded systems were research topic within the project ACROSS – Centre of Research Excellence for Advanced Cooperative Systems (FP7-REGPOT). Also, Brodarski institut ltd. is engaged in the process and embedded automation and control processes in the area of turbine governing and managing ship systems. Activities include research and turnkey solutions.

In the area of Internet-based services important RDI results are related to health and food. Various aspects of the application of ICT in health, assistance for old people and people with special needs are explored in a number of projects: UNIVERSAAL – Universal open platform and reference Specification for Ambient Assisted Living (FP7-ICT), eWall for Active Long Living (FP7-ICT), Carewell – Multi-level integration for patients with complex needs (CIP-ICT), ICT-AAC – ICT Competence Network for Innovative Services for Persons with complex Communication Needs (IPA SIIF), ICTGEN – Information and Communication Technology for Generic and Energy Efficient Solution with Applications in e/m-Health (ERDF), DIABICT – Technology Platform for New ICT Strategies in Diabetes Therapy and Control (ERDF). R&D projects in the business sector resulted in the solutions for hospital and laboratory information systems, electronic health care records, e-ordering, e-prescription, remote patient monitoring and other (products and services by IN2 Group, Ericsson Nikola Tesla and SMEs). Two internationally recognized start-ups are among the first

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199 http://www.fer.unizg.hr/istrazivanja/projekti?@=2h3gt#proj_16216
companies in the world developing web applications for managing different agricultural operations: Farmeron, Osijek and Agrivi, Kutina.
6. DEFINITION OF COHERENT POLICY MIX AND ACTION PLAN

6.1. Croatia’s policy mix is tailored to improve the National innovation system, improve innovation performance and competitiveness of the Croatian economy

The innovation performance is considered to be a key driver in increasing economic competitiveness, solving societal challenges and supporting the transformation of societies. It is essential that the challenge of designing broad and effective innovation policy mix is properly addressed. Innovation policy mixes are country specific and the Croatian government selected instruments based on strengths and weaknesses of the National Innovation System. While developing Policy Mix and Action Plan several key issues were considered: (i) factors that influence the composition of the mix such as the type of grant schemes, (ii) use of indirect measures or demand-side actions, (iii) thematic prioritization, (iv) the range and share of funding, the combination of single individual measures and (v) the delivery mechanisms.

Developing the national innovation policy mix is a long-term issue. Short-term innovation policy measures will not attain a full impact given the time necessary for any policy measure to induce structural or cultural change. The average duration of policy measures across all countries has been seven years. It has been stressed that the impact of innovation policy depends as much on the implementation mode as on the selection of policy instruments. For instance, a low level of innovation performance can be the result of a mismatch between the policy challenge and the policy instruments. Selecting appropriate policy mix is crucial for innovation development. Country needs to focus on the National Innovation System Strengths and Weaknesses in order to be effective a policy mix should cover the entire innovation process, target weak elements, reduce bottlenecks and build upon strengths.

Croatia carefully evaluated all these factors and reviewed experiences of other EU countries. Recent European Commission’s report analyzed innovation related policies for all member states. The analysis tends to confirm the mismatch between the innovation performance and the policy models that are implemented in countries with different innovation performance and fine-tuning is very much needed. “For example, the ‘Business R&D and innovation’ policy mix model can be found in leaders, followers and moderate innovators but not in modest innovators that might be expected to follow this policy mix as they are very weak in terms of business RDI. Likewise, the prevalent research orientation of innovation policies may be appropriate for technology leaders but not necessarily for modest and moderate innovator countries that have, in principle, less absorption capacity for businesses to innovate.” When designing the future S3 Policy Mix the Croatian Government considered the current weaknesses:

1. Perhaps the biggest challenge of all is strengthening the policy governance in order to increase spending impact. Currently, the system is not fully functional. Public funds for R&D are allocated without clear prioritization, structured innovation road that determines and awards in connected stages development of new product or service to the market (innovation road map) and result orientation. This is reflected in the low levels of government support to the business community as well as in the low share of experimental research in total research. Indirect

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201 Flanagan and al. (2010)  
government support through tax incentives is more significant in Croatia, although the total level of assistance does not exceed 0.05 percent of GDP.

2. **The technology and innovation policy is still fragmented in Croatia, resulting in programs with overlapping objectives and a lack of rationalization of resources.** Though there have been some changes and initiatives in that sense, there is a strong necessity for more efficient management of resources allocated for RDI. The process of restructuring PRO aiming at more efficient management of research institutes (centralization under the Ministry of Science, Education, and Sports (MSES) started in Croatia in 2015, but in order to avoid overlapping and design programs and measures there need to be more collaboration between different bodies. The Ministry of Economy and Ministry of Entrepreneurship also have also programs with a particular focus on increasing academy-industry linkages and good coordination between the ministries is ultimately needed.

3. **Croatia’s shows a lacklustre performance in business research and innovation.** Despite the economic benefits that innovation activity can have on firms-competitiveness, sales growth, employment growth, and survival, -the private sector shows only a moderate innovation performance. It is primarily large and old companies, which conduct innovation, and there is a missing-middle problem, as medium-sized firms do not invest significantly in R&D. This problem is mainly explained by limited access to internal and external resources (funds, qualified personnel), as well as market factors, including unfair competition and uncertain demand. Evidence regarding the composition of innovative activities shows that companies engage primarily in quality upgrading but do not perform well when it comes to the introduction of new goods and services.

4. **Croatian legislation on intellectual property is in line with EU directives, but it has failed to spur indigenous innovative activity due to the problems with effective protection.** Legislation on patent protection and registration of utility models is well developed and covers the key areas of new discoveries, scientific theories, and mathematical methods. The law puts no restrictions on the use of intellectual property for collateralization purposes; and research institutions, including universities, are given broad discretion in controlling their intellectual property rights. Although these measures have reduced unlawful appropriation of IP, their implementation remains uneven, and the uptake by the private sector has been minimal and predominantly limited to patents generated through international collaborative efforts. In order to ensure more efficient and transparent IPR protection the Croatian government is preparing revision of Patent Act related to Boards of Appeal and consensual patent. The efficiency of the judiciary has improved in recent years, though shortcomings persist, such as a large backlog of unresolved civil and commercial cases (EC, 2013). Croatian government will put in place effective IPR protection and will revise IPR guidelines pertaining to government-funded research, joint public/private and academic/private research. Government will encourage use of the IP system by enhancing knowledge of all its elements not only patents, but also trademarks, geographical indications, industrial designs, utility models, etc. Streamlining the IPR application process, making the dispute prevention and resolution process more effective and reducing transaction costs would also facilitate its use by inventors, researchers, entrepreneurs, and SMEs. The recent approval in January 2013 of an EU unitary patent system is a welcome development and should facilitate the protection and management of IPR in Croatia. Innovation Strategy foresees increasing number of patent applications per million inhabitants from 6,6 to 25 in 2020 as one of the main indicators for achievement of goals set by the Strategy. Therefore, one of the measures set by this strategy refers to establishing transparent system of IPR management oriented towards HEIs and PROs in order to increase patenting of research results. It is important that new regulations include guidelines related to distribution of commercialization profits as well as regulating researchers’ role in active collaboration with technology transfer offices and centres of competence in the process of commercialization. Several measures are planned in order to strengthen TTOs in having more active role in successful commercialization of research results.
5. **A number of factors have a negative impact on innovation including the tax regime, insufficient early stage financing (first and second round of investment), and the business environment.** An important structural problem that the country faces is that the volume of business R&D is low, despite the generosity of existing tax breaks for companies performing R&D. Although small firms represent the majority of the beneficiaries overall, large firms receive most of the benefits. In addition, there is concentration by sector, as only few sectors account for the majority of the tax advantages. The lack of early stage finance risks the premature death of potentially viable innovative start-ups. There are a number of reasons to believe that there is healthy demand for funds. This includes the existence of government programs for support of business R&D, as well as estimates of investable demand. Although recently Croatian Government started 20 million euro Venture Capital fund, this is the only major supply of venture capital in Croatia.

6. **Research excellence and science-industry collaboration are low compared to the EU average.** The quality of the scientific publications is low, both in terms of scientific publications among the top 10 percent most cited worldwide, and average citation impact. This is partly due to lack of funds for infrastructural investments in public research organisations resulting in inadequate equipment and working facilities. The country also falls slightly below the EU average in the share of doctorate graduates. Another of the barriers to innovation capacity building is the lack of adequate linkages between research institutions and the private sector. The country shows a poor performance in the number of public-private co-publications, and the percentage of innovative SMEs collaborating with ROs. Large firms mostly dominate cooperation. Measures are needed to foster research system in order to become globally competitive and economically relevant.

7. **Better innovation performance would help close the productivity gap between Croatia’s enterprise sector and its EU competitors.** The contribution of innovation to sales growth, labor productivity growth, and TFP is lower than that of its peers. The country also underperforms in the contribution of R&D expenditures per worker to firm performance although analytical evidence shows that returns to R&D are higher than returns to infrastructure or education.

As the moderate innovator in EU Croatia is characterized by weak business R&D and the policy mix is going to target much more business R&D and innovation. Selected Policy mix is going to foster industry-science links by using different instruments.

6.2. **Definition and description of Coherent S3 Policy mix and delivery instruments**

The implementation of the S3 in Croatia requires an integrated and effective mix of different policy instruments geared to the objectives set by the strategy. Croatia will have a wide range of fields of action which tries to group projects that can be financed from available ESI and national funds, private and other possible source of financing. There are 14 types of delivery instruments available for the implementation of the S3 in Croatia, each directed in its own way to contribute to the achievement of the S3 specific objective(s) (Figure 31) and raising competitiveness of each of 5 thematic and 13 sub-thematic priority areas.

Delivery instruments will horizontally create a nurturing environment for the growth of innovative business, strengthen the relationships between universities and industry, encourage the flow and transfer of knowledge and technology, and increase the ability of enterprises to develop, use, adapt and commercialize new technologies and innovative products. This will contribute to improved competitiveness of the Croatian economy concentrated on S3 thematic and sub-thematic priority areas through investment in RDI, and will improve its position in overall export and global value and supply chains. Moreover, upgrading the technological capabilities of enterprises would be an important step towards raising Croatia’s investments in R&D to reach the 1.4% of GDP target by 2023.
The S3 delivery instruments are designed to improve conditions and access to finance for research and innovation, so that innovative ideas can ultimately be turned into products and services and thereby create growth and jobs. It is important to convert the S3 objectives into targeted support measures and smart investments that will deliver concrete and tangible results. Upgrading innovation capabilities, increasing private research and innovation investments, increasing the number of start-ups and innovative companies, increasing revenue from new products and services, providing better and more tailor-made support services for SMEs, improving international exposure and commercial track-record of clusters, improving access to finance for start-ups (venture capital) and better positioning of Croatian economy in global value and supply chain are examples of areas that will be tackled by the strategy and have impact on overall economy.

The tools to reach the S3 objectives must cover whole innovation value chain and include all relevant stakeholders through carefully designed schemes as instruments for mobilizing specific target groups and resources from public and private sector in order to create an innovation ecosystem capable of transferring ideas into high value products.

Concerning the fact that delivery instruments developed for the implementation of the S3 are defined in a way that they tackle more than one of the determined objectives, they are grouped into 4 delivery areas, according to their role in innovation value chain:

1. **Establishment of the more effective National innovation system**
   i) Establishment of Innovation Network for Industry and development of Thematic Innovation Platforms;
   ii) Science and Technology Foresight project;
   iii) Development of Technology Transfer Offices and Science-Technology Parks;

2. **Developing RDI Infrastructure and enhancing RDI activities**
   A. **Development of RDI Infrastructure**
      i) Development of new and the improvement of existing RDI infrastructure in Croatia;
      ii) Centers of Competence
   B. **Enhancement of RDI activities**
      i) Support to business investment in RDI
      ii) Support to SMEs capacities to innovate
      iii) Support to social innovation
      iv) Support to research organizations conducting R&D projects directed towards the needs of economy
      v) Strengthening research excellence by supporting national Centers of Research Excellence and enabling synergies with ERC grants

3. **Upgrading in global value chain and promoting internationalization of Croatian economy**
   i) Support to competitiveness cluster initiatives

4. **Development of smart skills**
   i) Establishing infrastructure for smart skills policies
   ii) Medium term tools for skill assessment at the level of competences
   iii) Implementing the Croatian Qualification Framework mechanism for delivering timely and standardized training programmes based on future and medium term skill needs
6.2.1. Establishment of the more effective national innovation system

In order to enable more efficient evidence based policymaking and facilitate strategy and decision making within the public and private RDI sector, as well as to steer the implementation of the S3 strategy and to stimulate and increase collaboration between public research sector and business sector, following delivery instruments are foreseen: i) Establishment of Innovation Network for Industry and development of Thematic Innovation Platforms; ii) “Science and Technology Foresight” project and (iii) Development of Technology Transfer Offices and Science-Technology Parks.

i) Establishment of Innovation Network for Industry and development of Thematic Innovation Platforms
Establishment of Innovation Network for Industry (INI) and development of Thematic Innovation Platforms (TIPs)\textsuperscript{203} will be an effective way to stimulate RDI and provide the means to foster public-private partnerships between the research community and business sector with the aim to mobilize the research and innovation efforts towards achieving common goals. In achieving its wider goals, for each TIP will be established Thematic Innovation Council (TIC) which should, in a medium to long term perspective, provide operative leadership in the fields concerned, by identifying and approving new potentials for more effective investment in RDI (particularly in the business sector), accelerating innovation and experimental development phases of research connected to TPA’s and identifying and eliminating the barriers to the deployment and growth of new technologies. TICs will be industry led and formalized gatherings of relevant stakeholders in selected thematic priority areas, including representatives of business sector, academia and public administration. Hence, TICs will discuss and approve long-term visions to address a specific challenges and new potentials in particular TPA. They will be highest advisory and decision making body in creation of coherent RDI strategies aimed to the benefit of business sector to steer the implementation of agreed programs and activities and optimize the benefits for all stakeholders. The preparation of business sector RDI project pipeline will form a crucial part of the implementation strategy. TICs will be the main instrument for continuation of the process of smart specialization in the following years and they will enable continuous entrepreneurial discovery process (EDP) through formation of Priority Action Groups for each S3 Sub-thematic Priority Area and preparation of thematic RDI strategies. TICs will also encourage entrepreneurs and companies to discover ways to be more successful and more competitive on the EU and global market through learning process which will discover the research and innovation domains in which Croatia can hope to excel. In this learning process, entrepreneurial actors will likely play leading roles in discovering promising areas and niches which will allow structural changes of Croatian economy in the form of diversification, modernization, transition and radical changes (Figure 33).

Thematic RDI strategies and related Action plans will include a vision, key objectives and specific actions along with defined specific TPA indicators and targets (output, outcome/result and context), timelines and identification of parties responsible for leading and supporting delivery of action. It is planned to prepare thematic RDI strategies and related Action plans until the end of 2016. They will represent a base for more concentrated business sector activities targeted to S3 thematic and sub-thematic priority areas.

Figure 33 STPA Groups

\textsuperscript{203} Annex 6 explains INI structure and correlation between TIPs, TICs, PAGs and web platform.
In order to increase efficiency and effectiveness of RDI programmes and structures, during the process of preparation of thematic RDI strategies for business sector, results stemming from Science and Technology Foresight project (to be implemented by MSES) will be taken into consideration.

ii) “Science and Technology Foresight” project
Science and Technology Foresight project aims at enabling the systematic analysis of science and technology potentials of Croatia in order to improve the institutional framework for RDI policy-making and implementation in Croatia and to facilitate cooperation between government, scientific community and businesses, building a network of stakeholders.

In order to achieve these goals it is planned to develop integrated, coherent and permanently updated information system for science in Croatia which will compile different sets of statistical data and indicators fundamental for evidence based policy development. This will enable strong analytical base, built on comprehensive overview of performed activities, available resources (human and material) and outputs (publications, projects, patents, research income, etc.), which is necessary for evaluation and monitoring of national research system. Additionally, development of an open access information system including data on available research infrastructure, research groups’ competencies and research organizations’ services should encourage further cooperation between academia and industry. Mapping and expert assessment of the capacities of public RDI sector will enable identification of focal points of research excellence in Croatia.

By analysis, mapping and assessing the capacities of public RDI sector, research excellence spots in the Croatian research system will be identified, through creation of series of maps and visualizations (based on patent maps, maps of science and trade literature (including grant proposals, reports, etc.), regulatory literature maps, etc.), enriched with descriptive or tabular data on technologies, reflecting the current (at the moment of the analysis) technology state.

Furthermore, intense consultation process of a large number of representatives from business community (as well as representatives of established Thematic Innovation Councils), research community and public administration will be conducted, organized by thematic priority area and by horizontal issues (i.e. internationalization, human resources, competitiveness), in order to build a common vision for all stakeholders, of the future science and technology development in Croatia.

These two projects are complementary, in a sense that project "Scientific and technological foresight" is primarily focused on public scientific organizations and mapping of the science system as well as establishing long-term trends of its development, while project "Establishment of Innovation Network for Industry (INI) and development of Thematic Innovation Platforms (TIPs) to support the establishment of Innovation Network for Industry and Innovation Platform," primarily focuses on business sector and on identifying and mapping the needs of the business sector, with the final goal of encouraging and facilitating business sector investments in RDI. Implementation of both projects will start simultaneously, by the end of 2015.

Since these two projects are interconnected, to make their implementation more efficient, a cooperation agreement between the ME and MSES will be signed. The Agreement will include provisions to ensure coherent methodologies and tools for mapping and exchange of data and results from both projects, including dissemination of their results to the wider public. It will enable integrated approach to development of National innovation system and evidence based policy making in RDI sector. This will contribute to attainment of this delivery instrument objectives.

(iii) Development of Technology Transfer Offices and Science-Technology Parks
In order to strengthen links between scientific and business sector MSES plans two grant schemes intended to support activities of i) Technology Transfer offices and ii) Science and Technology Parks in identified TPAs / crosscutting themes and STPA of S3.
Through support to Technology Transfer Offices MSES wants to enhance transfer of technology from ROs towards business sector by supporting complex knowledge and technology transfer services to ROs and business sector. This includes activities such as:

- development of ROs capacities for technology transfer by enabling: advisory services of TTOs to RO in development of their Intellectual Property Rights (IPR), strategy knowledge and technology transfer policy and activities, networking and awareness raising activities related to technology transfer at the level of entire public research system;
- licensing and other IP/R&D agreements/contracts, negotiation, technology evaluation, exploitation and valorisation, technology screening, technology scouting (in thematic and sub-thematic priority areas of S3 or cross-cutting themes that will have a spill over effect on one or several sub-thematic priority areas).

Several universities in Croatia and RBI have established TT offices. So far the most successful were the TTOs at the University of Zagreb and University of Split, but most of them need to strengthen their capacities and expand services portfolio in order to ensure successful transfer of technology.

With support to Science and Technology Parks, MSES aims to enhance and encourage collaboration between science and business sector at local level with the intent of creating high technology economic development. The goal is to develop high quality STPs providing pro-innovative services and supporting innovation in SMEs, including R&D related activities.

### 6.2.2. Developing a globally competitive and economically relevant research system

#### A. Development of RDI Infrastructure

The aim of delivery instruments assembled within this group is the development of new and the improvement of existing RDI infrastructure in Croatia which should result in upgraded RDI ability for conducting excellent as well as focused research and cooperation on national and international levels. There are two delivery instruments whose objectives are: i) creation of Centres of Competences and ii) increased R&D ability for conducting top quality research and cooperation on national and international levels. While the former delivery instrument is managed by ME, the latter is managed by MSES and is composed of different measures and activities related to: i) modernization/building and equipping of RDI infrastructure of research organizations, ii) preparation of required documentation for these investments and iii) support for infrastructural investments with regards to Croatian priorities within Horizon 2020 measures for spreading excellence and widening participation: Teaming, Twinning and ERA chairs.

(i) **Development of new and the improvement of existing RDI infrastructure in Croatia is crucial for creation of globally competitive and economically relevant research system.** This is an important prerequisite that should result in upgraded RDI ability to conduct high quality and focused research and cooperation both on national and international levels. MSES is in the process of revision of current Croatian Research Infrastructure Roadmap in order to link it more closely to S3 strategic objectives described here. Ministry of Economy is developing a platform for creation of Centers of Competence, another important innovation related instrument which will be closely linked to Infrastructure Roadmap.

The implementation of MSES delivery instrument is envisaged in a way to address the above mentioned aim. Through the first grant scheme it is planned to invest into RDI infrastructure in identified TPA or cross-cutting themes with spill-over effect on numerous sub-thematic priority areas of S3. The support will be focused on investments in RDI infrastructure (construction of new, renovation and development of existing RDI infrastructure, including e-infrastructure, buildings and equipment needed) and equipping of the RDI facilities which will boost the capacities of RO. In order to be financed research organisation/research infrastructure has to submit strategic document including a well-defined research agenda with matching organisational improvements. The beneficiaries are
Since ICT technologies became inevitable asset in development of RDI capacities of ROs, it is necessary to invest also into development of e-infrastructure. E-infrastructures aims at empowering researchers with an easy and controlled online access to facilities, advance computing resources (HPC, HTC), storage resources, network connectivity and various collaboration tools. E-infrastructures foster the emergence of e-Science, i.e. new working methods based on the shared use of ICT tools and resources across different disciplines and technology domains. Such investment is the planned HR ZOO project (the Croatian scientific and educational cloud) that falls under strategic project category and is of major importance for Croatia. It has been recognized as an important prerequisite for the development of the Croatian research area since it will upgrade the whole Croatian research system. Its implementation will create a common infrastructure for the needs of modern science and high education and internationally relevant research, but at the same time it will serve as an instrument of integration into the European Research Area (ERA) and the European Higher Education Area (EHEA). The project consists of modernization, upgrading and equipping of current Croatian National Grid Infrastructure (CRO NGI) which is a common resource of the scientific community representing the basic infrastructure for the scientific research, the application of new technologies. Due to the lack of funds, only minimum operation and maintenance of existing hardware is being done which in the very near future could bring into question the viability of the entire system.

The main objective of the project conducted by the University Computing Centre (SRCE) is to establish computing and data clouds, as fundamental components of the national e-infrastructure. Strengthening research infrastructure, such as grid infrastructure and high-performance computing resources, forms an integral part of the Digital Agenda for Europe, one of seven flagship initiatives of the Europe 2020 Strategy, set out to define the key enabling role for better utilization of social and economic potential of Information and Communication Technologies (ICT). HR-ZOO is designed as a distributed, national e-infrastructure composed of grid resources nodes, high-performance computing resources nodes and cloud resources nodes. The implementation of the project will have an overall impact on the entire research community making it more connected - computing and storage resources located in the HR-ZOO data centres will be interconnected but also connected to international infrastructures (European Grid Initiative - EGI, etc.-), performant - providing sufficient long-term, advanced, reliable, efficient, flexible and sustainable computing resources, storage resources, and network connectivity, necessary for modern science- and as well as efficient in terms of answering the need of economy enhancing sharing of information and collaboration. The aim is to allow researchers to: exploit the power of advanced ICT and applications to continuously enhance the process of research itself; collaborate and communicate securely with others, across disciplines, institutions and sectors; maximise the potential of advanced technologies to support innovation and experimentation; share their research outputs with others and re-use them in the future; engage with industry in support of wider economic goals. This completion of this strategic project will act as booster for RO capacities.

It is also planned to invest into infrastructure which will not directly be related to specific TPA or STPA, but in identified cross cutting theme of S3 -KETs. However, its implementation will have to have an impact on several priority thematic and sub-thematic areas of S3. This is, for example,
applicable to major project “O-ZIP” of RBI which is partly in KET (cross-cutting theme) with spill-over effect on numerous priority sub-thematic areas of S3.

The second grant scheme within this delivery instrument will also influence capacities of research organizations in a way to attract more R&D funds and more collaboration with businesses. In order to ensure successful implementation of infrastructural projects MSES also plans to invest into development of projects documentation needed for successful application and further implementation of RDI infrastructural projects (see Annex 5). In this respect, the administrative and absorptive capacities of research organizations will be increased to be able/ready to implement complex infrastructural RDI projects.

Furthermore, through third MSES grant scheme it is planned to support infrastructural investments in regards to Croatian priorities within Horizon 2020: Teaming, Twinning and ERA chairs. Project that have received grant from Horizon 2020 will receive support for infrastructural investments which is necessary for successful implementation of Horizon 2020 project, but is not eligible expenditure under Horizon 2020 programme. However these projects will not be funded automatically, but they have to pass a compliance check with S3 priorities and with OPCC selection criteria. In this way MSES will enable synergies with Horizon 2020, by coordinated efforts to achieve greater impact and efficiency of projects.

ii) Centers of Competence (CoC)

One of the main instruments of the Ministry of Economy for bridging the gaps in the Croatian innovation value chain will be the establishment of highly focused Centers of Competences (the desirable number is at least one for each of S3 sub-thematic priority area) which will be a reflection of industrial needs and capabilities from one side, and future challenges and need for specific R&D on the other side of spectrum. Their function will be to enhance capacities for innovation of the business sector (especially SMEs) providing RDI infrastructure and services for industrial research and experimental development in areas which do not have adequately developed R&D infrastructure, and/or need a greater concentration of expertise in one or more TPAs. It is envisaged that each CoC will be established on the basis of the sound RDI strategy for specific field of research prepared together by the business community, science sector and/or regional authorities, as well as the framework consortium agreement signed by the stakeholders involved. Important element is the fact that CoC’s must provide evidence (consortium agreements) that substantial number of collaborative projects from industry stakeholders is willing to use the requested R&D infrastructure and invest private funds in projects to be conducted under CoC’s. It is envisaged 3 models for establishment of CoCs aligned to State Aid Regulations:

1st Model: CoC is consortium between at least two (2) business entities and one or more organizations for research and dissemination of knowledge in order to set up effective cooperation on research and development projects;
2nd Model: CoC is the innovation cluster, which includes at least three (3) business entities and, where appropriate, one or more organizations for research and dissemination of knowledge in order to encourage innovation activities;
3rd Model: CoC is the legal entity that manages the research infrastructure.

All CoC’s must fulfill general compliance to identified S3 Thematic and Sub-thematic Areas. The selection process is divided in 2 parts: Pre-selection of potential applicants on grant schemes for CoC and future call for proposals procedure. The main guiding principle for pre-selection of support to CoCs will be the ability of CoCs to serve the needs of enterprises, particularly SMEs, and their ability to prove that CoC will help the creation of critical mass of subjects and their interest to develop RDI activities. Pre-selection process along with fulfilling obligatory general alignment to identified S3 Thematic and Sub-thematic Areas identifies also following criteria:

- Label confirmation (approval decision) from at least one Competitiveness Cluster Board that proves that CoC present added value to the industry sector, companies operating in
presented research area, is aligned to the voted strategic guidelines of particular industry sector and represent benefit and significance to regional economy;

- Developed RDI Strategy defining the field of research, main objectives, number of companies and partners involved in the CoC project, type of projects, and etc. (All in accordance to Guidelines provided by Ministry of Economy);
- Defined legal status and model of CoC;
- Planned R&D project pipeline for requested investments targeting infrastructure investments.

Through the specific selection criteria’s Grant scheme applicant will be rewarded by extra points if CoC’s investments meet following criteria:

- CoC’s project partners from business side fall within scope of activity of identified key industrial Groups according to Industrial Strategy 2014-2020 – namely “Initiators” and “Guardians”. Selected Industry groups means that only Industry sectors (NACE classification: C21, C26, C25, J62, C27, C28, C10, and C31) that satisfy criteria’s in (i) profitability, (ii) export orientation and (iii) size of the group will get extra points on RDI tenders;
- Sustainability of CoC (targeting projects that are complementarily to current technological processes and development records of companies involved – offering them new innovative solutions, perspectives for potential spillovers and inclusion of critical mass of subjects supporting selected research topics)
- Degree of effective collaboration and number of partners involved;
- Level of innovativeness and significance of the proposed project’s activities under CoC to the market (new domain in innovation to the firm/national or global market (which drive to leadership position in selected niche));
- Proximity of the expected CoC’s projects result to the market (basic or industrial research/experimental development);
- The significance of CoC’s activities to national economy (in term of job, sales, export);
- Degree of connectedness of the activity vis-à-vis the rest of national economy;
- The contribution of CoCs research and innovation to the generation of one or more structural changes (modernization, diversification, transition, radical foundation);
- The contribution of CoCs research and innovation to the resolution of key societal challenges (Health, demographic change and wellbeing; Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bio-economy; Secure, clean and efficient energy; Smart, green and integrated transport; Climate action, environment, resource efficiency and raw materials; Inclusive, innovative and reflective societies; Secure & innovative societies);
- The contribution of Project’s to balanced regional development

B. Enhancement of RDI activities

Planned delivery instruments are addressing major weaknesses recognized by the main actors of the scientific and business community and are based on a long-term observation of weaknesses related to the stimulation of the RDI investments of the public and private sector mainly related to the lack of financing. The proposed actions therefore reflect the long-term problems of rather fragmented support system for RDI and propose the framework for addressing majority of issues. By concentrating and defining clear actions to follow and actions already being developed and prepared by different bodies, we are defragmenting the current obsolete and weak system of stimulating the private investments in

204 According to the Croatian Industrial strategy 2014-2020 key industrial group defined as large export oriented groups that generated positive EBITDA and employ a significant number of employees.
205 According to the Croatian Industrial strategy 2014-2020 large industrial groups focused on domestic market that generate positive EBITDA and employ a significant number of employees.
RDI and concentrating on the most important issues: business investment in RDI, collaboration, defragmentation of the innovation eco-system and scientific excellence.

In order to attain this objective, a set of instruments and activities are envisaged in order to support different types of RDI activities and projects of either research organizations or business actors as well as mutual collaborative projects, namely: i) Support to business investment in RDI, ii) Support to SMEs capacities to innovate, iii) Support to social innovation, vi) Support to research organizations conducting R&D projects directed towards the needs of economy and v) Strengthening research excellence by supporting national Centres of Research Excellence and enabling synergies with ERC grants.

i) Support to business investment in RDI

Croatian economy must ensure it is open and capable of adapting to more rapidly evolving technological developments. It must also be able to contribute to these developments and in particular acquire high level of expertise in key technologies. The smart specialization framework recognizes the role of both technological and non-technological innovation to the process of specialization/diversification. Comprehensive support for business innovation, especially for the long-term accumulation of in-house innovation capabilities in variety of companies, will have to address businesses and their needs more directly, be better endowed, and make more extensive use of policy instruments. In that sense, Ministry of Economy will support business investment in R&D and will allow enterprises to be more innovative and to foster their current capacities for RDI with aim to raise their productivity, competitiveness and export activity and diversify the production and services offer. Support will be given to in-house R&D, contracting research and collaborative R&D projects, especially ones between large enterprises and SMEs. Aim of this support will be to speed up the market uptake of new knowledge and technologies at national and regional level. It will be supported through joint research initiatives in all types of R&D (fundamental research, industrial research and experimental development), as well as preparation of feasibility studies and strengthening R&D infrastructure. As these activities are much closer to the market and commercialisation than those of CoRE and above mentioned activities of research organizations, they will require significant amount of private investments in the RDI projects and therefore will contribute to the increase (and matching) of private investments in R&D. The closer the RDI project will be to the market (e.g. experimental development Technology readiness level 8) the higher contribution of the private investments in R&D will be. Financial instruments being developed for SMEs will also allow further investments in innovation and new products and services which currently do not exist in Croatia but represent a significant limitation to the take-up of private investments. The proposed S3 delivery instruments oriented towards business investments in RDI currently cover the whole innovation value chain (from targeted investments to business R&D to investments in commercialization of R&D activities).

Animation of business sector already started through established competiveness clusters where industry sectors have well defined their targets and interests in investing in RDI.

Support to business investments in RDI will be implemented in two steps. In order to efficiently resolve lack of RDI investment culture present mainly in business sector, for the first time public funds will be targeted mainly to business sector investments in RDI in selected five S3 Thematic and 13 Sub-thematic Priority Area (eligibility criteria will be that each Project must fulfil general compliance to identified S3 Thematic and Sub-thematic Areas). Through the main specific selection criteria Grant scheme applicant will earn extra points if:

- Project applicant and partners (if applicable) from business side fall within scope of activity of identified key industrial Groups according to Industrial Strategy 2014-2020 – namely “Initiators” and “Guardians”. Selected Industry groups means that only Industry sectors (NACE classification: C21, C26, C25, J62, C27, C28, C10, and C31) that satisfy criteria in

206 A European strategy for Key Enabling Technologies – A bridge to growth and jobs’ /* COM/2012/0341 final, Eur-Lex, 52012DC0341
(i) profitability, (ii) export orientation and (iii) size of the group will get extra points on RDI

tenders;

- Exist effective collaboration (number of partners involved from the science and/or business

sector);

and according to:

- Level of innovativeness and significance of the proposed project’s activities to the market

(new domain in innovation to the firm/national or global market (which drive to leadership

position in selected niche);

- Proximity of the proposed projects result to the market (research infrastructure, basic or

industrial research/experimental development);

- Project (Global) Value Chain relevance (product, process, and inter-chain upgrading) –

which can be measured by two relevant indicators: **Ratio of exports of final goods in total

turnover or Export potential of the project**

- Proven technological expertise and operational capacities of project holders and partners in

direct relation to identified S3 Thematic an Sub-thematic Areas;

- The significance of Project’s activities to national economy (in term of job, sales, export);

- Degree of connectedness of the activity vis-à-vis the rest of national economy;

- The contribution of expected Project’s result to the generation of one or more structural

changes (modernization, diversification, transition, radical foundation);

- The contribution of expected project to the resolution of key societal challenges (Health,

demographic change and wellbeing; Food security, sustainable agriculture and forestry,

marine, maritime and inland water research, and the bio-economy; Secure, clean and

efficient energy; Smart, green and integrated transport; Climate action, environment,

resource efficiency and raw materials; Inclusive, innovative and reflective societies; Secure

& innovative societies).

This first step will enable business sector to focus their initial RDI investments towards selected

priority areas, thus forming the innovation capacities and RDI business innovation culture for future.

Along with support envisaged through establishment of effective innovation ecosystem (National

project for development of Innovation Network for Industry - INI), this will be base for setting goals

and priorities for future in depth investments in RDI for each TPA and STPA in period 2017-2020 and

creation of Project pipelines for Business sector R&D projects. These activities will be pre-condition

for even more effective use of available funds for RDI in period 2017-2020 (the second step) that will

allow monitoring of not only detailed output but also outcome/result and context indicator for each

identified TPA. This second step in R&D investments oriented towards business sector in identified

TPAs and STPAs will have 2 main objectives:

1. Support the started processes of entrepreneurial discovery, to further motivate mainly business

sector to discover and produce information about new activities and potentials inside the selected

thematic and sub-thematic priority areas.

2. Based on the results of initial RDI investments and set strategic goals for each Priority area (defined

through Thematic RDI strategies for business sector) this will allow policy maker (Ministry of

Economy) to focus remaining funding for R&D and support most capable actors for realizing the

potential for growth, raising competitiveness and enabling structural changes of Croatian economy

with regards to new trends on the global market.

**ii) Support to SMEs capacities to innovate**

According to the analysis provided by the SME Development Strategy of the Republic of Croatia 2013

- 2020, only one third of Croatian SMEs are engaged in introducing innovation, in contrast to the large

enterprise sector (79% of large enterprises implement innovation). More than 80% of innovation

activities of SMEs relate to the procurement of new plant, equipment and software, while a much
smaller share is dedicated to the strengthening of innovation capacity, or more importantly, to the generation of new knowledge through R&D (internally or by external suppliers of R&D and innovation services).

Thus, the Ministry of Entrepreneurship and Crafts formulated a delivery instrument aiming to enhance SMEs’ capacities to innovate by supporting investments in implementation of new solutions in the areas of technology, product, process and organizational innovations, including marketing innovations, design and innovation advisory, IPR and support services as well as non R&D based solutions applied by SMEs. Complementary to the support to R&D activities of SMEs and their partners (covered by previous group of delivery instruments), the support under this delivery instrument will be provided for commercialization of R&D results into SME business activity (both carried out by SMEs’ themselves or bought on the market).

iii) Support to Social innovation

Social innovation can be developed by effective collaboration of private, academy and public sector, with partners coming from NGO sector, i.e. quadruple helix, and can be implemented at national, regional and local level. Public sector however plays central role in obtaining many products and services that are result of R&D activities with potential social and economic value, especially by using the instrument of innovative public procurement. Major expected results for this instrument will be to facilitate national, regional and local governments in embracing the social innovation as an important tool for increasing social welfare and to educate them in adopting and using the innovative public procurement in solving identified problems connected to societal challenges. Ministry of Economy together with the OECD team started developing Policy Framework for Social Innovation, in which it is foreseen to develop detailed recommendations for improving the social innovation ecosystem in Croatia, along with developing financial instruments that can be used to support social innovation. Also, along with these policy recommendations, methodology for selection of social innovation projects will be developed and several pilot projects of social innovations will be prepared.

iv) Support to research organizations conducting R&D projects directed towards the needs of economy

In order for Croatian research organization to perform their activities more closely to the needs of economy and business, closer collaboration between two sectors must be enhanced, so the aim is to increase public-private collaboration and to stimulate research organization to perform R&D activities closer to the market. Furthermore, the knowledge and technology that is produced by research organizations must be transferred to the business sector in order to increase the level of competitiveness and contribute to the growth and resolving of particular problems in the society. Respectively, research organizations need to work together with each other as well as with business sector entities in order to mobilize as many resources possible and jointly contribute to solving of above mentioned problems. Currently the collaboration between private and public sector R&D actors is insufficient which presents major obstacle for better innovation performance. As a moderate innovator Croatia will address this problem through several newly developed instruments and interventions, but will also continue to implement several HAMAG BICRO established instruments tailored to develop innovations, like IRCRO program which finances specifically joint projects between private and public sector. Croatian Science Foundation (CSF) has UKF program tailored to fund excellent public and private research with aim of both publishing and patenting. Grants are available for junior and senior scientists. CSF has several other programs tailored to collaboration between private and public sector.

To achieve this particular objective MSES has within the OP Competitiveness and Cohesion developed one delivery instrument with two grant schemes in order to enhance RDI activities and to tackle the mentioned shortcomings of RDI sector.
First grant scheme, which is envisaged as support to research organizations conducting R&D projects directed towards the needs of economy, where supported projects need to be implemented in identified sub-thematic priority area or crosscutting themes with impact on sub-thematic priority area(s) in order to be financed. In that context, grant scheme will be focused on financing RDI projects initiated by the research organizations, in partnership with another RO, with the clear aim to respond to the needs of economy/society. The interventions will support RDI activities and technological dissemination aiming at solving practical problems for industry and society in cases where potential users are not individual organizations or where technology is not yet developed to the implementation stage but there is explicit interest of business sector for its use. Results of the first call within the scheme will be evaluated prior to the launch of the second call.

Second MSES grant scheme within this delivery instrument targets RDI projects of research organizations in collaboration with a stakeholder from business sector acting as a project partner. Both phases of applied research will be supported: (i) industrial research and (ii) experimental development. Furthermore, under this grant scheme support will be given to research organizations for market-oriented RDI activities and dissemination of results into the business sector. The aim is to create a stronger impact on economic growth by enabling access to technology and knowledge transfer and facilitating the exploitation of R&D results through its dissemination.

v) Strengthening research excellence by supporting national Centres of Research Excellence and enabling synergies with ERC grants

Second MSES delivery instrument within this group is designed to strengthen research excellence by supporting national Centres of Research Excellence (CoRE) and enabling synergies with ERC grants. In the perspective of fostering scientific quality and excellence, Croatia recently established 7 CoREs, with the purpose of focusing on research groups, facilities and projects on the frontiers of science, ensuring international relevance regarding quality and vision, but also addressing national strategic priorities and priorities identified within this strategy. Four out of 7 centers are in fields relevant to S3; two are in the field of natural sciences - Advanced materials: i) Centre for Advance Materials and Sensors (RBI, Institute of Physics), ii) Centre for science and technology (University of Split), and two are in the biomedical field - Health: i) Centre for reproductive and regenerative medicine (Faculty of Medicine at the University of Zagreb), ii) Centre for viral immunology and vaccines (Faculty of Medicine at the University of Rijeka). These centers are created with the purpose of focusing on the best research groups with international reputation, facilities and projects which are at the frontiers of science, ensuring both national and international relevance. CoRE presents scientific organization or the integral part of certain scientific organization or group of scientists that according to the originality, importance and actuality of results of specific scientific work can be qualified and rated (within their specific field of expertise) amongst the most respected scientific organizations or groups in the world. With one grant scheme MSES plans to support RDI projects of CoREs which will be provide with long term resources for carrying out ambitious, complex research projects. Due to the complexity of R&D projects that CoREs will conduct and a long term effect they tend to produce, the supported activities aiming at strengthening research excellence should raise international recognition and visibility while addressing issues of strategic importance for Croatia as well as objectives of societal challenges in accordance with Europe 2020. CoREs will focus on conducting research projects in thematic and sub-thematic priority areas of S3 or cross-cutting themes that will have a spillover effect on one or several sub-thematic priority areas.

Croatia has several recipients of highly competitive ERC grants. With second grant scheme within this instrument, it is planned to enable synergies with ERC grants that support research projects of future

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207 COREs were selected through international peer review process on the basis of criteria set by the National Council for Science, Higher Education and Technology Development and proclaimed by the Minister of Science, Education and sports in autumn 2014. Currently, a new process of establishing new ones is under way.
and established research leaders in order to contribute towards **research excellence in Croatia**. The projects that did not receive funding under ERC but were shortlisted in the evaluation process will be supported (if they are in thematic and sub-thematic priority areas of S3 or cross-cutting themes that will have a spillover effect on one or several sub-thematic priority areas). Research projects proposed for funding should aim high, both with regards to the ambition of the envisaged scientific achievements as well as to the creativity and originality of proposed approaches. They should involve new, ground-breaking or unconventional methodologies, whose risky prospect is justified by the possibility of a major breakthrough with an impact beyond a specific research domain/discipline. This effort will help to fund excellent research groups and will prepare them better for other funding such as Horizon 2020 or some other competitive mechanism.

6.2.3. **Upgrading in global value chain and promoting internationalization of Croatian economy**

International differentiation and technology diversification are key to (re-)positioning Croatia in a global, highly dynamic and changing context. Thus, the S3 process in Croatia needs to take account the positioning of the national economic and innovation system within the EU, assessing the competitive position of the Croatia with regard to other countries/regions in the EU and beyond. Another even more important task for Croatian industry will be to position itself within current global value chains. Through the Strategic project “Support to Competitiveness cluster initiatives”, technical support will be given to Ministry of Economy, Competitiveness clusters and other relevant institutions in series activities with main aim to support them in following aspects:

- preparation of analytical backgrounds and assessments and better positioning of Croatian economy within (Global) value chains according to defined S3 thematic and sub-thematic areas;
- drafting export promotion strategy for emerging industries and new niches resulted from RDI activities;
- development of corresponding action plans and policy mixes to enforce suggested plans and activities;
- pro-active approach to FDI;
- territorial and product branding in selected S3 thematic and sub-thematic priority areas,
- establishment of Academy for industrial development and related Competitiveness Summer School with aim to develop targeted vocational training programs (both for executives and public officials that work on Public policies);
- developing efficient monitoring and evaluation system for monitoring cluster initiatives and their impact on raising competitiveness of S3 thematic and sub-thematic areas.

(i) **Competitiveness cluster initiatives**

Croatian clusters of Competitiveness (CCCs) were the starting point of the EDP process during the development of S3. This process will be continued by supporting established CCCs through Strategic project Cluster initiatives and providing them with necessary informations and data sets to understand their current position, their targets and supported action plans to support reaching defined targets. Along with CI project, and building of capacities of CCC’s, they will be involved in work of TIP’s (as part of Strategic project INI). In this way, a bottom up, triple-helix approach in the preparation of project pipelines and collaboration opportunities among the stakeholders will be assured. Clusters will serve as operational networking vessels through which project holders will collaborate, find partners and complement jointly agreed strategic goals according to future developed RDI Strategies for each selected TPA of S3 Strategy. Project holders will be supported not only through financial support of CCCs but also through development of innovation infrastructure (where CCCs are obligatory involved), labeling of the project proposals and making suggestions for policy improvements. The complementarity of the CCCs with the governance bodies of the S3 will be assured through the close
connection of the HAMAG-BICRO and CCCs when performing annual surveys on policy instruments and their inclusion in work of TIPS’s.

1st Cluster initiative (CI) “Strengthening the position of the Croatian competitiveness clusters in selected global value chains of priority thematic and sub-thematic areas defined by the Strategy for smart specialization of Croatia” will include capacity Building and Development of Experts on the competitiveness of the Ministry of Economy and other relevant institutions; strategic analysis and GVC in selected S3 priority thematic and sub-thematic areas and identification of necessary actions to improve the position of the Republic of Croatia in GVC and to upgrade the industry; preparation of systematic prediction (“forecast”) to assess possibilities for further development of the Croatian economy in the context of S3 priority thematic and sub-thematic areas; proposing effective collaborations and partnerships within clusters to better position within the GVC and/or seize new opportunities; the organization of Public-private dialogue for value chains and preparation and implementation of the Action Plan with measures to strengthen the position of the Croatian companies in selected global value chains.

The 2nd CI “Proactive approach to FDI and implementation of outreach campaign for Competitiveness Clusters” includes the analysis of gaps in the Croatian value chains and identification of specific niches and markets with the aim of a proactive approach to attracting FDI and development and implementation of action plans for promotional activities and the implementation of marketing tools to encourage the inflow of investments (including targeted “outreach” campaign).

The 3rd CI “Drafting export promotion strategy for emerging industries and S3 priority niches and implementation of measures for internationalisation of business sector” includes preparation of Export Strategy for S3 TPAs and STPAs within the Competitiveness Clusters and preparation and implementation an action plan for export initiatives and targeted promotional activities for the purpose of opening new export markets and the retention of existing for identified potential strategic segments within the cluster competitiveness.

The 4th CI “Territorial and product branding within the S3 TPAs and STPAs covered by the Competitiveness Clusters” is related to identification of top Croatian brands according to identified TPA’s and the development and implementation of action plan for territorial and product branding in the global value chains. Support to the action plans will be provided through allocations of MoE strategic projects and National funding.

The 5th CI is related to establishment of Academy for Industrial development (AID) and Competitiveness Summer School and includes preparation of Guidelines for the establishment and promotion of AID and Competitiveness Summer School; development of Programme and the educational modules and comprehensive teaching materials in the field of S3 TPAs and STPAs (global value chain and supply, export promotion, FDI, branding, R & D and innovation, human resources management, project finance and other areas identified by the business sector); Development of system of accreditation of trainers, the training of trainers and monitoring their performance and establishment of AID and the financing of their operating costs in the first years.

The other CIs covered by the Project will include operational enforcement of above mentioned action plans and promotion of the Cluster concept in Croatia, for one clear purpose: Strengthening position of Croatian economy in Global value chains. These cluster initiatives (CI) will contribute to the specialization of the Croatian economy in accordance with the Strategy of smart specialization and to transformation and structural changes of the industry. They will, as well, encourage innovation, commercialization and internationalization of the business sector in Croatia.
6.2.4. Creation of smart skills

The main driving force of the S3 in Croatia will be the skilled workforce and the ability to understand future skill needs, to translate them on time into relevant training programmes and to deliver training to relevant groups of population, both employed and unemployed.

In this respect, following instruments and activities are foreseen:

i) Establishing infrastructure for smart skills policies

1) Developing Register of human resources in Croatia

First step in building smart skills instruments will include development of the Register of human resources in Croatia, which will combine individual level data from 6 different data sources: the Pension fund (employed, recipients of child benefits), Employment Service (the unemployed, recipients of active labour market measures, unemployment benefit recipients), Tax Authorities (wages and salaries, financial indicators of firms), Social Services (recipients of social benefits), Ministry of Public Management Administration (demographic data), Ministry of Science, Education and Sports (enrolment in all kinds of training).

The data warehouse will be used for multiple purposes. In this case, it will be used for analysis of skill use by economic sector, through occupations of employed, unemployed, transitions between labour market states, first entry to the labour market, etc.

2) Developing Macro econometric forecasting model for the Croatian economy:

The macro econometric model will be used to forecast long-term trends in turnover and employment by economic sector in the economy. The Register of human resources will give us the present structure of employment by occupation in each economic sector and this structure will be extrapolated in the first step, to the expected future employment from the macro econometric forecast results. At the same time it will support building quantitative data repository for future skill assessment for smart skills within the S3 framework;

3) Skill foresight

The foresight will be done in the final step to give input about the expected changes in skill structure by occupations that are expected to happen in the future. In this way we will assess expansion demand and the changes in skill structure. Expected changes of competences within occupations will be taken into account based on trends assessed from employers' surveys. The qualitative information based on the foresight exercise in combining qualitative and quantitative data will help to adjust the present to the expected future skill needs, taking into account the changes in the demographic structure, and the domination of diseases linked to old age and prevention methods.

All three instruments (A/1/2/3) will support smart skills development, and are planned to be financed through the ESF, as an activity starting in the course of 2015 or the beginning of the 2016. The Register of human resources is planned to start already this year (2015) since the first stage of the project, i.e. the architecture of the future system and a tender documentation for the ESF is currently drafted. The macro econometric model and the skills foresight will be tendered in the course of 2016.

ii) Additional instruments put in place for assessing medium term skill needs;

1) New annual Employers' survey on competences - Raw data sets will be analysed by sector experts and grouped accordingly in order to provide a solid evidence for: i) updating the National classification of occupations; ii) suggesting new or adjusting present occupational standards; iii) as an input to the information repository of the centres of life long career guidance portal. Permanent tenders for development of new occupational and qualification standards will be put in place as well as tenders for development of educational programmes based on these standards. The mentioned tenders are planned to be financed primarily from ESF resources as stated under the OP EHR, 8.vii.2.Specific
objective  Increase accessibility and quality of publicly provided labour market information and services, including ALMP

2) Skill sector profiles - will be developed for the 25 skill sectors\(^{208}\) which define medium-term supply and demand for sector occupations by region, economic sector and the supply of labour from education and job seekers. The profiles will be updated every 2-5 years to reflect changing labour market needs. Development of knowledge is seen as vertical and horizontal growth and development of skills.

Vertical growth is ability for individuals to access qualifications from VET to higher education levels and from simple occupations to more demanding ones, while the horizontal growth is the application of sector skills in different occupations and economic sectors. This means that both VET and HE levels of qualifications will be developed within a sector and there will be attempts to improve the transferability of skills across occupations and economic activities.

In this respect the mentioned resonates with the main phenomena skill sectors will be addressing 1.) In what way to apply knowledge in the economy and society as a whole - the characteristics of the demand for labour through occupational analysis; 2.) What kind of knowledge is created in the educational system - which qualifications are created in the educational system - the characteristics of the labour supply of education; 3.) What is the compliance of acquired knowledge in relation to the needs – comparing the structure for the demand and supply of labour - what is needed and what do we currently have 4.) What are the future needs for work - what kind of knowledge we need for replacing the existing workforce and for future growth

Related reform processes conducted by the MLPS and MSES supporting coherent policy (S3) mix

Since the MLPS is one of the crucial stakeholders of the National council for HRD, which besides other relevant policy coordinating tasks\(^{209}\) (see 7.2.4. the S3 governance) has a role of assessing and validating relevant policies from a perspective of their contribution to achieving strategic goals identified in various development strategies (S3 included), the mentioned will assure particular care will be devoted that the newly developed learning outcomes, occupational and qualification standards as outputs of CROQF are following and complementary within the areas mentioned by the S3.

Currently, MSES is conducting an assessment of human capital needs, and adjustment of the curricula and study programs to meet market demand is being developed. In that sense, university/business collaboration (such as developing courses with industry input, and offering scholarship together with industry) will be encouraged. It is critical to develop a system providing information on income and employability of different careers at the level of each HEI. Reliable information on existing and prospective career opportunities will be made available to graduates from the secondary and tertiary education. Furthermore, incentives for studying in technical and engineering specialties are introduced to steer students away from popular areas of study like economics and law where there are clear signs of oversupply.

The government expanded its efforts to introduce policy reforms, accountability into higher education financing, and is consolidating the sector based on performance and its potential impact on economy and society in general. MSES recent reform initiatives addressing some of these weaknesses include a major task of collect information on educational outcomes and graduate employment (as part of the reforms of the ongoing Croatian Comprehensive Educational Curriculum).

\(^{208}\) Definition of Sectors - groups of qualification in the education and occupation fields that use competence obtained through these qualifications in the workplace. Within the framework of CROQF there are 25 sectors. Coverage of the sector is a) a review of programs leading to qualifications in one sector and persons who are holders of such qualifications or are in the process of their acquisition, and b) a list of professions that use the knowledge and skills based in these qualifications and all of the persons who work or have worked in the mentioned sector occupations. (for instance – code 1100 - Transport and logistics)

\(^{209}\) See Chapter 7.2.4. (The S3 governance).
Comprehensive Curriculum Reform is the first measure that paved the way towards the realization of the Strategy of Education, Science and Technology. Changes proposed by the Comprehensive Curriculum Reform are not “cosmetic”, but mark the start of meaningful, systematic and profound changes to the Croatian education system.

Changes in the structure of the education and training system (which calls for the extension of the pre-higher education from the current 11/12 to 12/13 years) within Comprehensive Curriculum Reform represents, perhaps, the most complex change envisaged by the Strategy. The National Curriculum Framework (NCF) is another key document of the Croatian education policy, on which the Comprehensive Curriculum Reform is based upon and which emphasizes continuity. In the NCF – and this is especially important for drafting specific curriculum areas – descriptions and goals of educational areas as well as expected achievements according to educational cycles have been expressed for the first time, as well as the expected achievements according to educational cycles.

Some of the key features of the Comprehensive Curriculum Reform include: development of basic competencies for lifelong learning; increasing functional literacy levels; facilitating the interconnection between education and the interests life experiences, needs and abilities of students and the interconnection between education and the needs of society and the economy; providing a clear definition of educational outcomes (learning outcomes), not only those of a cognitive nature (knowledge); changing assessment procedures, evaluation and reporting of student achievements based on educational outcomes.

Besides supporting activities in building up mid-term and future skills instruments there is a clear link between the planned ESF activities and TPA areas identified within the S3.

More specifically, within OPEHR\textsuperscript{201}, Investment priority 10.ii. - Improving the quality and efficiency of, and access to, tertiary and equivalent education with a view to increasing participation and attainment levels, especially for disadvantaged groups – three specific objectives are developed.

The first specific objective, with the set of actions for the implementation of CROQF at HE level, aims to increase quality and labour-market relevance of study programmes. Additionally, in order to enhance graduates’ employability, a set of actions aimed at increasing work-placement schemes in study programmes, will be targeted at HEIs, students and employers.

Furthermore, concerning the improvement of quality, relevance and efficiency of HEI, support will be given through actions directly supporting CROQF such as:
* Development of analytical research of competences required by employers including skills forecasting, for the evidence-based implementation of the CROQF;
* Development of the CROQF occupational and qualifications standards by the consortia of HEIs and their partners from the business sector on the basis of analytical research and skills forecasting as well as through the implementation of the CROQF quality assurance mechanisms that are, embedded in the learning outcomes approach;
* Validation of the CROQF occupational and qualifications standards by the Sectoral Councils and their working groups on the basis of results of the analysis of the competences required by the occupations within specific sectors and in line with the regulations defining the role, the scope of work and the procedures of the Sectoral Councils;
* Development and revision of education programmes by the HEIs and based on qualifications standards from the CROQF Register described in terms of LOs and quality assured in terms of achieved LOs and in line with current and future labour market needs;

\textsuperscript{201} The Operational Programme Efficient Human Resources 2014-2020, p. 117-118
*Outgoing mobility of students and staff in STEM areas, ICT and other priority areas as identified by *the smart specialization*, national economic development strategies and key enabling technologies set by the Industrial Strategy 2014-2020; *Development of study programmes and joint/double study programmes provided in foreign languages in STEM areas, ICT and other priority areas as identified by *the smart specialization*, national economic development strategies and key enabling technologies set by the Industrial Strategy 2014-2020;*

To attain the second objective (increasing tertiary attainment rates) Croatia will establish attractive scholarship programs to stimulate students at both undergraduate and graduate levels enrolled in STEM, ICT.

More accurately, this specific objective includes; * provision of scholarships to students from lower socio-economic background in order to increase their access and completion rates; provision of scholarships to students enrolled in STEM areas, ICT and other priority areas as identified by *the smart specialization*, national economic development strategies and key enabling technologies set by the Industrial Strategy 2014-2020 in order to increase attainment rates in these areas; *Development of tailor-made remedial courses for students at risk of dropping-out in STEM and ICT areas; *Development and functioning of student career centres at HEIs; *Development and implementation of the CROQF programmes for validation of non-formal and informal learning at tertiary or equivalent level; *Support to learners to enrol into CROQF programmes for validation of non-formal and informal learning at tertiary or equivalent level aimed at continuation of education (YGIP measure).*

The third specific objective aims to increase the employability of researchers and to improve the environment for Croatian researchers by stimulating cooperation between business sectors and research institutions in order to address intersectoral mobility and forge development of transversal skills of researchers suitable for conducting business.

Programme's aim is to upgrade training of the young researchers, through business oriented tertiary education programmes at graduate and postgraduate level, in the specific research-related core skills and secures their training in the wider employment-related skills that could improve their participation on the labour market and future engagement in the business sector. Furthermore, OPEHR foresees development of two programmes as a support to the integration of young researchers in the Croatian research area. The first programme will aim to steer young researchers on the postgraduate level to conduct their research in TPA and cross-cutting themes defined in S3 in order to create closer linkage between science and business sectors. The second programme will target outstanding researchers and experts at post doctorate level, both Croatian researchers working in Croatia and those who are currently living abroad, with the aim of creating future leaders in the Croatian R&D.

Key results expected through this OPEHR objective will be increased number of early career researchers, employability of researchers, especially in STEM field and at the postgraduate and postdoctoral level in business sector, memberships of researchers in international research organizations and participation in large transnational projects and consortia, increased access to foreign research publications and databases and development of national bibliographic database.

iii) Implementing the Croatian Qualification Framework mechanism for delivering timely and standardized training programmes based on future and medium term skill needs;
The Ministry of labour and pension system together with the Ministry of Science, Education and Sports and other relevant stakeholders developed the Croatian Qualifications Framework (CROQF) as a mechanism of transferring skill needs into training outcomes\(^{211}\). One of the main goals of the CROQF is to permanently assess skill needs driven by the development. Within the CROQF, mechanisms such as the Annual Survey on Occupational Standards will be used to assess competences which need to be acquired through the education and lifelong learning training provision. The implementation of CROQF that started in the area of higher education is focused on making higher education more responsive to the needs of economy.

CROQF is planning to use national and foreign sources (primarily ESF) to define occupational standards as a precondition for designing qualification standards by MSES.

\(^{211}\) http://www.kvalifikacije.hr/hko-en
6.3. The main source of financing

Realization of S3 Action plan will be ensured through different initiatives and ensured by policy mix driven by government, as well as their financing. To be able to realize all goals set in this Strategy, a strong financial support should be ensured. S3 strategy sets out the framework for investments in research and innovation not only from ESIF, but also from other funding sources. For that reason, necessary resources will have to come from various sources: national funds and other public and private resources.

For the 2014-2020 period the Funds supporting cohesion policy (ERDF, ESF and CF) have been brought together with the EAFRD and the EMFF under a common strategic framework in order to maximize their effectiveness and optimize synergies. For S3 Action plan implementation the most relevant investments will be funded under ERDF - OP Competitiveness and Cohesion (OP CC), through two priority axis: Priority axis 1. Strengthening the Economy through Application of Research and Innovation which will focus on research, technological development and innovation; and Priority axis 3. Business Competitiveness which will provide support for small and medium-sized businesses (SMEs). In parallel, through the ESF – OP Efficient Human resources (OP EHR), a significant contribution will be provided to S3 implementation in the field of smart skills.

The overview of OP CC and OP EHR funding aimed solely at supporting TPAs of S3 strategy is presented in Figure 34.

Figure 34 The overview of OP CC and OP EHR funding aimed solely at supporting TPAs of S3 strategy
Total of the ESI funds allocation to S3 is estimated to be 1.042,4 M EUR, whereas EU contribution amounts to 704,5 M EUR, national cofinancing to 53,9 M EUR and private cofinancing to 284 M EUR.

In addition to these funds aimed solely to S3 strategy, further complementary sources of financing will contribute to the implementation of S3 strategy and will include ERDF, ESF, EAFRD, EMFF allocations as well as national budget.

EAFRD will include among its priorities the fostering of knowledge transfer and innovation in agriculture, forestry, and rural areas and enhancing farm viability and competitiveness of all types of agriculture in all regions and promoting innovative farm technologies and sustainable management of forests. Also, the EMFF has among its priorities the fostering of innovative, competitive and knowledge based fisheries and aquaculture including related processing. This includes strengthening technological development, innovation and knowledge transfer.

Supplementary programmes financed from national budget and managed by Croatian Science Foundation will also support S3 strategy through Research project grants and through Career development of young researchers (doctorate and post-doc grants). Main and complementary sources of financing of S3 implementation are provided in detail in the tables in Annex 5.

European Union programmes could also support the implementation of S3 strategy in Croatia. Horizon 2020 complements ESIF and supports the implementation of the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. This R&I Framework Programme is part of the drive to create new growth and jobs in Europe through 3 main priorities:

1. **Excellent Science** (European Research Council, Future and Emerging Technologies, Marie Skłodowska-Curie Actions for researchers’ training, mobility and career development; Research infrastructures (including e-infrastructures) – support to feasibility study and building (incl. for large infrastructures above EUR 20 million).

2. **Industrial Leadership** (applied research projects up to Technology Readiness Levels 7-8) - includes Enabling and Industrial Technologies such as: ICT (including two Key Enabling Technologies (KETs) photonics and micro- and nano-electronics) and other KETs: nanotechnologies, advanced materials, biotechnology, advanced manufacturing and processing, Space, Access to risk finance; and Support for "Innovation in SMEs" (including 'policy actions for better SME support’ and the topics addressed by the SME instrument, that provides staged support for feasibility study and an innovation project that is core to realise an ambitious business plan).

3. **Tackling societal challenges.**

Under horizontal activities “Spreading excellence and widening participation”, actions like ERA Chairs, Teaming and Twinning are also relevant for Croatia, because they can facilitate the development of COREs or centres of competence and the improvement of R&I capacities. These actions can easily be combined with ERDF operations thus enabling efficient synergies. Such ESIF support can either be cumulative to the Horizon 2020 grant or subsequent to it once the equipment and infrastructure needs have been identified via the Horizon 2020 project.

COSME focuses on projects strengthening the competitiveness and sustainability of the Union’s enterprises, particularly SMEs and encouraging, entrepreneurial culture and promoting the creation and growth of SMEs (no support to individual SME’s projects). Creative Europe also offers an interesting potential for synergies to ESIF because technology is often not enough to be a successful innovator. Besides entrepreneurial skills, creative thinking is also central in the innovation process. Cultural and creative activities such as, design related activities and the use of new media can be crucial for innovations to succeed. Creative Europe projects can be crystallization points for this and countries / regions could amplify or carry further these projects to achieve a durable impact on competitiveness, innovation and growth.
7. **THE S3 GOVERNANCE**

Governance for smart specialisation requires strategic capacities and operational jurisdiction to grasp future opportunities, mainly in order to align policy actions, build critical mass, develop a vision and implement the strategy in respect to overall EU surrounding.

The S3 governance represents demanding challenge for Croatian policy makers. Identified future fields of excellence and competences for research and industry (emergence of new niches and introduction of cross-cutting themes), growing importance of industrial competitiveness clusters, need for development of centres of research excellence and centres of competence combined with challenges of new financial programmes must be recognized and accounted by government authorities responsible for implementation. Current management system with widely spread roles, management and control of measures and programs cannot cover the focus and main goals that the S3 tends to boost in Croatian economy and society as a whole.

This strategy scope calls for creation of organizational structure which encompasses the best of existing governance models, involves new complementary structures and stakeholders recognized in the implementation process and most importantly, demands formation of one directing point of organization and management that will take into account collective leadership position of various stakeholders.

Formation of such coordination in Croatia will most certainly raise new challenges and tasks that will need to be addressed through newly formed structure, such as:

- Multi-level co-ordination (the difficulties for an efficient co-ordination of innovation-related policies across different ministries and agencies) and;
- Multi-disciplinary dimension of emerging activities in terms of knowledge, activities and actors (the emerging of cross-sectoral and cross-technological activities requires multi-level communication and policy coordination across a higher number of different ministries and agencies (local, regional, national and supranational) and across a higher number of policy areas (e.g. industry, innovation, education, energy, transport, health, agriculture and entrepreneurship).

### 7.1. Governance system for the S3

The configuration of Croatian institutions in charge of governing science, technology and innovation is similar to governance structures of most of the EU countries. Higher levels of governance are in charge of orienting and programming policy and include the Parliament (in particular, the Parliamentary Committee for Education, Science and Culture in addition to the general body’s say on changes in legislation) and four central government ministries: the Ministry of Science, Education and Sport (MSES), the Ministry of Economy (MoE), the Ministry of Entrepreneurship and Crafts (MoEC) and the Ministry of Regional Development and EU Funds (MRDEUF). In addition, each ministry has a fairly distinct set of stakeholders. Lower-level implementation, monitoring and funding involve various intermediaries in the form of councils, committees and funding agencies, although some funding functions remain in the ministries.

Effective policymaking to support the S3 is complex, given the long-term impact and systemic nature of RDI and the significant risk by stakeholders. In this context, institutional arrangements should embody the following governance principles:

1. Clarity of vision, objectives, and strategy. After the situation has been diagnosed and barriers to RDI identified, it is necessary to clearly define (a) expected outputs and outcomes; and (b) the inputs, lines of action, and strategic initiatives needed to achieve them.
2. Clear jurisdiction and mandate of responsible institutions. Each type of institution must have the authority and instruments needed to effectively carry out its role.

3. Coordination mechanisms at various levels. Establishing an effective governance system is complex and requires the participation of many institutions. The challenge is to put in place mechanisms that balance coordination with interdependence, in order to prevent duplication of efforts, reduce transaction costs and information problems, and take advantage of possible synergies.

4. Transparency and accountability. Both are key elements of effective governance.

5. Establishment of formal M&E mechanisms and feedback loops at different levels of government to inform decision and policy makers.

6. Public access to information on decision making processes, criteria and procedures for allocation of resources, and project performance.

7. Integrating learning into policy and practice. Good governance also requires that the system has the ability to continually adapt to change, and to incorporate lessons from both successes and failures.

The organizational structure of Governance system for the S3 in Croatia is shown on Figure 35.

**Figure 35 Organizational structure of the S3 governance system**
7.2. The role of institutions and bodies in the S3 governance system

7.2.1. National Innovation Council

Implementation and governance of S3 requires a common framework which will overcome the divisions of different levels of authorities and will enable an overall, national overview of S3 implementation system in Croatia allowing easier and more efficient coordination among stakeholders of the RDI system. This model requires mandatory involvement of the highest level of governance and only such structure will allow certain governance and monitoring structures to combine resources and competences into one integrated entity. Croatia intends to officially designate the role of the S3 supervision and management to the National Innovation Council which will be established by Croatian Government and co-chaired by ministries responsible for Economy and Science.

National Innovation Council will cover overall coordination of S3, independent and authorized decision making regarding necessary changes and revisions of S3, sharing of information, and collective evaluation of delivery instruments identified in the S3 and other instruments or programs (including financing from national budget) that supplement the financing of S3 provided by ESI funds (ERDF, ESF, CF, EMFF and EAFRD). Regarding its assigned role, National Innovation Council will be constituted of higher decision-making level officials involved in S3 implementation, with Head of MA for OP Competitiveness and Cohesion 2014-2020 and Head of MA for OP Human Resources Development 2014-2020, appointed representatives of three expert Advisory Councils that will provide advisory support from the expert side (Innovation Council for Industry - INNOVA; National Council for Human Resources Development and National Council for Science, Higher Education and Technology Development), and other stakeholders (Croatian Chamber of Economy, Croatian Chamber of Crafts, Presidents of Thematic Innovation Councils).

The National Innovation Council shall meet at least twice a year and shall:

1. Outline and identify main allocation of resources needed to execute confirmed shared vision and main targets of the S3 strategy;
2. Coordinate the implementation of the Action Plan and fulfillment through identified and defined indicator set for the S3 delivery instruments and supplement measures and programs;
3. Approve Annual Implementation Report and Evaluation Plan, examine the reports prepared through monitoring and evaluation activities;
4. Coordination of implementation of foresight projects in order to ensure complementarity of mapping of RDI capacities of science and business sectors;
5. On the basis of Annual Implementation Reports and Evaluation reports and inputs form the IWG bring quick and empowering corrective decisions for the stakeholders enforcing the S3 measures and programs that are not in line with shared vision and targets, or for inefficient programs and measures that don’t produce desired results and outcomes that were intended to support joint vision and targets of the S3;
6. Respond to noted changes and trends in implementation phase through providing policy recommendations and by proposing and approving revisions of Smart specialization strategy according the results of interim evaluation, outputs of Thematic Innovation Platforms (TIPs) activities and foresight projects.

Taking into account the responsibilities and main duties of this newly formed body, while at the same time considering the necessity for multi actor governance and context of Croatian institutional set-up,

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212 From ministries responsible for Economy, Science and Education, Entrepreneurship, Labor and EU Funds
213 Preparation of Science and Technology Foresight; Development of Innovation Network for Industry (INI) and creation of Thematic Innovation Platforms; Smart skills foresight
this body will be authorized by the Croatian government to fulfill above mentioned tasks in independent and obligatory way for all involved stakeholder in S3 implementation.

7.2.2. Interministerial working group for S3 management

Interministerial working group for S3 management (S3 IWG) will be a successor to the S3 Interministerial working group which was responsible for the design and drafting of S3 strategy. It will be a cross-cutting coordinating working body established by the National Innovation Council and created on a principle of partnership. It will be co-chaired by ministries responsible for Economy, Science and EU Funds. Such a comprehensive working group will be able to adapt to the eventual changes in the regulatory environment.

Other members of S3 IWG will be all bodies responsible for implementation of S3 delivery instruments, listed in the Annex 5. It will be supported by advisory councils described under point 7.2.4. and assisted by the S3 Technical Secretariat.

The main duties of S3 IWG will include:

1. Monitoring of the execution of delivery instruments and action plans of S3 implementation;
2. Supervision of the preparation of S3 evaluation plan by the S3 Technical Secretariat;
3. Coordination of evaluation activities related to the S3 strategy;
4. Supervision of monitoring activities performed by the S3 Technical Secretariat;
5. Submitting to the National Innovation Council suggestions and recommendations relating to S3 implementation and to eventual needs for corrective actions and revisions of S3 strategy;
6. Monitoring of the activities that are being done in relation recommendations of National Innovation Council;
7. Discussion on results of continued EDP, based on feedback of the experience received during the implementation of the Action Plans in the smart specialization process and elaborating the new directions of smart specialization.

S3 Technical Secretariat

The S3 Technical Secretariat is a supporting body to the National Innovation Council and to the S3 IWG and it is located within national agency HAMAG-BICRO. The main duties and tasks of this Technical Secretariat will include:

1. Technical and administrative support to ministries responsible for Economy, Science and EU Funds in coordination of work of National Innovation Council and S3 IWG;
2. Contracting and implementing technical assistance projects for support of S3 implementation
3. Collecting information on measures that contribute to implementation of the S3;
4. Preparation of the S3 Annual implementation report;
5. Design of the S3 Monitoring and evaluation plan;
6. Monitoring and “follow-through” of the decisions, recommendations and policies approved and voted on the National Innovation Council towards policy makers, relevant actors of the processes and responsible institutions;
7. One stop point for all the information concerning the S3 implementation, including information on related mechanisms and programmes presented in complementary strategies and programs (the EU and national funded) in order to ensure synergy.

MIS (Management Information System) represents an important element and tool of Technical Secretariat. This tool is used by all bodies in management and control system for OP Competitiveness and Cohesion and OP Efficient Human Resources. Data from this integrated management system will enable Technical Secretariat the easy set-up and preparation of key implementation reports, by providing result and output indicators and quantified target values related to the OP Competitiveness and Cohesion and OP Efficient Human Resources.
7.2.3. Managing Authorities (MAs) for OPs 2014 – 2020, supporting ministries (IB1) and other relevant institutions acting as IB2

Managing Authorities (MAs) have the overall responsibility for the management of Operational programmes financed by ESI funds. In 2014-2020 period 5 MAs are established for following operational programmes: MRDEUF for ERDF/CF programme (OP Competitiveness and Cohesion); Ministry of Labour and Pension System (MLPS) for ESF programme (OP Efficient Human Resources); Ministry of Agriculture is the Managing Authority (MA) for Rural Development Programme (RDP) and for the OP Fisheries is also designated on the level of the Ministry of Agriculture.

Regarding supervision and effective monitoring of implementation of the S3 each MA (IB where appropriate) shall submit to the Technical Secretariat an annual report on implementation of activities related to the S3 under their programme in the previous financial year. Annual implementation report shall set out key information on implementation of the activities by reference to the financial data and result and output indicators and quantified target values.

Due to the proposed scope of the S3 and inclusion of national funds supporting those allocated through ESI funds, other institutions designated as IB1 and IB2\textsuperscript{214}, as well as institutions managing national funds, are also important for the S3 implementation, due to their complementary programs to the S3, and they also will be included in governance structure of the S3 (as member of National Innovation Council and S3 IWG).

7.2.4. Advisory Councils

Advisory Councils include the following:

2. Innovation Council for Industry (INNOVA COUNCIL);

The main task of Advisory Councils in relation to S3 Governance and M&E will be monitoring and evaluating public policies in their domains and identifying growth path and trends and proposed priorities and measures for fostering RDI activities and maximising the impact of smart specialization implementation on economic growth and societal wellbeing.

1. National Council for Science, Higher Education and Technology Development is the highest expert strategic body for national policies in science, higher education and technological development. The Council proposes measures for enhancing scientific excellence, including setting evaluation criteria and approving establishment of Centres of Research Excellence. The scope of Council’s tasks includes discussing issues of importance to the development of the national innovation system and encouraging adoption of measures for improvement of technological development. Besides representatives from academia, National Council for Science, Higher Education and Technology Development includes also representatives from the economy and entrepreneurship.

\textsuperscript{214} Regulation on the bodies in management and control use of European Social Fund, European Fund for Regional Development and the Cohesion Fund, the goals of the “INVESTMENT FOR GROWTH AND JOBS”
Scientific and Arts Area Councils are established to discuss issues from the scope of work of National Council for Science, higher Education and Technology Development within particular scientific area (technical, biotechnical, health and biomedicine, social and life sciences, humanistic,) and arts. In line with the Strategy on Science, Education and Technology, National Council for Science, Higher Education and Technology Development contributes to the work of the National Innovation Council by:

- recommending measures for fostering research excellence, international cooperation and maximising impact of research on economic growth and societal wellbeing;
- proposing initiatives for strengthening knowledge and technology transfer activities;
- providing input related to the study programs (outputs and competences) and their alignment with the needs of business sector in order to reduce skills gap;
- providing thematic expertise in national foresight exercise (within Science and Technology Foresight Project), to ensure relevant mid-term and long-term perspective for R&D policy documents and investments.

Therefore, National Council for Science, Higher Education and Technology Development will advise and provide input on envisioned measures aimed at institutional reform in the field of Science, development of RDI human capacities, research infrastructure and research activities. It will be represented in the National Innovation Council by the president of the Council.

2. **Innovation Council for Industry (INNOVA COUNCIL)** will be established under initiative of Ministry of Economy and supported by strategic project “Innovation Network for Industry” (INI). Main goal of INNOVA council is to enable continuous process of entrepreneurial discovery through Triple helix communication and joint strategic planning of further development of S3 thematic and sub-thematic priority areas and creation of project pipelines for business sector RDI projects. INNOVA Council for Industry will continually inform National Innovation Council on results of implementation of designed thematic RDI strategies for business sector and on project pipeline preparation. As an institutionalized instrument very close to the market, it will allow fast flow of information regarding S3 measures to real sector, and will enable policy makers to adjust their policies to changes within the economy.

President of INNOVA council will participate in the work of National Innovation Council.

**Thematic innovation platforms (TIPs)** will be established under the INI framework and supported by strategic project “Innovation Network for Industry” (INI). They will serve as main operational support to INNOVA council. Each platform, assembled from industry and public and private research organizations representatives, will be established per one identified S3 TPA. Thematic innovation platform is constituted of: appointed Thematic Innovation Council (TIC) as the main coordinating body for each selected TPA; Priority action groups (with specific goals to address STPA’s themes in future in depth RDI strategies) and Competitiveness clusters related to specific TPA. Thematic innovation platforms are promoted through Innovation web platform that summons all relevant stakeholders, capacities, strategic framework, networking contacts and potentials for all TPAs. Main task of TIP’s is to unify stakeholder communities and capacities according to identified TPA’s in order to enable continuous entrepreneurial discovery process of all relevant stakeholders.

**Thematic Innovation Councils (TICs)** will be appointed and confirmed by main INNOVA council, for each established thematic innovation platform. Their main goal will be to provide strategic management and guidelines for each selected TPA.

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215 Act on scientific activity and higher education, Official Gazzete No 123/03, 198/03, 105/04, 174/04, 2/07 - OUSRH, 46/07, 45/09, 63/11, 94/13, 139/13 i 101/14 - O i RUSRH

216 For more information on INI project please consult chapter 6.3.1 Establishment of the efficient national innovation system and Annex 6.
Each TIC will be composed of cca 30 representatives of Triple helix stakeholders (representatives of business community, science and research community and public administration) according to following envisaged structure: 70% of stakeholders will be from private sector (mainly SME’s), 20% will be from science and research community, while 10% will be from nominated representatives of public authorities.

Mandatory TIC members from private sector will include: presidents of Competitiveness Clusters relevant to specific TPA, presidents of sectoral associations and affiliations of producers relevant to specific TPA operating under Croatian Chamber of Commerce and Croatian Employer Association. To fill the needed number of private sector representatives – the TIC will be composed of nominated representatives of mainly SMEs and large companies nominated by relevant Competitiveness Clusters, Croatian Chamber of Commerce and Croatian Employer Association according to criteria’s prepared by MoE (related to EBITDA, Export, R&D expenditure and number of researchers/high qualified working staff) The frequent rotation of members will be ensured with 2 year mandate of nominated representatives within TIC.

President of the Thematic Innovation Council will mandatory be from private sector (preferably medium or large company), that operates on the market, has high export results, continually invest in R&D, and works in collaboration with other industry players. As with the other members of TIC, President of TIC is also nominated to period of 2 years.

Research community will be represented in TIC through - appointed representatives of Centres of Research Excellence (those relevant for certain TIP), representatives of Universities and polytechnics, directors of relevant research institutes and Competence Centers. From side of public administration in TIC, members will be a representatives of government structures connected to relevant TPA, with possibility of appointing external experts in relevant TPA (suggested by Ministry of Economy). Beside Ministry of Economy, Ministry of Science will mandatory be represented in the TICs as a competent authority in the field of public RDI, together with representatives of Scientific Area Councils (related to the specific TPA), appointed by the National Council for Science, Higher Education and Technology Development

In the total nuber of TIC Membeers 70% of voting rights will be in hands of private sector representatives, 20% research community and 10% public administration. The principle of voting will be 1 member, 1 vote. Within the framework of TICs, stakeholders will be brought together to discuss and approve a long-term vision of development of each selected TPA represented through coherent RDI strategy for business sector. Their task will be final approval of RDI strategies for business sector per S3 TPA and decision to approve strategic importance of prepared Project pipelines in accordance to future RDI Strategies. TICs will also encourage entrepreneurs and companies to discover ways to become more successful and more competitive on the EU and global market, through learning process which will discover the research and innovation domains, in which Croatia can hope to excel.

Priority Action Groups (PAG) –together with TICs, will be the main instrument for continuation of the process of smart specialization in the following years and they will enable continuous entrepreneurial discovery process (EPD) through open involvement of all interested stakeholders and counselling in process of drafting and addressing specific STPA's issues within RDI Strategies and Action plans. In this process, all actors (from business and science and reseach sectors) will be encouraged and supported through guided processes to participate in exchange of ideas, opinions and directions relevant to specific S3 sub-thematic areas, and beyond. This less formalized, open structures, that will publically announce their regular gatherings, will play leading role in process in discovering promising areas and niches, but even more importantly to be starting points of preparing project pipelines and ideas to support identified niches and areas.

Even though the TIC and PAG structures will ensure coordination of activities and processes, they do not exclude or limit success to other potential relevant projects and ideas that will evolve maybe somewhere elsewhere in process. However this will certainly boost the needed innovation culture.
within enterprises mainly and allow needed structural changes of Croatian economy in the form of diversification, modernization, transition and radical changes.

Main tasks of the thematic innovation platforms and main operational forces within them (TICs/PAGs) include:

1. Identification and approval of growth path and trends, along with in-depth profile of the selected thematic and sub-thematic priority area as part of a long-term RDI strategy for business sector;
2. Coordination of S3 thematic priority areas and future Action plans 2017-2020;
3. Coordination of actions and measures regarding the implementation of Thematic/sub-thematic priority areas strategic activities;
4. Continuous entrepreneurial discovery in formalized structures that will enable exchange of experience, networking and flow of idea between all relevant stakeholders within TIP’s, in relation to strategic orientation and further development;
5. Joint definition of main challenges and priorities of TPAs;
6. Based on prepared RDI strategies for business sector for each identified TPA/STPA, thematic innovation platforms will provide support to entrepreneurs in development and technical support to RDI projects (Project pipeline preparation).

TICs will label prepared RDI projects with strategic importance for business sector in project pipeline, for each TPA. In 2017 Ministry of Economy plans to announce 2nd Call for proposals for business sector R&D projects, in which bonus points will be given to projects labeled by TICs.

INNOVA Council and related Thematic Innovation Councils will focus usage of RDI financing for business sector in accordance with industrial forecasts and development trends, with aim to promote structural changes in Croatian economy.

3. National Council for human resource development (NCHRD) is a Parliamentary body responsible for monitoring the process of human resource development in Croatia. It encompasses representatives of all relevant stakeholders in this field in Croatia and presents the main platform for smart skills development. Out of 24 representatives, there are 5 representatives of state administrative bodies participating in the work of NCHRD (representatives of ministries in charge for following sectors: science and education, labour, entrepreneurship and crafts, economy and ministry in charge for regional development).

The following functions of the Council are important in view of the implementation of S3:

- Monitors and evaluates public policies in the domain of education, employment, life-long learning career guidance and regional development from the point of view of human resource development and its contribution to attainment of strategic development goals and competitiveness
- Gives recommendations on integrated and coordinated policies of education, employment and regional development
- Monitors and evaluates the impact of the Croatian Qualification Framework and gives recommendations on links between education and labour market needs.

In view of the above, the NCHRD has, at its disposal necessary instruments for initiating the development of smart skills as one of the areas of human resource development and is responsible for the functioning of the Croatian Qualification Framework mechanism which is the main instrument for developing new skills in line with labour market needs. Furthermore, it can initiate new activities such as the anticipation of future skill needs particularly in line with the planning horizon of S3. Results of these analyses can be translated into initiatives to develop new occupational and qualification standards and training programmes based on S3 RDI strategies, to recommend enrolment quotas which open opportunities for adequate number of the right skill mixes, to focus active labour market measures into training for these skills. Furthermore, the financing of these activities can be
implemented through the ESF fund which is under the auspices of the Ministry of labour and the pension system, in the area of human resources development.

In summary, The NCHRD will promote active links between identification of skill needs, the activation of the CROQF mechanism and the use of ESI funds to support the process of the generating Smart skills for the S3 strategy.
8. MONITORING AND EVALUATION

Smart specialization emphasizes the need for Croatian policy makers to carry out evidence-based monitoring and evaluation and use the feedback for policy design. It also requires flexibility in policy making to enable identification of ineffective programs and easily terminate or reallocate public RDI support towards more successful ones.

In the context of S3, monitoring and evaluation mechanisms will perform two fundamental functions: (1) inform about what the strategy achieved and whether implementation is on track and making this information available to decision makers; (2) support the constructive involvement and participation of stakeholders through transparent communication and promote trust building. The monitoring mechanism should be able to capture and follow the relevant expected changes that are foreseen in each S3 priority by means of an appropriate choice of outcome/result and context indicators; it should also capture and follow the policy output that ought to make expected changes happen. Furthermore, S3 monitoring should focus on tracking the developments related to policy interventions within the each priority thematic areas identified in the Strategy.

In order to efficiently achieve goals of the S3, it is necessary to secure adequate mechanisms of monitoring and evaluation supported by the reliable information and data gathering at the national level. Given its importance, S3 will set up an efficient, overall, and easy-to-implement, integrated national S3 monitoring system, which will rely on existing capacities and governance structure for the implementation of the ESI funds and additional expertise to be developed in the Department for support of National innovation system within HAMAG-BICRO in cooperation with external and independent experts. Only objective, independent and well integrated S3 monitoring and evaluation system, supported by existing governance structure for ESI Funds, will be able to efficiently and meaningfully keep track of the delivery of the S3’s outputs and results through planned policy mix. Objectivity and independence of S3 monitoring and evaluation system will be ensured through supervision of monitoring and evaluation by National Innovation Council and by engaging independent experts for performing evaluation activities. It will allow the policy-makers, media and public to clearly see the planned outcomes of certain policy actions and to provide measurable and recognizable outputs thus bringing the S3 closer to the users and beneficiaries of the S3 and enable adjustments of the S3 if needed.

8.1. Monitoring and evaluation framework of the S3

The monitoring and evaluation of the S3 will remain a complex set of elements that needs continuous but coordinated work toward the common goals. Experiences teach us that so far the innovation system in Croatia was divided into two almost completely separate spheres: (1) public RDI institutions that served almost entirely for the public sector, and (2) business community that, aside from rare innovative enterprises, didn’t really cooperate on a regular basis with the public RDI institutions. Therefore, to enhance cooperation between these two sectors is the common national goal and priority of the National Innovation System.

Aside from setting up the clear methodology for further developing the indicators for S3, it is envisaged to appoint one central place within the national innovation system that will collect, process, report and advise on these indicators – S3 IWG. It is foreseen that the administrative and technical role for assisting the process of monitoring and evaluation will be operated by the agency HAMAG – BICRO. As already mentioned, the S3 Technical Secretariat, as a supporting body to the National Innovation Council and S3 IWG is located within national agency HAMAG-BICRO (Department for Support to Innovation System) and it will support work of National Innovation Council coordinated by ministries responsible for Economy and Science. Proposed governance, monitoring and evaluation the
S3 framework is based on optimal utilization of already existing resources in institutional structure (Annex 7). With proposed structure of governance, monitoring and evaluation of the S3 system will not be additionally knotted, rather the intention is to make it more clearly focused, oriented and to use existing structures for meaningful and flexible support.

Any issues, which could potentially arise from performing potentially conflicting duties of ESI funds implementation and monitoring and evaluation activities for S3 by HAMAG-BICRO Agency, will be addressed by improving structure of the agency according to identified challenges and planned duties through the already established separate Department for Support to Innovation System. This independent Department is not part of accredited structure for ESI funds – Intermediate Body 2. This department will be autonomous in performing the role of S3 Technical Secretariat and thus ensuring the professionalism and independence of work and segregation of duties within the Agency. National Innovation Council and S3 IWG will ensure that enough resources are allocated and impartiality guaranteed to the S3 Technical Secretariat in all its tasks, and particularly in performing monitoring and evaluation related to the S3 strategy. The separate budget for the running of the S3 Technical Secretary will be guaranteed and management autonomy ensured throughout all management levels of the HAMAG-BICRO Agency (Management Board and Governing Board). National Innovation Council will ensure that their interests are properly represented in the Governing Board of HAMAG-BICRO.

The M&E system will play an important role in the Croatian entrepreneurial discovery process (EDP). On the one hand, M&E will encourage regular communication among actors of the innovation system. On the other hand, it will provide stakeholders with data about results of a public intervention. That will contribute to systemic learning and continuous improvement of the innovation policies and programs as well as trust building. Moreover, it will facilitate dialogue between authorities, business sector and other stakeholders, e.g. research organizations, business support institutions (BSIs), non-governmental organizations (NGOs). Thanks to such relations Croatian authorities can more easily collect and process information, which is essential for design, implementation and modification of public intervention, directly from stakeholders.

For the S3 strategy it is necessary to enable the monitoring and evaluation mechanisms in order to link the S3 output indicators with the overall strategic policy and expected outcomes and impacts which are measured through result/outcome and context indicators. According to RIS3 Guidelines, there is a need to concentrate on monitoring and evaluation of outputs and its contribution to the innovation policy as a whole rather than monitoring the absorption of financial allocations designated for the S3. The monitoring system of the S3 should therefore allow, through the monitoring of selected output indicators, their assessment against the targets and change the policy approach in case of failure. This will be done through several monitoring and evaluation tools (Figure 36) and mechanisms involving external experts:

- **ex-ante** assessment of Croatian S3 as a first milestone for setting up the baseline values, targets for indicators and expected results, including cost-benefit assessment,
- institutionalization of the monitoring and evaluation system for S3 using existing institutional capacities (including data collection system (MIS)) and external experts resources,
- **interim** evaluation of the selected S3 indicators (output, outcome/result and context),
- **ex-post** evaluation of the S3 through integrated monitoring and evaluation system and final reporting of the S3 achievements.

**Figure 36 Monitoring and evaluation tools**
Monitoring and evaluation as a public management tool will help policymakers in Croatia to track performance and determine the impact of policy interventions. Monitoring is first of all a process of information gathering and systematization. The main purpose of monitoring in this respect is to enhance understanding of the achievements that have been put in place through policy interventions. Monitoring will provide quantitative and qualitative information on the progress of a policy, program, or project to defined baseline or objective. Moreover, monitoring is a pre-condition for conducting any meaningful evaluation. Evaluation will attempt to provide an evidence of a change and show whether interventions are achieving the desired outcomes. Evaluation will be carried out by independent experts, facilitated by those responsible for the policy i.e. by the National Innovation Council which will approve the Evaluation plan and by the S3 IWG which will approve terms of references for every evaluation study.

Ex-ante assessment of the Croatian S3 showed that the selected context and intended results are in line with the Europe 2020 goals and result-oriented approach and yet enough specific for the Croatian current state of play when it comes to RDI. The ex-ante assessment also showed that there must be a more integrated approach toward the implementation of the Croatian S3 and also the financial allocations from the ESI funds which are planned for the investments in RDI must be used as a catalyst for the private investments into RDI and for RO capacity building, among other things.

Institutionalization of the monitoring and evaluation system through establishment of National Innovation Council will become a priority after Croatian S3 Government adoption and planned to be finished at the end of 2015.

Interim evaluations will allow detailed insight into the planned measures and how far we are from achieving the milestones as well as the first revision of the Croatian S3. Also, interim evaluations will give basis for possible changes in the S3 as some projects or programs can be extended or withdrawn, depending on the evaluation results. Evaluation plan providing the list of planned interim evaluations will be drafted and interim evaluations will be conducted in 2017.

For the ex-post evaluation, specific monitoring and evaluation measures are envisaged to ensure the follow-up of the implementation of the S3 principles and how these results of monitoring and evaluation will be taken into account. Assessment of past policies and overall evaluation of the Croatian S3 will provide a learning possibility for future policy measures. On the basis of the findings of the interim and ex-post evaluations, S3 IWG will prepare proposal regarding the necessary actions to the National Innovation Council for adoption in order to improve delivery of S3.
In relation to evaluation activities (preparation of Evaluation plan, conducting of interim and ex post evaluations, etc.) related to S3 strategy, S3 IWG and Technical Secretariat will consult when necessary the Evaluation working group for EU Funds which is an inter-institutional working group chaired by the Ministry of Regional Development and EU Funds (Coordinating body) and whose aim is to ensure that evaluation is actively used as a tool for enhancing the management of EU Cohesion Policy funding in Croatia. The evaluation will follow the European Commission's Guidance document on Monitoring and Evaluation and will be conducted by independent external experts with the experience of evaluating the RDI programs.

The actors involved in S3 implementation (MAs, IB1, IB2 and other responsible institutions and bodies as National Council for Science, Higher Education and Technology Development, Innovation Council for Industry with Thematic Innovation Councils and National Council for Human Resources Development) will be included in S3 monitoring and evaluation, and will use the set of indicators presented within this section in order to address and evaluate the impact of the implementation; to warn about setbacks, review and propose updates, assess and use evidence-based results to report on progress of certain policy measures to the HAMAG-BICRO, S3 IWG and National Innovation Council.

Established well-functioning M&E system in Croatia should provide inputs to each stage of the policy cycle composed of three phases – (i) strategic planning, (ii) operationalization and (iii) implementation – which subsequently complement and follow each other. In the center of this policy cycle will be stakeholders, who use information coming from monitoring, evaluation or both at every stage of cycle. For instance, at the planning and operationalization stage ex ante evaluations will be useful to validate whether the envisioned intervention is feasible. At the implementation stage monitoring will play a vital role to keep track of the intervention development, which will be supplemented with interim evaluation. After the end of the intervention, ex post evaluation will deliver knowledge about its effectiveness and delivery, which is indispensable for planning of following interventions. Generally, M&E data will help amend the implementation processes, distribute resources, adjust indicators, fine tune definitions etc.

**Revision(s) of the S3**

National smart specializations are a continuous processes which are responding to changing external factors. With this in mind, where the monitoring and evaluation process shows the need to redefine already defined TPAs and STPAs or where the new ones potentially emerge, revision of the S3 strategy will be initialized.

On the basis of the monitoring & evaluation system, Thematic Innovation Platforms activities (through which entrepreneurial discovery process will be continued), results of foresight projects217 and new rounds of partnership consultations, as well as ongoing socio-economic changes, corrective actions related to the S3 implementation or revisions of the S3 will be prepared. As already stated in section 7. S3 IWG will be authorized to propose corrective actions or revisions related to the S3 strategy, while National Innovation Council will be entitled to approve them. Research and innovation stakeholders will be involved in the revision process in the same way as during the drafting of S3 strategy, through continuation of entrepreneurial discovery process, through their involvement in the work of Thematic Innovation Platforms and through new rounds of partnership consultations. In line with the Croatian internal procedures for the adoptions and revisions of various strategies, the Government of the Republic of Croatia will have to adopt a Decision on the revision of S3. **Figure 37** bellow shows how corrective actions or revisions will be facilitated.

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217 Development of Innovation Network for Industry (INI) and creation of Thematic Innovation Platforms; Preparation of Science and Technology Foresight; Smart skills foresight
In the development of Smart Specialization Strategy 2021-2027, Croatia will include a section dedicated to assessing the impact of the implementation of Smart Specialization Strategy 2016-2020. This study will generate an ex-post evaluation report, which will include an analysis of:

- the achievements based on the indicators included in the strategy and effectiveness of its implementation;
- actual impact in terms of elimination of problems or valorization of chances underlying the Strategy and sustainability of results;
- causal mechanisms underlying the success or failure in implementing of the strategy’ priorities;
- possible unplanned side effects;
- lessons learned from the implementation of this strategy for future planning exercises - identifying, for example, the registering and indicating the weaknesses in relation to the initial design priorities, measures, actions, targets, indicators and listing the recommendations to reduce or eliminate these deficiencies on future planning periods.

8.2. Methodology of monitoring and set of indicators

The monitoring of the implementation of the strategy will be developed according to the following:

1. Activities of monitoring of the implementation of Smart Specialization Strategy will be realized annually through S3 Annual Implementation Report (S3 AIR) prepared by HAMAG-BICRO. The main purpose of the AIR will be to highlight progress on the implementation of S3 and propose recommendations for improving the implementation of it.

S3 AIR will have the following minimum structure:

- **Introduction**: The Monitoring report will have an introductory section in which it will be provided information on the monitoring period covered by the report, the sources of data used to assess progress in implementing the strategy, difficulties encountered.
- **Chapter 1**: This chapter will describe the activities developed during the monitoring process.
• **Chapter 2**: This chapter is an overview of measures and actions which have been taken during the monitoring process. There will be, then, listed recommendations to streamline the implementation of each measure and action, each party;

• **Final conclusions**: The report concludes with an overall assessment on progress in implementing smart specialization strategy.

The S3 AIR will be discussed at the National Innovation Council in order to analyse progress of implementation. Based on this analysis obligatory recommendations for improving the implementation of the Strategy will be proposed and communicated to the wider public with aim to promote the result and impact of invested public money (including ESI funds) to RDI.

2. As part of the monitoring and evaluation of the Croatian S3, a clear link of delivery instruments and foreseen measures and a set of output, outcome/result (economic, innovation intermediate and enabling indicators) and context indicators, as presented in the RIS3 guidelines, is provided in the Table 19. It presents a proposed set of evidence-based indicators that are planned to be used for the monitoring and evaluation of the S3.

The follow-up and reporting on these indicators through the S3 IWG and HAMAG-BICRO as the Technical Secretariat for monitoring and evaluation of the S3, and consulted with the Evaluation working group chaired by MRDEUF when necessary, for the purpose of evaluating the effects of proposed measures will allow proper decision-making of the National Innovation council and, if necessary, the change in the scope and type of all S3 elements. The list of indicators will be updated depending on the further development of the Strategy.

Besides on indicators shown in Table 19 and Table 20 peer review panels involving national and international leading experts will be organized for each S3 priority thematic area. The full results should be evaluated after a minimum of three to five year horizon when scientific and economic results can be expected.
### Table 19 List of indicators planned to be used for monitoring and evaluation of the S3

<table>
<thead>
<tr>
<th>Specific strategic objective</th>
<th>Delivery instrument</th>
<th>Output indicators</th>
<th>Outcome/result indicators (show change that can be credibly attributed to an intervention)</th>
<th>Context indicators on program level (show general changes in the socio-economic situation and are used to define or modify the scope of public intervention)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased capacities of RDI sector to perform excellent research and to serve the needs of the economy</td>
<td>FOR EACH THEMATIC PRIORITY AREA</td>
<td>Number of RDI infrastructural projects</td>
<td>Scientific publications published in the journals indexed in the Web of Science Core Collection</td>
<td>Increased R&amp;D expenditure as % of GDP (GERD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of researchers working in improved research infrastructure facilities (Common OI)</td>
<td>1.215</td>
<td>Increased Summary Innovation Index</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of supported Teaming, Twinning and ERA chair projects</td>
<td>3</td>
<td>Increased HRST as % of labour force</td>
</tr>
<tr>
<td>Strengthening research excellence by supporting</td>
<td>EACH THEMATIC PRIORITY</td>
<td>Number of National Centres of Research Excellence’ projects supported</td>
<td>Scientific publications published in the journals indexed in the Web of Science Core Collection</td>
<td><strong>218</strong> Will be measured separately for each TPA and then aggregated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>219</strong> Calculated on cumulative basis 2014-2023</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>220</strong> Indicator refers to participation of Croatian stakeholders in all H2020 programmes, regardless on its form of participation (lead, partner, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>221</strong> Calculated on cumulative basis 2014-2020</td>
</tr>
<tr>
<td>Specific strategic objective</td>
<td>Delivery instrument</td>
<td>Output indicators</td>
<td>Output indicators</td>
<td>Outcome/result indicators (show change that can be credibly attributed to an intervention)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------</td>
<td>------------------</td>
<td>------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>National Centres of Research Excellence and enabling synergies with ERC grants</td>
<td></td>
<td>Number of researchers working in supported CoRE</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Share of funding of CoRE as % of public funding of R&amp;D</td>
<td>3.6 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of supported projects enabling synergies with ERC grants</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Support to research organizations conducting EACH THEMATIC PRIORIT</td>
<td></td>
<td>Number of RDI projects conducted by ROs</td>
<td>75</td>
<td>Number of patent applications by resident legal entities</td>
</tr>
</tbody>
</table>

\(^{222}\) Calculated on cumulative basis 2014-2023.
\(^{223}\) Calculated on cumulative basis 2004-2013
\(^{224}\) Calculated on cumulative basis 2014-2023.
<table>
<thead>
<tr>
<th>Specific strategic objective</th>
<th>Delivery instrument</th>
<th>Output indicators</th>
<th>Output indicators</th>
<th>Outcome/result indicators (show change that can be credibly attributed to an intervention)</th>
<th>Outcome/result indicators</th>
<th>Outcome/result indicators</th>
<th>Outcome/result indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D projects directed towards the needs of economy</td>
<td>Number of enterprises cooperating with ROs (Common OI)</td>
<td>30</td>
<td>Outcome/result indicators</td>
<td>Baseline (baseline year)</td>
<td>Target (2023)</td>
<td>Context indicators on program level (show general changes in the socio-economic situation and are used to define or modify the scope of public intervention)</td>
<td></td>
</tr>
<tr>
<td>Project ‘Science and Technology Foresight’</td>
<td>Web based user interface for input, management and analysis of data developed and productive Maps and visualization of defined research disciplines and technology areas</td>
<td>1</td>
<td>Creating a priority setting system for Scientific R&amp;D policy in Croatia</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Legal framework for collection and management of RDI data in research organizations developed</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reports and common vision (foresight) developed</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overcoming the fragmentation of innovation value</td>
<td>No of established Thematic innovation councils</td>
<td>0</td>
<td>Business enterprise R&amp;D expenditure (BERD) as % of GDP</td>
<td>0,41% GDP (2013)</td>
<td>0,70% GDP</td>
<td>Increased number of new companies in</td>
<td></td>
</tr>
<tr>
<td>Specific strategic objective</td>
<td>Delivery instrument</td>
<td>Output indicators</td>
<td>Output indicators</td>
<td>Outcome/result indicators</td>
<td>Context indicators on program level (show general changes in the socio-economic situation and are used to define or modify the scope of public intervention)</td>
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<td>--------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>218 chain and the gap between research and business sector network for industry and development of thematic innovation platforms</td>
<td></td>
<td>No of established web innovation platforms</td>
<td>1</td>
<td></td>
<td>economic areas included in a smart specialization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No of identified strategic projects under Thematic innovation platforms</td>
<td>25</td>
<td>Business enterprise R&amp;D expenditure (BERD) as % of GDP</td>
<td>0,41% GDP (2013)</td>
<td>Increased employment in knowledge-intensive activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No of prepared Thematic Strategies for RDI</td>
<td>5</td>
<td></td>
<td>0,70% GDP</td>
<td>Increased Medium/high-tech products contribution to trade balance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOR EACH THEMATIC PRIORITY AREA</td>
<td>Number of TTO agreements/contracts</td>
<td>330</td>
<td>Baseline and target value will be set after completion of ‘Science and Technology Foresight’ project</td>
<td></td>
<td>Increased sales of new to market and new to firm innovations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of RO’s employees trained (in topics related to knowledge and technology transfer)</td>
<td>720</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of supported science and technology parks</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>No of identified strategic projects under Thematic innovation platforms</td>
<td>25</td>
<td>Business enterprise R&amp;D expenditure (BERD) as % of GDP</td>
<td>0,41% GDP (2013)</td>
<td>Increased employment in knowledge-intensive activities</td>
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<tr>
<td></td>
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<td>5</td>
<td></td>
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<td>330</td>
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<td></td>
<td>Number of supported science and technology parks</td>
<td>4</td>
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<tr>
<td>Specific strategic objective</td>
<td>Delivery instrument</td>
<td>Output indicators 218</td>
<td>Output indicators</td>
<td>Outcome/result indicators (show change that can be credibly attributed to an intervention)</td>
<td>Outcome/result indicators</td>
<td>Context indicators on program level (show general changes in the socio-economic situation and are used to define or modify the scope of public intervention)</td>
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<td></td>
</tr>
<tr>
<td>Creation of centers of competence</td>
<td>FOR EACH THEMATIC PRIORITY AREA</td>
<td>Number of supported R&amp;D projects</td>
<td>100</td>
<td>Business enterprise R&amp;D expenditure (BERD) as % of GDP</td>
<td>0,41% GDP (2013)</td>
<td>Increased Gross Domestic Product (GDP) / capita (EUR PPS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of enterprises supported to introduce new to the market products (CO28)</td>
<td>30</td>
<td>Sales from new products/services (percentage of turnover)</td>
<td>10,5 (2010)</td>
<td>Increased R&amp;D expenditure as % of GDP (GERD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of enterprises supported to introduce new to the firm products (CO29)</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Number of enterprises cooperating with research institutions (CO26)</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of new researchers working in supported entities (CO24)</td>
<td>30</td>
<td>Number of researchers (FTE) employed in Business sector</td>
<td>1,058 (2013)</td>
<td>Increased Summary Innovation Index</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Private investment matching public support in innovation or R&amp;D projects (CO27)</td>
<td>30,000,000</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Increased share of innovative companies in industry and services</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Increased number of new companies in economic areas included in a smart specialization</td>
<td></td>
</tr>
<tr>
<td>Specific strategic objective</td>
<td>Delivery instrument</td>
<td>Output indicators</td>
<td>Output indicators</td>
<td>Outcome/result indicators</td>
<td>Context indicators on program level (show general changes in the socio-economic situation and are used to define or modify the scope of public intervention)</td>
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</tr>
<tr>
<td>Modernizing and diversifying Croatian economy through increasing private R&amp;D and non R&amp;D investment</td>
<td>FOR EACH THEMATIC PRIORITY AREA</td>
<td>Number of enterprises supported to introduce new to the market products (CO28)</td>
<td>70 (2016)</td>
<td>Sales of new to the market and new to the firm innovations (as percentage of turnover)</td>
<td>Increased Gross Domestic Product (GDP) / capita (EUR PPS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support to business investment in RDI</td>
<td></td>
<td>Number of enterprises supported to introduce new to the firm products (CO29)</td>
<td>330</td>
<td>Increase of patent applications, trademarks and industrial design in Croatia</td>
<td>Increased R&amp;D expenditure as % of GDP (GERD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of R&amp;D projects supported</td>
<td>500</td>
<td></td>
<td>Increased Summary Innovation Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of enterprises supported cooperating with research institutions (CO26)</td>
<td>100</td>
<td>Business enterprise R&amp;D expenditure (BERD) as % of GDP</td>
<td>Increased share of innovative companies in industry and services</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of enterprises receiving grants (CO02)</td>
<td>400</td>
<td></td>
<td>Increased number of new companies in economic areas included in a smart specialization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Private investment matching public support in innovation or R&amp;D projects (CO27)</td>
<td>136,666,666.66</td>
<td></td>
<td>Increased employment rates in knowledge-intensive sectors</td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Baseline (baseline year)</strong></th>
<th><strong>Target (2023)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased GDP / capita</td>
<td>10,5% (2010)</td>
</tr>
<tr>
<td>14,4%</td>
<td></td>
</tr>
<tr>
<td>Increased R&amp;D expenditure</td>
<td>1.826</td>
</tr>
<tr>
<td>2.700</td>
<td></td>
</tr>
<tr>
<td>Increased Summary Innovation Index</td>
<td>0.41% BDP (2013)</td>
</tr>
</tbody>
</table>

Modernizing and diversifying Croatian economy through increasing private R&D and non R&D investment.
<table>
<thead>
<tr>
<th>Specific strategic objective</th>
<th>Delivery instrument</th>
<th>Output indicators</th>
<th>Output indicators</th>
<th>Outcome/result indicators</th>
<th>Outcome/result indicators</th>
<th>Context indicators on program level (show general changes in the socio-economic situation and are used to define or modify the scope of public intervention)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FOR EACH THEMATIC PRIORITY AREA</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Support to SMEs capacities to innovate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of enterprises supported to introduce new to the market products (CO28)</td>
<td>36</td>
<td>Innovative SMEs compared to total number of SMEs</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of enterprises supported to introduce new to the firm products (CO29)</td>
<td>83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Support to competitiveness cluster initiatives</td>
<td>Number of implemented competitiveness cluster initiatives</td>
<td>0</td>
<td>Increased number of Competitiveness Clusters members</td>
<td>500 (2020)</td>
<td>Increased Gross Domestic Product (GDP) / capita (EUR PPS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of identified new brands under STPA</td>
<td>0</td>
<td>Exports of medium and high-technology products as a share of total products exports</td>
<td>41.36 (2020)</td>
<td></td>
</tr>
<tr>
<td>Specific strategic objective</td>
<td>Delivery instrument</td>
<td>Output indicators</td>
<td>Output indicators</td>
<td>Outcome/result indicators</td>
<td>Outcome/result indicators</td>
<td>Context indicators on program level (show general changes in the socio-economic situation and are used to define or modify the scope of public intervention)</td>
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<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Number of companies/associations (competitiveness clusters) taking part in an internationalization initiative (Fairs, Exhibitions, Trade visit.)</td>
<td></td>
<td>2016</td>
<td>Target (2023)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working in partnerships to address societal challenges</td>
<td>Support to social innovation</td>
<td>Number of social innovation projects</td>
<td>3</td>
<td>Increased number of PCT patent applications in societal challenges per billion GDP (PPS EUR)</td>
<td>0.22 (2011)</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- Increased value of FDI/capita (Euro)
- Increased share of FDI in GDP
- Increased share of foreign investment in R&D expenditure
- Increased medium and high-tech products exports as % of total product exports
- Export growth
<table>
<thead>
<tr>
<th>Specific strategic objective</th>
<th>Delivery instrument</th>
<th>Output indicators (^{218})</th>
<th>Output indicators</th>
<th>Outcome/result indicators (^{218}) (show change that can be credibly attributed to an intervention)</th>
<th>Outcome/result indicators</th>
<th>Context indicators on program level (show general changes in the socio-economic situation and are used to define or modify the scope of public intervention)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating smart skills - upgrading the qualifications of existing and new work force for smart specialization (^{225})</td>
<td>Establishing infrastructure for smart skills policies</td>
<td><strong>FOR EACH THEMATIC AREA</strong></td>
<td><strong>Development of new econometric forecasting model</strong></td>
<td>Developed forecasting system by the Ministry of Labour and Pension (System for creating occupational and qualification standards which meets the needs of the S3)</td>
<td><strong>Baseline (baseline year)</strong></td>
<td>Increased employment in knowledge-intensive activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>0 (2014)</td>
<td>2</td>
<td><strong>Number of persons who in the reference year acquired a PhD degree in STEM areas</strong> (^{227})</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15000</td>
<td><strong>Completion rate of students who received scholarships</strong></td>
<td>45,84%</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td><strong>Increased number of employed researchers in early stage of career development in Croatian research system</strong></td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>405 (^{227})</td>
<td><strong>Increased number of new PhDs in STEM areas</strong></td>
<td>33,59% ((2013))</td>
<td>43,59% ((2020))</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>445</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{225}\) Output and result indicators and its baseline/targets are based on the OP EHR 2014-2020 and MSES Strategic plan (2016-2018), therefore all of the Baseline/target years for the delivery instr. do not match. Also the mentioned indicators currently assume only ESF planned financing therefore are indicative and subject to a certain increase in num. or %

\(^{226}\) Output and result indicators and its baseline/targets, related to smart skills instruments are based on the OP EHR 2014-2020 target content (except the last indicator (**)) and assume only ESF planned financing therefore are indicative on the national level and subject to a certain increase in num. or %

\(^{227}\) Data for 2015
<table>
<thead>
<tr>
<th>Specific strategic objective</th>
<th>Delivery instrument</th>
<th>Output indicators 218</th>
<th>Output indicators</th>
<th>Outcome/result indicators (show change that can be credibly attributed to an intervention)</th>
<th>Outcome/result indicators</th>
<th>Context indicators on program level (show general changes in the socio-economic situation and are used to define or modify the scope of public intervention)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Additional instruments put in place for assessing medium term skill needs</td>
<td>Number of Sectoral curricula for vocational education and training based on learning outcomes and targeted sectors of the national / regional strategic interests supported through the development of the projects.</td>
<td>0 5</td>
<td>Percentage of vocational schools in which they carried a newly developed sectoral curricula based on learning outcomes and targeted sectors of the national / regional strategic interests</td>
<td>0% 10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Implementing the Croatian Qualification Framework mechanism for delivering timely and standardized training programmes based on future and medium term skill needs;</td>
<td>Number of education programs/qualifications standards in line with CROQF developed</td>
<td>200</td>
<td>Increased number of education programs/qualifications standards in the CROQF Register</td>
<td>0 100</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of adult learners awarded with vouchers</td>
<td>10000</td>
<td>Increased number of adult learners gaining qualifications</td>
<td>0 5000</td>
<td></td>
</tr>
</tbody>
</table>

* The same indicator types, e.g. output or outcome, can be used at different intervention levels, but they then possess different characteristics (scope, target group, frequency of measurement)
*Each of the utilized indicators should possess its own ID card specifying its characteristics (type of indicator, name, unit of measurement, data source, frequency of measurement and specific date, methodology of measurement, and baseline and target value.)
<table>
<thead>
<tr>
<th>Priority Thematic Area</th>
<th>Context indicator: Increase the contribution of research and innovation to the resolution of key societal challenges</th>
<th>Indicator</th>
<th>Baseline Value</th>
<th>Target Value (2023)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health and quality-of-life</strong></td>
<td></td>
<td>Increase of life expectancy at birth</td>
<td>78 years (2013)</td>
<td>79.5 years</td>
</tr>
<tr>
<td><strong>Energy and sustainable environment</strong></td>
<td></td>
<td>Increase in ranking on Euro Health Consumer Index</td>
<td>24th place (2014)</td>
<td>20th place</td>
</tr>
<tr>
<td><strong>Energy and sustainable environment</strong></td>
<td></td>
<td>Share of renewable energy in gross final energy consumption (%)</td>
<td>18 (2013)</td>
<td>20</td>
</tr>
<tr>
<td><strong>Energy and sustainable environment</strong></td>
<td></td>
<td>Decrease in Greenhouse gas emissions (CO₂ equivalent)</td>
<td>26,449 thousand tonnes (2012)</td>
<td>24,000 thousand tonnes</td>
</tr>
<tr>
<td><strong>Transport and mobility</strong></td>
<td></td>
<td>Better quality transport services and reduced environmental pollution – reduction of Greenhouse gas emissions in transport sector (CO₂ equivalent)</td>
<td>5,709 thousand tonnes (2012)</td>
<td>5,200 thousand tonnes</td>
</tr>
<tr>
<td><strong>Transport and mobility</strong></td>
<td></td>
<td>Reduction of energy consumption of transport and mobility sector</td>
<td>2,037.9 thousand tonnes of oil equivalent (2013)</td>
<td>1,700 thousand tonnes of oil equivalent</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td></td>
<td>Increased GDP contribution of military and non-military goods and products (approved value of licenses issued for military goods and products)</td>
<td>€ 711,535,861.19 (2013)</td>
<td>10% Increase</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td></td>
<td>Reduced number of companies and individuals in Croatia experiencing cyber crimes</td>
<td>8% (2013)</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td></td>
<td>AQAP²²⁸ standardisation to be implemented in Croatia</td>
<td>not implemented</td>
<td>implemented</td>
</tr>
<tr>
<td><strong>Food and Bio-economy</strong></td>
<td></td>
<td>Increase of areas under organic farming</td>
<td>2.4% (2012)</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Food and Bio-economy</strong></td>
<td></td>
<td>Increase of total waste recovered (other than energy recovery)</td>
<td>243 kilograms per capita (2012)</td>
<td>300 kilograms per capita</td>
</tr>
</tbody>
</table>

²²⁸ AQAP - Allied Quality Assurance Publication
3. Croatia will use the following sources of data and documentation for assessing the achievement of context, output and result indicators:

- **for context indicators**: the values of indicators will be obtained from secondary sources – statistical data from the National Statistics Office;
- **for output and result indicators**: the values of indicators will be obtained from Annual Implementation Reports of Operational Programs related to period 2014-2020, elaborated by Management Authorities/Intermediate Bodies (based on data from MIS and prepared monitoring sheets and reports for programs that are not part of MIS), in the context that all delivery mechanism will be proposed to be financed from Operational Programmes.

In the context in which it is found that the information available on the existing information sources (MIS databases, annual implementation reports) are not sufficient to reflect the progress of implementation of the strategy, M&E body or MA/IB can collect it via monitoring questionnaires by those organizations which are implementing projects relevant to the strategy.

4. An important role of monitoring system will be to communicate the relevant information about S3 implementation to all stakeholder and wider public. After adoption of S3 by Croatian Government, Ministry of Economy in cooperation with relevant ministries included in S3 implementation will prepare S3 Communication strategy and related Communication Action Plan for implementation of measures and activities with aim of presenting results and impacts of S3 related RDI projects financed through ESI funds and other public resources and submit it to the National Innovation Council for the final adoption. Communication activities will include Annual S3 conference and will be supported through continuation of the dialogue with those stakeholders that were involved during the design of the S3 what will contribute to building and maintaining dialogue and consensus regarding S3 topics.
9. ANNEXES

9.1. Annex 1 - The results and continuation of entrepreneurial discovery and partnership consultations

Stakeholder involvement is of utmost importance in the course of development of the S3 for Croatia. Stakeholder groups have an advisory role and are expected to provide their view on the direction of development of the Croatian national and regional economy in relation to smart specialization and ensure that a full-fledged entrepreneurial discovery process has taken place in the process of the S3 elaboration and that the final outcome is indeed consensus-based.

The most important stakeholder inputs in process of smart specialisation in Croatia have come from 4 main series (rounds) of partnership consultation and a lot of expert groups meetings, leader industries meetings, bilateral consultation meetings with relevant ministries and cross-border meetings.

The first group of consultations were organized through five regional workshops, followed a both thematic and regional approach, aimed to allow the stakeholders to provide their direct views on the S3 context and possible directions. In total in all 5 regional workshops there were 160 participants: 27 representatives of universities, 9 representatives of research institutes, 18 representatives of business support organizations, 30 representatives of regional development agencies, 46 representatives of business sector (SMEs and large industry, including clusters). The most efficient way to hold the regional workshops was to have a combination of focus group (3 groups: I. regional and local government, II. business representatives, III. science and research sector) and plenary discussions. In addition, it was decided to outline a questionnaire for each of the focus groups, as a basis for discussions and to facilitate reaching relevant conclusions within each of the 3 aforementioned groups.

From the discussion with regional and local governments (as well as from inputs of questionnaire), it can be drawn several conclusions in relation to inputs to the further elaboration of the S3 in Croatia:

- There is indeed a strong need for limiting the number of supported sectors and focusing on those thematic areas which could bring measurable positive impacts by 2020 in economic development in Croatian regions;
- From the perspective of regional development, the choice of priority thematic areas should take into consideration that the major part of Croatian economy and economic resources still lays between low and medium tech industry;
- Smart specialisation should acknowledge the fact that Croatia is above average rich in cultural heritage and natural resources (find a place for tourism and kind of bio-economy);
- Most of the issues discussed with the business sector were not specific to a certain sector. One topic which has brought most attention and discussion is the still insufficient level of cooperation between the industry and science and research institutions; need for better mobility of research staff between public and private sector; too-low level of R&D in the business sector.

In relation to use of Key Enabling Technologies (KETs), overall there is a very weak signal that KETs are being used or further developed through R&D process but some positive examples were found, related to either existing activities or future business plans that involve the use of KETs: advanced materials; advanced manufacturing, micro and nanotechnology used in packaging of food, electrical engineering, defence industry; biotechnology; ICT and photonics.

Moreover, all sectors have recognized opportunities to position themselves through specific niches developed towards targeting societal challenges. This is especially relevant for traditional (and declining) sectors that could turn toward possible competitive niches targeting societal challenges.

Related to conclusions from the discussion with the science and research sector, in general, science and public research community has agreed that there is too little cooperation with the industry and that
the resources found in universities and institutes could be much more put in the function of socio-economic development of Croatia.

The value of public science and research organization for the further technological development of Croatian industry can also be seen in the fact that, as opposed to the business sector, the use of KETs in the science and research sector is much more evident. The numerous examples were demonstrated in the use of nanotechnology, micro- and nano-electronics, biotechnology, photonics (bit less), advance materials, bio-imaging, bio-informatics, advanced manufacturing methods (3D scanning and printing). In this sense, public science and research organizations could very well facilitate improving of competitiveness of certain sectors by stimulating the introduction of KETs.

The second group of consultations were organized through six regional workshops, followed thematic approach as well and aimed to discuss key priority thematic areas and cross-cutting themes for smart specialization and try to define narrower thematic areas. Through consultation with major stakeholders it was important to enable harmonization with strategic goals of business and scientific sector in Croatia. In total in all 6 thematic workshops there were 188 participants: 20 representatives of universities, 27 representatives of research institutes, 20 representatives of business support organizations, 10 representatives of regional development agencies, 37 representatives of local governments, 12 representatives of central governments, 3 representatives of NGOs, 59 representatives of business sector (SMEs and large industry, including clusters).

Several conclusions from the discussion for priority area Sustainable energy and environment are as follows: importance of development and production of hard materials; usage of plasma technology for waste disposal; plasma technology and plasma research in production of graphene; usage of polymers possible in development of bio-degradable packaging, and network for waste collection (waste management network); CO₂ disposal in production; development of enameled trusses for sustainable construction; usage of wood facade instead of aluminium façade; importance of AutoCAD and AutoCAM technologies in textile industry.

Conclusions from the discussion for priority area Engineering are as follows: the area currently defined as "engineering" is too broad and does not represent a specialization which should weigh the economy, aimed at increasing competitiveness. Currently set thematic area within the S3 does not represent the area of appliance what should be the main task of this strategy (as the ex-ante evaluator confirmed and who was also attending the meeting); incorporate three new thematic areas that represent the real strength of Croatia and the areas in which they should specialize in relation to the relevant manufacturing sector, the relevant forces and capabilities that can support suggested areas, and those are following: mobility, security and agrofood; redefining and changing the titles of current areas of "Sustainable Energy and Environment" in "Energy and Sustainable Environment" and adding links quality of life under the Health theme: "Health and Quality of Life."

Conclusions from the discussion for priority area Bio-technology and Bio-economy: priority measures of aquaculture sector (the primary production); improvement and diversification of aquaculture production through development and implementation of new technologies tested in production; education for implementation of new technologies and promotion of environmentally sustainable aquaculture; priority measures of primary production sector in food-processing (processing of aquaculture and fishing products); improving the processing technology through development and implementation of new technologies; diversification of aquaculture products; quality improvement for ensuring the value added product; education of manufacturers and other stakeholders of food chain on implementation of new technologies, quality characteristics, certification and branding; strengthen links between customers, production and science sector.

Conclusions from the discussion for priority area Health: recommendation to use generic terms in the S3 (and in defining particular niches as well); it was suggested and agreed to use term health tourism instead of term medicine tourism; part of ICT-cross-cutting theme should be following themes: e-health, business process management (as potential area for investment) and lifelong learning in health sector; within the biotechnology area chemistry are not only related to drugs and drug research; need for using wider terminology of medical products; for biotechnology area, in addition to RED TECH
and WHITE TECH it is important to add BLUE TECH; term dietary food supplements refers not only to dietary food but also customized nutrition.

Conclusions from the discussion for cross-cutting theme Culture and Tourism and cross-cutting theme Creative Industry: need for linking tourism and culture; valorization of culture heritage for cultural tourism; non-technological innovation in the form of new tourism product and services (cooperation tourism/ICT); need for mapping of Croatian cultural and natural heritage and identification of cultural destination on local, regional, national and macro-regional level; creative industries can give added value to Croatian industries and improve Croatian position in global value chains; need for mapping of Creative industries and establishment of Creative platforms, development of financial instruments for collaboration between Creative industries and other sectors (Creative vouchers).

Joint conclusion from 2nd round of partnership consultation with agreement of EC ex-ante evaluator is that in defining thematic priority areas Croatia will not follow sectoral or technological approach but will define thematic priority areas according to priority area of application. Reason for this is that smart specialization needs to be inclusive. This does not mean that the strategy will support a project in every sector but inclusive smart specialization means giving every sector a chance to be present in the strategy through a good project if fulfil main S3 criteria’s and can contribute to overall objective of TPA.

Further to above mentioned conclusions from 2nd round of partnership consultation, thematic priority areas were redefined, different approach is applied in order to define priority areas in accordance to fields of highest potential for implementation of RDI investments. Based on suggestions from ex-ante evaluator, relevant national and European strategic documents, existing analysis (strengthened by new inputs from World Bank), and stakeholders contributions and inputs regarding their current strategic goals and investments, five key thematic priority areas (TPA) are identified in the context of the Croatian S3. Those are: (1) health and quality of life; (2) energy and sustainable environment; (3) transport and mobility; (4) security and (5) agrofood and bioeconomy.

The 3rd round of partnership consultations was organized with the purpose to elaborate each thematic priority areas and define relevant subfields correlated with the strategic goals of the business and scientific research sector in Croatia. Consultations were organized through five meetings/workshops by each thematic priority area. Additional separated consultations were organized for sub-thematic priority area Cyber security and Defence dual-use within thematic priority area Security for the purpose of thoroughly verifying the identified TPA topics with business sector representatives operating and interested for RDI projects within mentioned sub-thematic areas. All 6 thematic workshops attended 142 participants: 17 representatives of universities, 9 representatives of research institutes, 11 representatives of business support organizations, 14 representatives of regional development agencies, 8 representatives of local governments, 50 representatives of central governments, 3 representative of NGOs, 30 representatives of business sector (SMEs and large industry, including clusters).

Participants were informed about ongoing process of defining thematic priority area; during and post meeting they were able to fill in distributed questionnaires and provide inputs to relevant materials and text of the S3 by 29th October. The consultation process finally resulted with improved text of the S3, as well as conclusion of sub-thematic priority areas:

1. Within TPA Health and quality of life 4 sub-thematic areas are recognized: (1) pharmaceuticals and medical equipment and devices with main RDI topics: new chemical and bio-tech entities, generic and patenting drugs, health products for animal and OTC medicine, also medical and stomatological equipment and medical and stomatological devices; (2) health services and methods for preventive and personalized medicine and diagnostics with main RDI topics: medical care to elderly and disabled, regenerative medicine and tissue engineering, neurosciences, immunology and microbiology and biochemistry, genetics, molecular biology and (4) nutrition with main RDI topics: health and functional food, herbal medicine, dietary supplements.
2. Within TPA Energy and sustainable environment 4 STPAs are defined: (1) energy technologies and equipment with main RDI topics: renewable energy, oil and gas, new light sources, EMC and security, energy systems management; (2) environment technologies and equipment with main RDI topics: waste and wastewater systems, utilization of waste streams, water management and techniques, technologies and methods for protection of bio-diversity; (3) green construction with main RDI topics: green and functional construction and building material and component, reliable and improved infrastructure management and operations, advanced measurement system (Smart Metering); (4) smart grid and energy systems with main RDI topics: smart cities, smart electric grids, smart buildings, MES (management of energy services), systems for energy generation, storage and distribution.

3. Within TPA Transport and mobility 4 STPAs are defined: (1) green transport with main RDI topics: green boats and vehicles, alternative drive technologies, low emission vehicle power train; (2) advanced vehicle structures with main RDI topics: complex and custom-made manufacturing, specialized boats and special purpose ships, advance production of parts for automotive industry; (3) smart, safe and intelligent transport system with main RDI topics: technology-assisted drive (“drive by wire”), surveying graphics systems with wide range of applications, smart management systems for security processes, integrated electric transport systems and infrastructure, smart and secure mobility and logistics, sustainable mobility plan and (4) innovative transport and logistics services.

4. Within TPA Security STPAs are defined and confirmed by industry: (1) cyber security with main RDI topics: Cyber space monitoring systems, Cyber security of IT systems, Systems for detection, collection and processing of cyber security information, Cryptographic equipment for protection of classified information, TEMPEST solutions, Security of SCADA systems and other control systems, ICT systems for spatial monitoring, Digital Forensics and reverse engineering. Early warning systems – identification of security threats customized to customer needs, Vulnerability assessment systems, Systems for security education and awareness increase (control policies, the use of personal information and trust in institutions); (2) defence dual-use with main RDI topics: Protective clothing for police forces and fire fighters; Materials engineering (advanced materials, new materials); Automated advanced production (industrial robots and simulation lines - Process and integrated computer automation and process control (microcontrollers, sensors, analyzers); Automated devices for dimensional control of static and dynamic measures, tolerance analysis, surface and profiles quality control; Laser technologies for 3D visualization; Advanced digital and communication technologies (namely; equipment and programme packages for simulation and prototype development); Robotized and automated remote control systems for CBRN responses (EOD/IOD), natural disasters and technological catastrophes; Process and embedded computer automation and management processes (microcontrollers, sensors, analyzers, generators, lasers for positioning the object, PLC’s, HMI’s, SCADA systems); The development of antidotes for chemical weapons; Control and protection against the use of biological agents for terrorist purposes; KET Technologies (in areas: Micro and nano electronics, Photonic technologies, Advanced materials) and (3) mine action program with main RDI topics: ICT (Mine-information and geo-information systems; Systems for multi-criterial decision making based on geo-information system; Development of electronic learning at distance (E-learning) for EOD training); KET (Photonic (hyper spectral, thermal), technologies for acquisition, processing, and visualization of data and scene interpretation, as well as 3D mapping (ground scanners, aircrafts for 3D scanning)); ADVANCED PRODUCTION (Development of robots for survey and quality assurance - ground platforms; Remotely piloted aerial systems (RPAS), light manned helicopters, for multi-sensor, hyperspectral, thermal survey for mine action, natural disasters; Multi-purpose, integrated programs, systems (Engineering)); TECHNOLOGY CONVERGENCES (Biotechnology + ICT; ICT + sensor and digital technology; ICT + airborne and ground platforms for countering large scale natural disasters); MINE ACTION TECHNOLOGIES FOR DIFFERENT APPLICATIONS - natural disasters, detection of coca fields and border security (Land systems of control and scanning; Services of the aerial civil reconnaissance, surveillance, monitoring, survey for humanitarian mine action, in case of natural disasters (floods, landslides, torrents, forest fires); Production of protective
5. Within TPA Agro food and bioeconomy 3 STPAs are defined: (1) Sustainable Food production and processing, (2) Sustainable wood production and processing and (3) Biomass and Bio-products. As the main RDI topics under this TPA are defined sustainable and integrated supply chain (from primary production to product distribution - integrated supply chain solutions; new services; logistics, and management systems; sustainable and innovative packaging); efficient and sustainable resource management (eco-system services, soil functionality, water management, genetic resources, etc.), industrial application of renewable resources and biomass.

All workshops resulted not only with proposed priority STPAs but also with eliminated possible STPAs which having traditionally strong position in Croatian economy and employing a lot of people but which are related to Sunset industries with low value added, loosing market and don’t have a growth possibility (as traditional textile industries based on lohn jobs, traditional shipbuilding centred on construction of large non-specialised boats, semi-product by woods with low value added, non-branded food products …).

The 4th round of partnership consultations was organized through four meetings/workshops for thematic&sub/thematic priority areas: Transport and mobility, Agro food and bioeconomy, Health and quality of life and Energy and sustainable environment. Main purpose was to inform public about the possibility of financing R&D activities from the ESI funds with focus on S3 delivery instruments and to present and on one more time discuss thematic priority areas and sub-thematic areas of S3 Strategy that were sent to the EC for informal consultations. All participants confirmed the relevance of defined priority thematic and sub-thematic areas and readiness to prepare R&D project and in this way transform their economic activities and that was the main conclusion for all workshops. Fourth thematic workshops attended 94 participants: 20 representatives of R&D sector, 15 representatives of business support organizations, 38 representatives of public sector and 21 representatives of business sector (SMEs and large industry, including clusters).

Additional inputs for preparation of the S3 Ministry of Economy, as a responsible institution for the preparation of the S3, got from the meeting with Lead representatives from the business sector from pharmaceutical, defence, ICT, Food, Wood and Energy sectors, bilateral meeting with stakeholders from public, science and business sectors, meetings with business association, meetings with existing and potential Centres of Competence and county perfects and county development agencies and representatives from emergences sectors and gazelles as Rimac enterprise. The main purpose of these meetings was to use the entrepreneurial discovery process to identify synergies: detect different stakeholders/interest groups, new innovative entrepreneurs (e.g. technology-based ICT start-ups), hidden champions among existing enterprises or persons with an entrepreneurial potential and an international outlook and capacity to create cooperation between the different groups.

In purpose to exchange information and best practices in process of preparation of the S3 with other EU countries and regions Croatia has participated on S3 Peer Review organized by S3 Platform (Bratislava, Budapest, Seville, Dublin, Novi Sad and Pisa). Croatia also presented own experience and the main results of the preparation of the S3 in Peer Review in Portorož together with Slovenia and Cyprus. In purpose to be in compliance with neighbourhood countries the meeting was hold with Hungarian national authorities responsible for the S3 preparation but also with representatives of Italy, Netherlands and France. Very important inputs and guidelines Croatia got from the side of World Bank Team through TA projects and OECD Team (in the field of Social innovation).

During the whole period of preparation of the S3, meetings of relevant ministries and agencies on national level (operation meeting of Working group and Assistant level meeting) were organized. Also, in the purpose of raising awareness of the importance of whole process of smart specialization in Croatia Ministry of Economy has participated numerous of round tables on this topic. Under the TA project financed by the EU, on 25th March 2014 was also organized large visibility event on smart specialization theme in Zagreb.

MSES had also consultations on this matter which have concluded with the final feedback reports from Croatian universities and public research institutes. A questionnaire with a number of sub-
For the purpose of further selection and narrowing of the TPAs and STPAs within S3 strategy of the Republic of Croatia, a number of expert working groups composed of public and private R&D experts, as well as a working group composed of state officials, were established. Their task was to define where are the common strengths and potential of both scientific-research and business sector, based on conducted analysis and statistical data as well as on the results of entrepreneurial discovery process. Additionally, the working groups were also taking into consideration the efforts done by the ex-ante evaluation of the EC on the draft versions of the S3 which pinpointed the main concerns and questions need to be addressed within the S3. This dialogue further enhanced the EDP. It was necessary to use this additional information as an objective review of the process which broaden the scope of information to be processed by the expert working groups and therefore allowed further selection and narrowing of the STPAs.

After consistent and coherent presentation of all data justifying selection of TPAs, STPAs and some specific topics was made it became obvious that in some areas there were no sufficient critical mass. The end result was in September 2015 when the final selection of 5 thematic priority areas, 13 sub-thematic priority areas (decreased from 16 to 13) and 2 cross-cutting themes (decreased from 4 to 2) within the framework of the S3 strategy was made. The final selection demonstrate better coherence between the selected areas and the justifications provided and brings additional focus and further specialisation.

Based on the comments received from EC and during further consultations within S3 working group it was decided, that Tourism as well as Creative and Cultural industries are to be excluded from S3 as cross-cutting themes. Reason for excluding Tourism was due to the fact that this sector is largely a user sector, an area of application of innovation which are the result of R&D activities, rather than being sector from where innovations can be spread throughout the economy. As for Creative and Cultural industries, although they could generate innovations, it became obvious that, at the time being it would be difficult to use it as cross-cutting theme in the same way as ICT and KETs, although some aspects of innovation from CCI will still be present, namely through design of new product or services.

In TPA “Health and quality of life”, the title of the first STPA was slightly changed, in order to better reflect the content and scope of that STPA. Health tourism as such, is no longer listed as areas of investment in STPA “Health services and new methods of preventive medicine and diagnostics”, but it can be the sector in which the application of the results of RDI activities that will be supported in this STPA.

TPA “Energy and sustainable environment” has two instead of previously four STPAs. The STPAs “Green construction” and “Efficient grid and energy systems” are excluded as independent sub-thematic priority areas, i.e. their content is partially integrated in first two sub-thematic areas whose titles and scopes where slightly changed in order to better reflect the proved strengths and potential. “Green construction” sub-area was not enough focused, and it is already partially covered by STPA “Environmentally friendly technologies, equipment and advanced materials”, it is listed as an indicative RDI topic. Former STPA “Efficient grid and energy system” as stated above, was reformulated and partial elements included under STPA 1. In connection to STPA 1, this specific area, provides more clear justification for its selection as one of the Croatian priorities based on existing capacities and potentials.

TPA “Transport and mobility” has changed in a way that 3 former STPAs (Green transport, Sustainable Mobility, Intelligent transport system and logistics) were reformulated and modified
accordingly in order to achieve better compliance with demonstrated potential and the selected sub-TPAs. In this way their justification as priorities based on the demonstrated potential is more evident providing the necessary narrowing of the scope of this TPA. In the third STPA “Intelligent transport systems and logistics” some of the RDI topics were modified (e.g. „integrated electric transport systems and infrastructure“) since the financing of the transport infrastructure is not eligible under Thematic objective 1, or the scope of S3.

In final version of TPA “Food and bio-economy” apart from the slight change of title to better match the areas it covers (food instead of agro-food since fishery and aquaculture are part of this thematic area), the number of STPAs was reduced since “Biomass and bio-based products” was excluded. This was primarily done due to the lack of ground for its selection as a standalone STPA, but some of its content was incorporated in remaining two STPAs. In general, the text on both sub-thematic priority areas was modified in a way to give better evidence on RDI potential and perspective, thus providing justification for its selection. This is particularly relevant for STPA “Sustainable wood production and processing” where such data were missing.

Figure 38 The final selection of thematic priority areas, sub- thematic priority areas and cross-cutting themes

<table>
<thead>
<tr>
<th>S3 previous version</th>
<th>Revised S3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPA</td>
<td></td>
</tr>
<tr>
<td>(1) Health and quality of life</td>
<td>(1) Health and quality of life</td>
</tr>
<tr>
<td>(2) Energy and sustainable environment</td>
<td>(2) Energy and sustainable environment</td>
</tr>
<tr>
<td>(3) Transport and mobility</td>
<td>(3) Transport and mobility</td>
</tr>
<tr>
<td>(4) Security</td>
<td>(4) Security</td>
</tr>
<tr>
<td>(5) Agro-food and bio-economy</td>
<td>(5) Food and bio-economy</td>
</tr>
</tbody>
</table>

NO CHANGES IN NUMBER AND THEME OF S3 THEMATIC PRIORITY AREAS (TPA) IN REVISED S3

<table>
<thead>
<tr>
<th>STPA</th>
<th>STPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Pharmaceuticals and medical equipment and devices</td>
<td>(1) Pharmaceuticals, biopharmaceuticals and medical equipment and devices</td>
</tr>
<tr>
<td>(2) Health services and new methods of preventive and personalize medicine and diagnostics</td>
<td>(2) Health services and new methods of preventive medicine and diagnostics</td>
</tr>
<tr>
<td>(3) Nutrition</td>
<td>(3) Nutrition</td>
</tr>
<tr>
<td>(4) Renewable energy technologies and equipment</td>
<td>(4) Renewable energy and energy storage technologies and equipment</td>
</tr>
<tr>
<td>(5) Environmentally-friendly technologies and equipment</td>
<td>(5) Environmentally-friendly technologies, equipment and new materials</td>
</tr>
<tr>
<td>(6) Green construction</td>
<td>(6) Added value manufacturing of road and rail vehicles parts and systems</td>
</tr>
<tr>
<td>(7) Efficient grid and energy systems</td>
<td>(7) Environmental friendly transport solutions</td>
</tr>
<tr>
<td>(8) Green transport</td>
<td>(8) Intelligent transport systems and logistics</td>
</tr>
<tr>
<td>(9) Sustainable Mobility</td>
<td>(9) Defense dual-use</td>
</tr>
<tr>
<td>(10) Intelligent transport system and logistics</td>
<td>(10) Mine action program</td>
</tr>
<tr>
<td>(11) Cyber security</td>
<td>(11) Cyber Security</td>
</tr>
<tr>
<td>(12) Defense dual-use</td>
<td>(12) Sustainable food production and processing</td>
</tr>
<tr>
<td>(13) Mine action program</td>
<td>(13) Sustainable wood production and processing</td>
</tr>
<tr>
<td>(14) Sustainable food production and processing</td>
<td>Biomass and bio-based products</td>
</tr>
</tbody>
</table>

CHANGES IN THE NUMBER AND THEMES OF SUB-THEMATIC PRIORITY AREAS (STPA)
- Decreased number of STPAs from 16 to 13;
- Excluded STPAs: Green construction, Efficient grid and energy systems, Sustainable Mobility and Biomass and bio-based product;
- Included 1 STPA: Added value manufacturing of road and rail vehicles parts and systems.

CHANGES IN THE NUMBER CROSS-CUTTING THEMES:
- Decreased number of cross-cutting themes from 4 to 2;
Continuation of EDP and partnership consultations
It is important to emphasise that the process of smart specialization should be seen as the permanent process which stimulates policy makers to support the continuous entrepreneurial discovery and communication between all relevant stakeholders in Croatian development. This may lead to changes which are usually unpredictable and may also convince the actors to give up their erroneous development approach. It could in turn lead to structural economic changes by modernization, diversification, transition or radical modification of economic activities. Also, it is worth mentioning that the priorities which are being set now will not be so forever. In order to handle this unpredictable future, EDP will continue and there will be a predicted mechanism for revision of defined priorities through effective S3 governance system, mainly through the National S3 Committee.

The envisaged governance system and action plan for S3 implementation will ensure that the process of EDP will be continuous through formal recognition of the structure for the revision of the S3, mainly within the work of S3 Committee. As part of the data collection and stakeholder involvement in the EDP process, along with the formal data collection and technical preparation for the annual report on implementation of S3, the HAMAG-BICRO will also work on communicating with TIPs, CCCs and other stakeholders of the INI and reviewing their conclusions and progress, which will need to be incorporated within the S3 Committee reports and recommendations. Additional important mechanism which will help the S3 committee to revaluate certain policy mix and parts of S3, are the planned technology foresight projects and technology mapping initiatives within the MSES and strategic projects of the Ministry of Economy. There will be a need to broaden the scope of the S3 involving additional stakeholders. This will be accomplished through annual surveys on the policy mix and will be delivered through the bodies implementing the policy instruments to the audience targeted by the specific policy instrument.

### 9.2. Annex 2 Cross-sectoral table - matching of business and scientific research sectors strengths, capacities for RDI and the ability to connect with the response to social challenges

<table>
<thead>
<tr>
<th>TPA</th>
<th>HEALTH AND QUALITY OF LIFE</th>
<th>ENERGY AND SUSTAINABLE ENVIRONMENT</th>
<th>TRANSPORT AND MOBILITY</th>
<th>SECURITY</th>
<th>FOOD AND BIOECONOMY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Societal challenges</td>
<td>Health, demographic change and wellbeing</td>
<td>Secure, clean and efficient energy/Climate change</td>
<td>Smart, green and integrated transport</td>
<td>Inclusive, innovative, secure society</td>
<td>Food security, sustainable agriculture and maritime research and bioeconomy</td>
</tr>
<tr>
<td>Added value</td>
<td>High-tech pharmacy sector</td>
<td>Cross-sectoral approach</td>
<td>Logistic sector close to final demand</td>
<td>High-tech defence sector</td>
<td>Resource based sectors (Agro-food and Wood processing industries)</td>
</tr>
<tr>
<td></td>
<td>Good connections between the business and scientific research sectors</td>
<td>Integrated and complex products of high added value</td>
<td>Inclusion of automotive sector in global value chain</td>
<td>Integrated and complex products of high added value</td>
<td></td>
</tr>
<tr>
<td>Business strengths</td>
<td>Tradition in Manufacture of basic pharmaceutical products and preparations</td>
<td>Tradition in Manufacture of electrical equipment and machinery and equipment</td>
<td>Tradition in Manufacture of motor vehicles, trailers and semi-trailers, Manufacture of other transport equipment and Manufacture of</td>
<td>Tradition in Manufacture of computer, electronic and optical products, Manufacture of machinery and equipment, Manufacture of</td>
<td>Tradition in Agriculture, fisheries and aquaculture and Manufacture of food products</td>
</tr>
<tr>
<td></td>
<td>Definition of new niches (nutrition,</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>TPA HEALTH AND QUALITY OF LIFE</td>
<td>ENERGY AND SUSTAINABLE ENVIRONMENT</td>
<td>TRANSPORT AND MOBILITY</td>
<td>SECURITY</td>
<td>FOOD AND BIOECONOMY</td>
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<td></td>
</tr>
<tr>
<td>health services, prevention and diagnostics</td>
<td>the Croatian economy according to the Industrial Strategy of the Republic of Croatia</td>
<td>fabricated metal products</td>
<td>fabricated metal products</td>
<td>products</td>
<td></td>
</tr>
<tr>
<td>Recognized as “driver” sector of the Croatian economy according to the Industrial Strategy of the Republic of Croatia</td>
<td>Availability of own R&amp;D capacities (Končar Institute)</td>
<td>Recognized as “driver” sectors of the Croatian economy according to the Industrial Strategy of the Republic of Croatia</td>
<td>Manufacture of other transport equipment and Computer programming, consultancy and related services</td>
<td>Continuous growth of exports</td>
<td></td>
</tr>
<tr>
<td>Croatia is one of the 10 countries which developed their own molecule</td>
<td>Availability of highly-educated workforce</td>
<td>Application of international quality standards</td>
<td>Recognized as “driver” sectors of the Croatian economy according to the Industrial Strategy of the Republic of Croatia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous growth of production and exports</td>
<td>Supply chains</td>
<td>Definition of new niches (electric mobility)</td>
<td>Products of high added value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability of highly-educated workforce</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BERD</th>
<th>Healthcare</th>
<th>Energy technology</th>
<th>Motor vehicles</th>
<th>Motor vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain research</td>
<td>Development of new pharmaceutical products and preparations</td>
<td>Energy technology</td>
<td>Machinery and Shipbuilding</td>
<td>Electrical and mechanical Engineering</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Energy technology</td>
<td>Electrical engineering</td>
<td>Electrical and mechanical engineering</td>
<td>Electronics and Advanced materials</td>
</tr>
<tr>
<td>Immunology</td>
<td>Energy technology</td>
<td>Electronics and Advanced materials</td>
<td>Electronics and Advanced materials</td>
<td>Motor vehicles</td>
</tr>
<tr>
<td>Medical and dental equipment and appliances</td>
<td>New methods of preventive medicine</td>
<td>Renewable energy sources</td>
<td>Motor vehicles</td>
<td>Electrical and mechanical Engineering</td>
</tr>
<tr>
<td>Personalized medical care and new methods of diagnostics</td>
<td>Quality of life of elderly and dependent people</td>
<td>Systems for energy generation, storage and distribution</td>
<td>Electronics and Advanced materials</td>
<td>Chemicals and materials</td>
</tr>
<tr>
<td>Regenerative medicine and tissue engineering</td>
<td>Public healthcare management</td>
<td>Climate change management (bioclimates, prognosis, tourism)</td>
<td>Shipbuilding</td>
<td>Chemical Engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste management</td>
<td>Electrical and mechanical engineering</td>
<td>Advanced materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utilization of waste streams</td>
<td>Agriculture and agro</td>
<td>\begin{itemize}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contamination tracking and management</td>
<td>machinery and equipment</td>
<td>\item Biotechnology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Biodiversity management</td>
<td>\item Fisheries and aquaculture</td>
<td>\item Chemical Sciences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smart electric grids</td>
<td>\item Novel/Functional food</td>
<td>\item Medical and dental equipment and appliances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Functional construction and building material and component</td>
<td>\item Wood technology</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R&amp;D institutions MSES</th>
<th>Brain research</th>
<th>Marine engineering</th>
<th>Security in combating terrorism and crime: explosives, but also privacy safety and use of personal data</th>
<th>Security in combating terrorism and crime: explosives, but also privacy safety and use of personal data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical and dental equipment and appliances</td>
<td>Advanced trains</td>
<td>Transport control systems</td>
<td>Certification of products</td>
<td>Certification of products</td>
</tr>
<tr>
<td>Personalized medical care and new methods of diagnostics</td>
<td>Transport solutions in tourism</td>
<td>ICT in maritime transport</td>
<td>New materials engineering</td>
<td>New materials engineering</td>
</tr>
<tr>
<td>Quality of life of elderly and dependent people</td>
<td>Integrated transport solutions</td>
<td>ICT in transport safety</td>
<td>Protective equipment, particularly CBRN equipment</td>
<td>Protective equipment, particularly CBRN equipment</td>
</tr>
<tr>
<td>Regenerative medicine and tissue engineering</td>
<td></td>
<td></td>
<td>\begin{itemize}</td>
<td>\begin{itemize}</td>
</tr>
<tr>
<td>Public healthcare management</td>
<td></td>
<td></td>
<td>\item Plant Biotechnology</td>
<td>\item Agricultural production</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\item Innovative agricultural machinery and equipment</td>
<td>\item Fisheries and aquaculture</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\item Novel/Functional food</td>
<td>\item Wood technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\item Food:</td>
<td>\item Biomass</td>
</tr>
<tr>
<td>Partnership consultation (emerging niches identified through entrepreneurial)</td>
<td>Development of new methods of preventive medicine</td>
<td>Advanced transport structures (vehicles and vessels)</td>
<td>Food:</td>
<td>Producing novel food</td>
</tr>
<tr>
<td></td>
<td>Medical care to elderly and disabled</td>
<td>Integrated automation processes in distribution and logistics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regenerative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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219
<table>
<thead>
<tr>
<th>TPA</th>
<th>HEALTH AND QUALITY OF LIFE</th>
<th>ENERGY AND SUSTAINABLE ENVIRONMENT</th>
<th>TRANSPORT AND MOBILITY</th>
<th>SECURITY</th>
<th>FOOD AND BIOECONOMY</th>
</tr>
</thead>
<tbody>
<tr>
<td>discovery</td>
<td>medicine &amp; tissue engineering</td>
<td>Energy systems management</td>
<td>Advance production of parts and equipment for transport structures (vehicles and vessels)</td>
<td>protection of classified information</td>
<td>traditional products</td>
</tr>
<tr>
<td></td>
<td>Pharmacy-genomics &amp; biomarker analysis</td>
<td>Technology and equipment for renewable energy</td>
<td>Smart, safe and intelligent transport systems,</td>
<td>TEMPEST solutions</td>
<td>Bio economy:</td>
</tr>
<tr>
<td></td>
<td>OTC – Adriatic sea salt based products (JGL)</td>
<td>Technology and equipment for environment</td>
<td>Innovative transport and logistics services</td>
<td>Security of SCADA systems and other control systems</td>
<td>• Biomass and utilization of wood for energy production</td>
</tr>
<tr>
<td></td>
<td>Healthy and functional food</td>
<td>Smart Advanced Utilities (Smart utilities)</td>
<td>Safety of maritime ICT systems</td>
<td>Vulnerability assessment systems (penetration testing systems)</td>
<td>• Development and promotion of safe, healthy and new value added wood products</td>
</tr>
<tr>
<td></td>
<td>Food supplements</td>
<td>Offshore engineering and structures</td>
<td>new automation processes in management and distribution processes</td>
<td>Identity and access management systems</td>
<td>• Bio-based paints, eco – surface treatments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Offshore engineering and structures</td>
<td>mobile solutions connected to post offices logistics and distribution</td>
<td>Automated devices for dimensional control of static and dynamic measures, tolerance analysis, surface and profiles quality control.</td>
<td>• Development of new materials and substances in liquid and solid form that are environmentally friendly (biochemical and bio-plastic production)</td>
</tr>
</tbody>
</table>

Cluster development

1. Health and ICT Competitive ness Cluster
2. Construction, ICT and Machinery: Competitiveness Clusters
3. Automotive, Maritime and ICT Competitiveness Cluster
4. Defence and ICT Competitiveness Cluster
5. Chemical, Agro-food and Wood processing Competitiveness Cluster
### 9.3. Annex 3 Short description of Sub-thematic Priority Areas

<table>
<thead>
<tr>
<th>Priority Thematic Area (PTA)</th>
<th>Sub-thematic Priority Area (STPA)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health and quality of life</td>
<td>1. Pharmaceuticals, biopharmaceuticals, medical equipment and devices</td>
<td>This STPA is focused on strengthening Croatia’s position as a hub for health product manufacturing, through integrating existing enterprise and research strengths to drive development and manufacture of next generation of drugs and OTC products, medical equipment and devices.</td>
</tr>
<tr>
<td></td>
<td>2. Health services and new methods of preventive medicine and diagnostics</td>
<td>This STPA is focused on E-solutions for health an on technologies that remote delivery of healthcare and assisted living, moving the emphasis of care to patient in their own home. Health services have the potential to transform healthcare and service delivery, thereby reducing burdens on health systems and improving the quality of life. The priority wants to cover the entire health care industry innovation chain ranging from the better understanding of the diseases to prevention and recognition. To this end, there will be a possibility to use advanced technologies, such as biotechnology in health industry, biomedicine and pharmaceutical industry, systems biology-based remedy, advanced diagnostic and therapeutic methods.</td>
</tr>
<tr>
<td></td>
<td>3. Nutrition</td>
<td>This STPA is focused on building capacity to develop and produce high nutrition health foods or ingredients in relation to maintenance, growth, reproduction, health and disease of an organism. The challenge is to ensure full integration of the research base and enterprise to enable product development and validation of product claims to meet regulatory requirements. These developments (may) contribute to improving the general health condition of the society; in addition to being beneficial from an environmental aspect.</td>
</tr>
<tr>
<td>Energy and sustainable environment</td>
<td>4. Energy technologies, systems and equipment</td>
<td>STPA focuses on the development and implementation of modern energy technologies and production of equipment that are expected to be efficient, remotely controlled and monitored, smart grid compatible, environmentally friendly and recyclable at the end of its lifetime. This requires introduction of new optimized technical solutions and often new advanced materials as well as application of various sensors for functionality and condition monitoring based on ICT. Technical and cost optimization is not possible without modern computer tools and knowledge on materials and phenomena in the equipment and its environment.</td>
</tr>
<tr>
<td></td>
<td>5. Environment friendly technologies, equipment and advanced materials</td>
<td>Primary focus for this STPA is to tackle challenges of climate change and development of economy with decreased emission of carbon dioxide in Croatia. The priority is aimed at promoting the sustainability of the environment through the R&amp;D oriented to production of clean technologies, power saving technologies and equipment and new materials as bio-polimers which promote “cascade” economy (“cascade” economy circle will be to efficiently provide solutions and products for efficient collecting, compacting and discharge of municipal and selected waste. Important feature and emphasize for R&amp;D investments were put in area of biomass and bio-based production as well as in sustainable water management (water treatment and water utilization).</td>
</tr>
<tr>
<td>Transport and mobility</td>
<td>6. Added value manufacturing of road and rail vehicles parts and systems</td>
<td>This STPA is oriented to development and production of higher value-added automotive and railway components, new materials for automobile and railway industry needs, technologies supporting positive environmental impacts (noise reduction, reducing CO2 emissions, etc.) and supporting technologies in fields of automation, safety, auxiliary power supplies technologies and advanced manufacturing processes and systems.</td>
</tr>
<tr>
<td></td>
<td>7. Environment friendly transport solutions</td>
<td>Focus of the STPA is mainly on development of alternative drive technologies (efficient combustion engines, environmentally-friendly vehicle design) and propulsion systems oriented towards sustainable mobility. In addition, STPA targets inclusion of next generation materials into production processes and development along with production of added value products and systems in automotive and maritime sector.</td>
</tr>
<tr>
<td></td>
<td>8. Intelligent transport systems and logistics</td>
<td>STPA mainly targets development and efficient application of integrated ICT systems and applications in area of mobility, transport and logistics. R&amp;D investments targeted in advanced embedded positioning and navigation systems, offshore engineering and logistic services will most definitely support and boost complementary development of transport systems and infrastructure.</td>
</tr>
<tr>
<td>Security</td>
<td>9. Cyber security</td>
<td>STPA focuses on enabling protection and confidentiality of digital data at all levels. This STPA aims develop computer systems for the secure exchange of information for the purpose of development of future digital business and public activities. Strong partnerships between public and private sector identified following as priorities in dealing with critical issues for future development: cyber security monitoring systems, next generation encryption (krypto) systems tailored to NATO standards, digital forensics, upgrade of SCADA systems and tailored made cyber security IT systems.</td>
</tr>
<tr>
<td></td>
<td>10. Defense dual-use</td>
<td>STPA is oriented towards development of new high performance products and platforms arising from dual use technological perspectives represented in materials engineering; automated advanced production (industry power plants 4.0); unmanned and automated remotely controlled systems, process and embedded computer automation and control processes, real-time aerial multispectral imaging solutions in connection to laser technologies, Technological solutions for control and protection against the use of biological agents in terrorist purposes, etc. The intention is to expand Croatian companies operating in</td>
</tr>
<tr>
<td>Cross-cutting sub-thematic priority areas</td>
<td>KET</td>
<td>ICT</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>11. Mine action program</td>
<td>This STPA is oriented towards upgrade and development of state of the art product solutions and technologies oriented towards mine action programs, protection of human life’s in mine infected areas and development of potential technological convergences with different applications aiming to secure societies and enable economic benefits.</td>
<td>ICT as cross-sectoral STPA planned to be used across large number of industries in thematic priority areas as a source of dramatic change in business practices of industrial activities. The ICT sector is supporting the development of the entire society by strengthening the economy, health care, education, cultural identity and public management and administration, but also raising the quality of life in general. Consequently, it has a potential to become a booster of the global economy development in Croatia and generator of high added value.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific strategic objective 1</th>
<th>Increased capacities of RDI sector to perform excellent research and to serve the needs of the economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities</td>
<td>Benefit</td>
</tr>
<tr>
<td>Mapping of RDI capacities in Science and Research sector</td>
<td>Avoidance of duplication or underutilisation of exchequer funded infrastructure</td>
</tr>
<tr>
<td></td>
<td>Better understanding of what research strengths currently exist which will inform what gaps need to be filled</td>
</tr>
<tr>
<td></td>
<td>Facilitated access to enabling design, prototyping and pilot production infrastructure and expertise</td>
</tr>
<tr>
<td>Development of project documentation for RDI infrastructural projects and upgrading of RDI infrastructural/e-infrastructure capacities</td>
<td>Upgraded RDI ability for conducting excellent as well as highly focused research; Enhancing participation in HORIZON 2020</td>
</tr>
<tr>
<td>Frontier research conducted by Centres of Research Excellence</td>
<td>European research area integration through cutting-edge research</td>
</tr>
<tr>
<td>Pre-commercial research performed by research organizations</td>
<td>Research conducted for the needs of economy</td>
</tr>
<tr>
<td>Infrastructural support for Horizon 2020 grant beneficiaries: Teaming, Twinning and ERA Chair projects</td>
<td>Enhancing the impact of participation in HORIZON 2020</td>
</tr>
<tr>
<td>Development of research teams and advancement of new research leaders</td>
<td>Better integration in European research area through cutting-edge research</td>
</tr>
<tr>
<td>Applied research conducted by research organizations and business entities</td>
<td>Enhanced university-industry collaboration through knowledge transfer and application of research results to the market</td>
</tr>
<tr>
<td>Preparation of TPAs Science foresight</td>
<td>Validation of selection of TPAs and relevant inputs for the revision of S3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific strategic objective 2</th>
<th>Overcoming the fragmentation of innovation value chain and the gap between research and business sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities</td>
<td>Benefit</td>
</tr>
<tr>
<td>Support to TTOs in building technology transfer capacities and in providing services to businesses</td>
<td>Transfer of technology from ROs to business sector</td>
</tr>
<tr>
<td>Pro-innovative services provided to business sector through Science Technology Parks</td>
<td>Technology transfer and commercialization of RDI results</td>
</tr>
<tr>
<td>Establishment of Innovation Network for...</td>
<td>Institutional set up for Innovation system</td>
</tr>
<tr>
<td>Industry and Thematic innovation Councils</td>
<td>Increased industry - academic collaboration</td>
</tr>
<tr>
<td>Establishment of Thematic Innovation Platforms</td>
<td>Operating Networking Mechanism for constant alignment of the current technologies with industry research trends and potentials for each identified STPA and strategic planning</td>
</tr>
<tr>
<td>Preparation of TPAs RDI strategy of business sector</td>
<td>Concentration of available funding for RDI activities on the most promising areas with highest added-values and market potential</td>
</tr>
<tr>
<td></td>
<td>Consolidated blueprint for the on-going guidance of publicly funded research in priority thematic areas</td>
</tr>
<tr>
<td></td>
<td>Defined outcome/result and context indicator for each TPAs for each RDI strategy of business sector</td>
</tr>
</tbody>
</table>

**Specific strategic objective 3**

**Modernizing and diversifying Croatian economy through increasing private R&D and non R&D investment**

| | | |
| In addition to potential targeted calls and identified RDI priorities, preparation of TPAs Project pipelines for collaborative RDI Project | Prioritisation mechanisms implemented to identify and support development of potential with the greatest chance of commercial success (based on strong analysis of market pull and research gaps) | 2017 |
| Support to business investment in RDI for activities of in-house R&D, contracting research and collaborative R&D projects - joint research initiatives in all types of R&D (fundamental research, industrial research and experimental development), as well as preparation of feasibility studies and strengthening R&D infrastructure. | Strengthened capacities for RDI of enterprises; their productivity, competitiveness and export activity raised and diversified production and services offer | 2016 |
| Creation of Centres of Competence as necessary innovation infrastructure – particularly one that involves cooperation of larger enterprises with SME’s | Strengthened capacities for RDI of enterprises (especially SME’S); their productivity, competitiveness and export activity raised and diversified production and services offer | 2016/2017 |
| Support to SMEs investments in implementation of new solutions in the areas of technology, product, process and organizational innovations, including marketing innovations, design and innovation advisory, IPR and support | SMEs capacities to innovate strengthened | 2016/2017 |

Ministry of Economy

Ministry of Entrepreneurship and Crafts
<table>
<thead>
<tr>
<th>Specific strategic objective 4</th>
<th>Upgrading in global value chain and promoting internationalization of Croatian economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitiveness Cluster Initiatives that involve spectre of: analysis; policy recommendations; benchmarking; and targeted support in internationalization</td>
<td>Benchmark of industrial sectors according to Global perspective, for purpose of better international positioning, focused policy defining and targeted investments in future</td>
</tr>
<tr>
<td></td>
<td>2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific strategic objective 5</th>
<th>Working in partnerships to address societal challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of policy framework for social innovation</td>
<td>National, regional and local governments facilitated in embracing the social innovation as a tool for increasing social welfare.</td>
</tr>
<tr>
<td>Preparation of detailed recommendations for improving the social innovation ecosystem in Croatia</td>
<td>Adopting and using the innovative public procurement in solving identified problems connected to societal challenges</td>
</tr>
<tr>
<td>Developing financial instruments that can be used to support social innovation</td>
<td>2016</td>
</tr>
<tr>
<td>Development of methodology for selection of social innovation projects</td>
<td>2016</td>
</tr>
<tr>
<td>Preparation of several pilot projects of social innovations</td>
<td>2016</td>
</tr>
<tr>
<td></td>
<td>2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific strategic objective 6</th>
<th>Creating smart skills – upgrading the qualifications of existing and new work force for smart specialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishing infrastructure for smart skills policies</td>
<td>Increased skills to drive R&amp;D and innovation under TPAs</td>
</tr>
<tr>
<td>Implementing the Croatian Qualification Framework mechanism for delivering timely and standardized training programmes based on future and medium term skill needs</td>
<td>Relevant LLL training content at all levels for up-grading</td>
</tr>
<tr>
<td>Medium term tools for skill assessment at the level of competences</td>
<td>Better alignment of skillsets with the needs of the sector to facilitate economic growth</td>
</tr>
<tr>
<td></td>
<td>2017</td>
</tr>
<tr>
<td></td>
<td>2017</td>
</tr>
<tr>
<td></td>
<td>2018</td>
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</table>
### 9.5. Annex 5 Main and complementary sources of financing of S3 implementation

#### Table of main sources of financing of S3 implementation

<table>
<thead>
<tr>
<th>Delivery area</th>
<th>Delivery instrument</th>
<th>Responsible institution</th>
<th>Way of implementation</th>
<th>Financing sources /Indicative Financial allocation (in EUR)</th>
<th>Time schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>President in charge of the steering committee</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Development of Technology Transfer Offices and Science-Technology Parks</td>
<td>Ministry of Science, Education and Sports/DEFCO</td>
<td>Grant scheme for Technology Transfer Offices Programme (open call)</td>
<td>ERDF: 3.500.000, ESF: 617.674, Total: 4.117.674</td>
<td>2016-2019</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ministry of Science, Education and Sports/DEFCO</td>
<td>Grant scheme for Science-Technology Parks Programme (open call)</td>
<td>ESF: 529.411, Total: 3.529.411</td>
<td>2017-2020 (ongoing call)</td>
</tr>
<tr>
<td></td>
<td>A. Development of RDI Infrastructure</td>
<td>Ministry of Science, Education and Sports/ CFCA</td>
<td>Grant scheme for development of project documentation ‘Project pipeline preparation for ERDF 2014 – 2020’ (restricted)</td>
<td>ESF: 900.000, Total: 6.000.000</td>
<td>2016-2020 (ongoing call)</td>
</tr>
</tbody>
</table>
### Developing RDI Infrastructure and enhancing RDI activities

<table>
<thead>
<tr>
<th>Description</th>
<th>Ministry/Agency</th>
<th>Grant Scheme/Description</th>
<th>Amounts (€)</th>
<th>2016-2020 (ongoing call)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant scheme <em>(Restricted)</em></td>
<td></td>
<td>3.000.000</td>
<td>529.411</td>
<td>3.529.411</td>
</tr>
<tr>
<td>&quot;Enabling synergies with HORIZON 2020 through infrastructural investment&quot;.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Enabling synergies with HORIZON 2020 initiatives for spreading excellence:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaming, Twinning and ERA chairs&quot; (open)</td>
<td></td>
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</tr>
</tbody>
</table>

| Centers of Competence            | Ministry of Economy/CFCA           | Grant scheme for Centers of Competence (open)                                           | 105.000.000       | 1st quarter of 2016 (launching the GS) |

### B. Enhancement of RDI activities

<table>
<thead>
<tr>
<th>Description</th>
<th>Ministry/Agency</th>
<th>Grant Scheme/Description</th>
<th>Amounts (€)</th>
<th>2016-2020 (ongoing call)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support to business investment in RDI</td>
<td>Ministry of Economy/HAMAG-BICRO</td>
<td>Grant schemes for business investment in RDI (open)</td>
<td>205.000.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(I. Grant scheme 100.000.000)</td>
<td>136.666.666</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(II. Grant scheme 105.000.000)</td>
<td>341.666.666</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I. phase – 1st quarter of 2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>II. phase – 1st quarter of 2017</td>
</tr>
<tr>
<td>Support to SMEs capacities to innovate</td>
<td>Ministry of Entrepreneurship and Crafts/HAMAG-BICRO</td>
<td>Grant scheme</td>
<td>100.000.000</td>
<td>2016-2020</td>
</tr>
<tr>
<td>Support to research organizations conducting R&amp;D projects directed towards the needs of economy</td>
<td>Ministry of Science, Education and Sports/DEFCO</td>
<td>Grant scheme Strengthening capacities for research, development and innovation-R&amp;D collaboration</td>
<td>15.000.000</td>
<td>2016-2018</td>
</tr>
<tr>
<td>Project Area</td>
<td>Description</td>
<td>Ministry/Authority</td>
<td>Funding Details</td>
<td>Timeline</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td><strong>Projects (open)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Science and Innovation Investment Fund</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grant scheme 'Science and Innovation Investment Fund' (open)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.850.000</td>
<td>2.973.529</td>
<td>19.823.529 2016-2018</td>
</tr>
<tr>
<td><strong>Strengthening research excellence</strong></td>
<td>Ministry of Science, Education and Sports/DEFCO</td>
<td>Restricted Grant schemes</td>
<td>29.750.000</td>
<td>5.250.000 2016-2021</td>
</tr>
<tr>
<td>and enabling synergies with ERC grants</td>
<td>Ministry of Science, Education and Sports/DEFCO</td>
<td>Grant scheme (open call)</td>
<td>3.000.000</td>
<td>529.411 2016-2020</td>
</tr>
<tr>
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<tr>
<td><strong>Upgrading in global value chain and promoting internationalization of Croatian economy</strong></td>
<td>Support to competitiveness cluster initiatives</td>
<td>Ministry of Economy</td>
<td>Strategic project</td>
<td>7.735.213 2016-2019</td>
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<tr>
<td><strong>Development of Smart skills</strong></td>
<td>Establishing infrastructure for smart skills policies</td>
<td>Ministry of Labour and the Pension System/</td>
<td>Direct Award procedure</td>
<td>42.500 2016-2017</td>
</tr>
<tr>
<td></td>
<td>Medium term tools for skill assessment at the level of competences</td>
<td>Ministry of Labour and the Pension System/</td>
<td>Grant scheme (open call)</td>
<td>166.600 2016-2017</td>
</tr>
<tr>
<td></td>
<td>Implementing the Croatian Qualification Framework mechanism for delivering timely and standardized training programmes based on future and medium term skill needs</td>
<td>Ministry of Labour and the Pension System/</td>
<td>Direct Award procedure</td>
<td>101.728 2016-2018</td>
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<td><strong>TOTAL</strong></td>
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<td>704.192.165</td>
<td>310.828 53.427.020 283.916.666 1.042.346.653</td>
</tr>
</tbody>
</table>
## Table of complementary sources of financing which will contribute to the implementation of S3 strategy

<table>
<thead>
<tr>
<th>Delivery instrument / Specific objective / Measure</th>
<th>Responsible institution</th>
<th>Way of implementation</th>
<th>Financing sources / Indicative overall financial allocation under the Delivery instrument/ Specific objective / Measure (in EUR)</th>
<th>Indicative estimate of percentage of allocation which will contribute to S3</th>
<th>Indicative estimate of allocation which will contribute to S3 (in EUR)</th>
<th>Time schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OPCC - Financial engineering instruments</strong></td>
<td>Ministry of Entrepreneurship and Crafts /HAMAG-BICRO/HBOR/EIF</td>
<td>Venture Capital Fund</td>
<td>ERDF: 20.000.000, ESF: -, EAFRD: -, EMFF: -</td>
<td>National public financing: 26.000.000, National private financing: 46.000.000, Total: 72.000.000</td>
<td>20 %</td>
<td>9.200.000</td>
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<tr>
<td></td>
<td></td>
<td>Pilot Venture Capital Fund</td>
<td>ERDF: -, ESF: -, EAFRD: -, EMFF: -</td>
<td>National public financing: 12.000.000 (WB loan), National private financing: 8.000.000, Total: 20.000.000</td>
<td>20 %</td>
<td>4.000.000</td>
</tr>
<tr>
<td><strong>OPCC - Innovation driven SMEs (including start-ups and spin-offs)</strong></td>
<td>Ministry of Entrepreneurship and Crafts /HAMAG-BICRO</td>
<td>Grant scheme</td>
<td>ERDF: 80.000.000, ESF: -, EAFRD: -, EMFF: -</td>
<td>National public financing: 80.000.000, National private financing: 160.000.000, Total: 240.000.000</td>
<td>25 %</td>
<td>40.000.000</td>
</tr>
<tr>
<td><strong>OP EHR - Specific objective 10 ii – 2 Increasing tertiary attainment rates</strong></td>
<td>Ministry of Science, Education and Sports</td>
<td>Grant scheme</td>
<td>ERDF: 45.000.000, ESF: 7.941.176, EAFRD: 52.941.176</td>
<td>National public financing: 15.882.353, National private financing: 160.000.000, Total: 175.882.353</td>
<td>30 %</td>
<td>15.882.353</td>
</tr>
<tr>
<td><strong>OP EHR - Specific objective 10 ii – 3 Improving the environment for Croatian researchers</strong></td>
<td>Ministry of Science, Education and Sports</td>
<td>Grant scheme</td>
<td>ERDF: 50.000.000, ESF: 8.823.529, EAFRD: 58.823.529</td>
<td>National public financing: 17.647.059, National private financing: 160.000.000, Total: 187.647.059</td>
<td>30 %</td>
<td>17.647.059</td>
</tr>
<tr>
<td>Programme Measure 16.2. Pilot projects and the development of new products, practices, processes and technologies</td>
<td>Agriculture</td>
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<tr>
<td><strong>Draft OP for Maritime Affairs and Fisheries - Unio priority 1 - Specific Objective 5.</strong></td>
<td>Ministry of Agriculture</td>
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</tr>
<tr>
<td>the provision of support to strengthen technological development and innovation, including increasing energy efficiency, and knowledge transfer - Measure: Article 26. Innovation</td>
<td>2.500.020</td>
<td>833.340</td>
<td>3.333.360</td>
<td>20%</td>
<td>666.672</td>
<td>2016-2020</td>
</tr>
<tr>
<td><strong>Draft OP for Maritime Affairs and Fisheries - Unio priority 1 - Specific Objective 5.</strong></td>
<td>Ministry of Agriculture</td>
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</tr>
<tr>
<td>the provision of support to strengthen technological development and innovation, including increasing energy efficiency, and knowledge transfer - Measure: Article 28. Partnerships between scientists and fishermen</td>
<td>2.500.020</td>
<td>833.340</td>
<td>3.333.360</td>
<td>20%</td>
<td>666.672</td>
<td>2016-2020</td>
</tr>
<tr>
<td><strong>Draft OP for Maritime Affairs and Fisheries -</strong></td>
<td>Ministry of Agriculture</td>
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<tr>
<td><strong>Ministry of Agriculture</strong></td>
<td>6.000.000</td>
<td>2.000.000</td>
<td>2.000.000</td>
<td>20%</td>
<td>400.000</td>
<td>2016-2020</td>
</tr>
<tr>
<td>National sources:</td>
<td>Croatian Science Foundation (Ministry of Science, Education and Sports)</td>
<td>10.395.000 (per year)</td>
<td>10.395.000 (per year)</td>
<td>60%</td>
<td>6.237.000 (per year)</td>
<td>2016-onwards</td>
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<tr>
<td>Research project grants</td>
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</tr>
<tr>
<td>Career development of young researchers (doctorate and post-doc grants)</td>
<td>Croatian Science Foundation (Ministry of Science, Education and Sports)</td>
<td>3.684.210 (per year)</td>
<td>3.684.210 (per year)</td>
<td>60%</td>
<td>2.210.526 (per year)</td>
<td>2016-onwards</td>
</tr>
<tr>
<td>Investment box 2 of the Action plan for the implementation of Industrial strategy of Croatia 2014-2020</td>
<td>Ministry of Economy</td>
<td>1.300.000</td>
<td>150.000</td>
<td>1.450.000</td>
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</tr>
</tbody>
</table>

9.6. Annex 6 Innovation Network for Industry
### Innovation Council for Industry

**Chaired by Ministry of Economy**

Members: MSES, MRDEUF, MEC, MT, MLPS, MA, AIC, HAMAG-BICRO, Representatives of the Universities, Croatian Chamber of Economy, Croatian Chamber of Crafts, Croatian Exporters Association, Presidents of Thematic Innovation Councils

#### Thematic Innovation Councils

- **TIP HEALTH**
  - Thematic Innovation Council for Health and Quality of Life
  - 3 sub-thematic priority action groups

- **TIP ENERGY**
  - Thematic Innovation Council for Energy and Sustainable Environment
  - 2 sub-thematic priority action groups

- **TIP MOBILITY**
  - Thematic Innovation Council for Transport and Mobility
  - 3 sub-thematic priority action groups

- **TIP SECURITY**
  - Thematic Innovation Council for Security
  - 3 sub-thematic priority action groups

- **TIP FOOD**
  - Thematic Innovation Council for Food and Bio-Economy
  - 2 sub-thematic priority action groups

### Innovation WEB platform

(covering all 5 TPAs)

### Activities

- 1. Coordination of Thematic Innovation Councils
- 2. Monitoring of Thematic Innovation Platforms
- 3. Monitoring of impact on the Croatian economy

### Source of financing

- Support to Ministry of Economy through strategic project "Establishment of Innovation Network for the Industry" (9,1 mln EUR)
- Support to Competitiveness clusters (through national funding – Operating grants) 3 mln HRK
- Support to Competitiveness clusters initiatives (7.5 mln EUR)
- OPCC project Support to Competitiveness clusters initiatives (3 mln EUR)

### Results

- Strengthening competitiveness of the Croatian economy and achievement of industrial growth through boosting productivity and diversification of the economy (development of new products and services)
- Increase in investments in R&D of the business sector (BERD)
- Increase in investments in R&D of the business sector (BERD)
- Communication of development stakeholders within TPAs, Effective collaboration on RDI projects
- 1. Increase in exports
  - 2. Increase in FDI
  - 3. Increase in value added of industrial sectors
  - 4. Inclusion in global value chains
  - 5. Increase in number of RDI projects
9.7. Annex 7 Policy mix and innovation value chain

- Business investment in RDI
- Social innovations
- Research organizations conducting R&D projects directed towards the needs of economy
- Enabling synergies with ERC grants

### Preconditions
- Innovation Network for Industry and Thematic Innovation Platforms
- Science and Technology Foresight

### Activities of Investments in R&D
- Fundamental research
  - Idea generation and research
- Industrial research
- Development
- Commercialization and diffusion

### Infrastructure
- National centres of Excellence
- Increase R&D ability for conducting top quality research and cooperation on national and international levels

### Centers of Competences
- Grant scheme: “Increase of development of new goods and services resulting from the research and development activities”

### Commercialization
- Competitiveness cluster initiatives
- Innovation friendly business environment for SMEs
- Technology Transfer Offices and Science Technology Parks

### Smart skills
9.8. Annex 8 S3 monitoring and Evaluation System in Croatia