European Commission

JRC SCIENCE FOR POLICY REPORT

POINT Review of Industrial Transition of Bulgaria

Harnessing digitalisation to link and strengthen the ICT and mechatronics sectors

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2021

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JRCJRC123901

EUR 30643 EN

PDF ISBN 978-92-76-32322-8 ISSN 1831-9424 doi:10.2760/241737

Luxembourg: Publications Office of the European Union, 2021

How to cite this report: Stefanov, R., Boekholt, P., Pontikakis, D., POINT Review of Industrial Transition of Bulgaria, EUR 30643 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-32322-8, doi:10.2760/241737, JRC 123901.

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Abstract

This report documents the findings of a review of industrial transition of Bulgaria launched in 2019 in partnership with the Bulgarian Council of Ministers, which follows the POINT (Projecting Opportunities for INdustrial Transitions) methodology of the JRC. The review explores some of the policy pathways that Bulgaria might take as it seeks to digitalise its economy and derive multiple associated benefits in terms of pervasive productivity improvements and the creation of knowledge-intensive and therefore well-paid jobs for a broad cross section of the workforce.

The Bulgarian information and communication technologies (ICT) sector has been on a meteoric growth trajectory over the past decade fuelled by the export of software solutions. However, ICT is still insufficiently connected to other sectors nationally and faces important skills bottlenecks. An important premise of this exercise is that the emerging strengths of the domestic ICT sector can contribute to the digitalisation of manufacturing and in particular of the mechatronics sector. This is because the needs of one sector closely correspond to the abilities of the other. Bulgaria has production strengths in both ICT and mechatronics dating back to the 1980s, which provides the necessary depth of the system for transformation.

Based on extensive research, consultations with key stakeholders, and drawing from international experience the review makes a number of suggestions for improvement in long-term policy orientation, coordination and implementation. Importantly, there are significant gaps in the education and training systems that prevent systematic investments in human capital. Recent cluster initiatives by the ICT and mechatronics sectors and a proliferation of start-ups in both sectors are encouraging signs but will require considerable additional support to further develop and deliver broad-based benefits for the Bulgarian economy and society. The European Green Deal and the EU Recovery Fund offer a unique opportunity to address the gaps in the system and enable long-term transformation. In the medium term, there are considerable opportunities for further growth by nurturing greater domestic ICT use, including by government.

A government-orchestrated effort to strengthen the linkages between ICT and mechatronics could help develop world-class production capabilities and also create a platform for wider digitalisation in other areas such as clean technologies, telemedicine and tele-education. For this effort to be successful, policy makers should consider actions that: Elevate human capital investment into a major national goal; Ensure sufficient public investments and encourage business investment on digital innovation, worker training, and upgrading of productive capabilities; Use the occasion of the digital transition to revamp rules and the structure of information flows, in order to improve governance and enable whole-of-government mobilisation; Strengthen and extend mechanisms that allow for coordination and collaboration with the business sector, ensure that policies leverage private investment and facilitate a continuous dialog that informs government policies.

Acknowledgements

This review is an output of the Working Group Understanding and Managing Industrial Transitions (https://s3platform.jrc.ec.europa.eu/industrial-transition), under the European Commission Joint Research Centre (JRC) Project "RIS3 Support to Lagging Regions". It draws on extensive stakeholder inputs received during two workshops organised on 6 December 2019 and on 4 June 2020, in close collaboration with the Bulgarian Council of Ministers and the Ministry of Economy.

We would like to thank the team at the Council of Ministers Mr. Ivan Ivanov, Director, Central Coordination Unit, Ms Lyudmila Tozeva, Head of Unit, Strategic Planning and Programming, Central Coordination Unit, and Ms Vera Markova, Chief Expert, Central Coordination Unit for their ongoing support and feedback. We also thank Mr. Zheliaz Enev, Director, Economic Policy Directorate and Ms Tihomira Pavlova, State Expert, Innovation and Entrepreneurship Unit at the Ministry of Economy for providing us with data and insights on the implementation of the RIS3 in Bulgaria.

We would like to thank our Applied Research and Communications Fund colleagues in Sofia, Professor Teodora Georgieva, Mr Petar Terziev, Dr. Todor Galev, and Associate Professor Todor Yalamov for their ongoing support, tedious work on data and provision of pointers and feedback on early versions of the text. They also helped us make the stakeholder meetings a success.

We thank the over 50 participants to the two stakeholder consultation workshops who contributed with their perspectives to this report.

The production of this report was supervised and includes contributions by Dimitrios Pontikakis (JRC). Elisa Gerussi (JRC) contributed to the stakeholder consultation meetings. Paula Galnares (JRC) prepared the final report for publication. Particular thanks go to Ken Guy (Wise Guys) who provided extensive comments to earlier drafts in his role as Chair of the Working Group. We thank Anabela Marques Santos (JRC) for providing figures on employment gains and losses and Jayne Woolford (JRC) for useful comments on an earlier draft. We gratefully acknowledge the review and ideas provided to an early draft by Antonio Andreoni (University College London) during the Working Group meeting in December 2019 in Brussels and to the members of the Working Group Advisory Board for stimulating discussions.

Executive Summary

Understanding and Managing Industrial Transitions is a Working Group launched by the Joint Research Centre (JRC), which aims to support regional and national authorities facing major industrial transitions. The Working Group is carrying out reviews of industrial transition under the common POINT (Projecting Opportunities for INdustrial Transitions) methodology developed by the JRC to help countries and regions in transition identify opportunities for addressing transition challenges and enhancing their capacity to deliver system-level innovations.

The Republic of Bulgaria, at the initiative of the Council of Ministers and the Ministry of Economy was one of the four countries taking part in this exercise in 2019-2020. The POINT review of Bulgaria analyses the current situation and also sketches alternative future directions for the country that, in the spirit of the European Green Deal, jointly tackle economic and societal challenges. Focusing on the digital transition and the opportunities it presents for co-developing the Bulgarian ICT and manufacturing sectors, the review undertakes a bold system innovation approach, aiming to enable a whole of government response and extensive coordination between government, business sector and civil society stakeholders. The Bulgarian government and other stakeholders could in particular use the findings of this POINT review to plan their interventions under the next Multiannual Financial Framework 2021 – 2027, as well as under the Recovery and Resilience Plan.

The route followed in the production of this report involved:

- Discussions with a broad range of public and private stakeholders to identify and validate the focus of the report on digitalisation as a way to link and strengthen the ICT and mechatronics sectors;
- An articulation of the rationale for the proposed transition, based on stakeholder discussions and background research;
- A broad overview of the current state of the socio-economic system that is likely to be involved in, and impacted by, a transition, including an analysis of strengths, weaknesses, opportunities and threats (SWOT);
- An outline of one possible future state, based on its desirability amongst key stakeholders and a pragmatic assessment of the SWOT analysis;
- Suggestions and recommendations concerning the steps needed to progress along potential pathways to this envisaged future.

The executive summary presents the main, high-level, action-oriented findings, recommendations and implications for future policy.

The digital transition represents a rare opportunity to tackle a number of long-standing socio-economic challenges

Bulgaria faces a number of interlinked socio-economic challenges that could be addressed through a managed industrial transition. These include the need:

- To bring about the labour productivity improvements that can underpin sustained increases in income per capita;
- To increase the share of high-tech production in the economy and create more knowledge-intensive and well-paid jobs;
- To address the demographic crisis which leads to a shortage of labour and skills;
- To provide a high quality and healthy life.

The focus of the review of Bulgaria is on digitalisation, a global trend of pervasive impact, which holds much potential for transformative innovation. The theme of interest as agreed in discussion with the Bulgarian national authorities is the linkage between mechatronics and the domestic ICT sector in order to open up new pathways for digitalisation in society and manufacturing in particular. The theme coincides with the (twin) green and digital transitions as defined by the EU in the European Green Deal and responds to the country's policy priorities as laid out in its strategic documents and the relevant EU country recommendations.

An important premise of this exercise is that the emerging strengths of the domestic ICT sector can contribute to the digitalisation of manufacturing and in particular of the mechatronics sector. This is because the needs of each one sector closely correspond to the abilities of the other. One the one hand, domestic ICT companies

have been successful in providing software solutions to international markets but are facing persistent difficulties in graduating to higher-value added markets and activities. On the other hand, mechatronics manufacturers are facing a productivity shortfall but have a long experience and established productive capabilities ripe for modernisation. It is therefore worth considering a host of government-orchestrated actions to link the two sectors with the objective of obtaining world-class productive capabilities. Productive capabilities and experience gained in the process of digitalising domestic manufacturing could then favourably position Bulgarian ICT and manufacturing firms in global markets for advanced manufacturing solutions. Moreover, the reinforcement of the linkage can create a platform for wider digitalisation in other areas such as clean tech, telemedicine and tele-education. This would require considerable planning, in close collaboration with the business sector, in addition to sharpening the focus of human capital investments, of innovation efforts and of support for business investment.

To achieve successful digital transformation it will be necessary to accelerate the rate of *human* and *physical capital* investment. Government leadership in setting a high ambition, whole of government mobilisation, close collaboration with the business sector and strengthening the rule of law will be central elements of this effort.

Based on consultations with stakeholders and careful examination of available evidence, the following policy directions seem especially relevant:

- **Elevate human capital investment into a major national goal**. Bulgaria can address multiple socio-economic challenges through a sharp focus of national effort on human capital for the digital future. A key review finding is that the common thread that links many of Bulgaria's socio-economic challenges – from low labour productivity, to low knowledge intensity in the economy, to skill shortages and a level of income below the EU average is *underinvestment in human capital***.** Underinvestment coupled with high levels of historical emigration of Bulgarian talent, have resulted in a pronounced lack of human resources for the digital transition. The European Green Deal and the considerable resources accompanying it represent an occasion to address this long-standing challenge, if human capital investment is elevated into a major national goal. Addressing a challenge of this magnitude will require holistic planning to provide both the necessary quantity of skills (which can be additionally strengthened with an ambitious drive to attract highly skilled workers to Bulgaria) and in terms of quality (which can improve substantially across all forms of education, learning, and training). As the outcomes of a national human capital drive will take time to realise, Bulgaria will have to build political and social consensus about the goals of transformation and agree on continuous support for these priorities regardless the political leadership of the country.
- **Ensure sufficient public investments and encourage business investment on digital innovation, worker training, and upgrading of productive capabilities**. For the national human capital drive to result in tangible economic benefits, it will be imperative to rapidly and steadily *increase the growth rate of the stock of capital*. By some estimates, for Bulgaria to reach the capital stock per worker of more advanced countries, it would *need a tenfold increase*. This would require the attracting of increasing volume of foreign and domestic business investment, to gradually reduce the overreliance on EU funds, and seek to establish investment loops between currently disparate pockets of domestic strength with potential complementarities (e.g., between ICT and mechatronics).
- **Use the occasion of the digital transition to revamp rules and the structure of information flows, in order to improve governance and enable whole-of-government mobilisation**. Like many other lagging regions in Europe, Bulgaria needs to considerably strengthen the rule of law and nurture confidence that can facilitate the flow of investments to the country. It needs to further reduce bureaucracy and modernise the information flows within government and to the outside world. Rapid and transformative digitalisation of government itself can contribute to all the above objectives. The Bulgarian government can position itself as a digital champion and ensure effective governance of public investments (including RIS3), in particular by ensuring better coordination among different ministries, agencies and operational programmes (Ops). Critically, the government can use the opportunity of digitalisation to rethink and modernise administrative structures and use digital technologies to make public administrations more responsive to emerging needs. Success will require capacity building within the public administration.
- **Strengthen and extend mechanisms that allow for coordination and collaboration with the business sector, ensure that policies leverage private investment and facilitate a continuous dialog that informs government policies**. International experience suggests that public-private partnerships (e.g. in training and education) can be successful vehicles for this purpose.

Government strategic planning will have to respond to emerging business needs. The report contains a number of recommendations for strengthening the linkages between the orientation and planning sub-system and the production sub-system. Finally, it will be important to ensure continuation of support to already established intermediary organisations on the basis of clear objectives and targets that are jointly defined with stakeholders.

Structure of the POINT review report

The first two chapters of the POINT review focus on outlining the rationale for transition in Bulgaria, the thematic coverage of the review and its scope. They map the key actors in mechatronics and ICT, their relations, their current state (including existing planning arrangements and directions of deliberate change by stakeholders), and the strategic and framework conditions within which they function. The next and final two chapters of the review try to identify critical points of leverage for enabling industrial transition pathways, which hold the greatest promise for addressing the socio-economic challenges Bulgaria faces. The review concludes with a discussion on concrete suggestions for the advancement of the transition and for managing its downsides. Following the POINT methodology, the review examines four sub-systems the correct functioning of which will be key to a successful transition, namely: planning and orientation (including government functions and key business stakeholders), resource mobilisation (with a focus on key knowledge providers and financing instruments), production (of knowledge as well as of goods and services and associated production capabilities) and consumption or use (understood as both the current and prospective demand for goods and services produced in Bulgaria).

The findings of the review are based on desk research, in-depth interviews and two stakeholder meetings. The first meeting was held in December 2019 at the Bulgarian Council of Ministers and involved key actors in Mechatronics and ICT from the public sector, business, finance, education, intermediaries and other societal groups. Participants were asked to chart out the main existing challenges, planning arrangements and strategic directions for change. The second meeting was held online in June 2020, and asked stakeholders to consider future visions for the sub-systems examined the POINT review.

Planning and Orientation: More coherence and coordination is a prerequisite for aligned policy strategies

Planning and Orientation relates to activities and processes that shape the future ambitions of the country and regions. This consists in large part of the multi-annual policy strategies of various government authorities that underpin the priorities for public investments. It also includes ambitions and plans of stakeholder communities and in particular parts of the business sectors (whether grouped in clusters or associations, leading companies or entrepreneurs) that develop a medium- to long-term vision for their economic activities in Bulgaria.

The review mapped these activities and the key actors involved. While there are many government strategies that affect the domain of mechatronics and ICT, currently the most relevant policy document spelling out future ambitions is the *National Development Programme: Bulgaria 2030* with its three strategic goals: accelerated economic development, demographic upswing and reduction of inequalities. Particularly the Development Axis Innovative and Intelligent Bulgaria aims to increase coherence between education and the needs of business and society, raise digital competences, develop regional and local laboratories for testing new technologies and to build human, scientific, organisational and institutional capacity for Industry 4.0.

In the future, the orientation and planning system will have to be reconfigured to ensure:

- Better coordination and policy coherence between policy domains that shape industrial transformation (e.g. education, innovation, digitalisation, industrial and regional policies);
- Stronger interaction and coordination between the national and regional authorities;
- Effective, durable and transparent implementation of strategies and policy interventions;
- Stronger rule of law to encourage trust in government and support investor confidence;
- Enhanced partnership and engagement between the public authorities, the business sector and other stakeholders affected by industrial transformation.

Resource Mobilisation: Upgrading and extending education and skills development and ensuring public investments leverage additional business investments, will be key to enabling digitalisation pathways that have a lasting economic impact.

Bulgaria is lacks investment, both in terms of financial and human resources. The population is projected to shrink even further in the coming decades. Overall resource mobilisation is heavily dependent on financial support from the European Union. R&D spending in Bulgaria is relatively low with 0.84% of GDP although it has increased twofold as a share of GDP and even more in absolute terms over the past decade. Moreover, enterprise R&D accounts for two thirds of R&D. At the same time public sector outlays have stagnated at below and around 0.20% of GDP over the past decade, with a slight uptick in 2019.

For the mechatronics domain the EU Funds' Operational Programmes (OP) *Innovation and Competitiveness* (OPIC) and *Science and Education for Smart Growth* (OP SESG) are particularly relevant. Many companies from the mechatronics sector have used these resources for research and innovation projects.

The government has used OP resources to build a stronger intermediary infrastructure in the innovation eco-system. The Centres of Competence and Centres of Excellence were set up under these programmes, following different business models. Most of these centres have direct relevance for the Mechatronics and ICT domains. As the centres have only been established in the last year, it is too early to demonstrate impacts on changing the transition paths of economic and societal actors. Nevertheless, in the future these organisations can be expected to play an important role in the industrial transition process. In addition, the government plans to devote OP resources to the establishment of Regional Innovation Centres (postponed to the next planning period due to the onset of COVID-19), as well as for the support of other intermediary organisations, such as Digital Innovation Hubs.

Education is particularly important for the digital transition in Bulgaria in view of its pervasive impact on the economy and on society. Available evidence suggest severe shortfalls on both the quality and quantity of education and on training from the business sector in Bulgaria compared to its EU peers. The concerns with quality are corroborated by international studies such as OECD's PISA. The gap prompted the business sector to step in and initiate education and training initiatives privately. There is a need for larger coherence between the needs of business and society on the one hand and programmes in higher education and training on the other, as is also noted in *the Bulgaria 2030 National Development Programme*. A positive development is that the number of ICT experts in Bulgaria is increasing and the number of people employed in ICT as well as their share in employment is growing. The international performance of both patenting and publication activity shows that Bulgaria is still likely to rely largely on imported technology and fundamental knowledge to deliver on its industrial transformation. This underscores the importance of attracting new and retaining existing foreign investors in the country, particularly in knowledge-intensive activities relevant to the ICT and mechatronics sectors.

In the future, a reconfigured Resource Mobilisation sub-system should become successful in:

- Leveraging private sector funding, in particular attracting strategic investors in the priority areas of Bulgaria's RIS3, including ICT and mechatronics, and other private investments that contribute to the national effort to digitalise Bulgarian industry, and improve its competitive position internationally.
- Developing a nation-wide multiannual skills agenda that prepares Bulgaria for industrial transformation, supported by a high-level strategic platform involving stakeholders to jointly develop that agenda;
- Making better use of synergies between the different EU funding mechanisms and resources (co-managed by the Bulgarian authorities and the EU) to achieve joined up and coherent policies to support industrial transformation.

Production: Linking the fast-growing ICT sector with the established mechatronics sector and strengthening the intermediary organisations would boost the industrial ecosystem

Bulgaria has a history in both ICT and mechatronics dating back to the 1980s, which provides the necessary depth of the system for transformation.

In 2018 the extended mechatronics sector comprised of 8,349 enterprises with a total turnover of € 8.9 billion, employing more than 162,000 people. The enterprises in this sector have been actively using the Operational Programme *Innovation and Competitiveness* (OPIC) for R&D projects. They are amongst the most R&D-intensive companies in the country and those that used OPIC had higher operating revenues than other companies in the mechatronics sectors. Some of the large global multinationals in mechatronics have located manufacturing capacity in Bulgaria in diverse sub-sectors such as automotive, consumer products and general engineering. At the same time, local companies have been developing their sectoral governance structure by establishing their

own cluster, which has been one of the more active, and has recently been awarded further support for innovation through the Operational Programmes.

The Bulgarian ICT sector has experienced steady growth in the last twenty years. This trend continued in 2018 when ICT generated €7.4 billion annual revenue and provided more than 127,000 jobs. This represents an increase by 204% in revenues and 226% in number of jobs compared to 2010, significantly outpacing the growth of these indicators for the whole economy for the same period. In the period 2010-2018 the fastest growing ICT sub-sector in terms of revenue was "Computer programming, consultancy and other ICT services". The sector shows a mix of multinationals, mostly in software development, indigenous companies, some with an international reputation, and many spin-offs and start-ups.

Shortage of skilled ICT staff is a persistent issue for the business sector and hampers its growth potential.

There is a large concentration of the mechatronics and ICT sectors in the capital Sofia region. Therefore, there is also a concentration of financial and human resource mobilisation in the capital region. Nevertheless, all regions, have selected mechatronics and/or ICT as a priority area for specialisation under the regional dimension of the national RIS3 strategy.

For a transition path aiming to deliver higher incomes and wealth for Bulgaria both sectors offer good opportunities. A closer integration between these two sectors could reinforce and accelerate these opportunities. Today the competences and business capabilities of the ICT sector are mostly geared to the export markets and foreign clients. They have only to a limited degree been mobilised to enhance the digitalisation of indigenous companies, for instance in the mechatronics sector. For Bulgaria to embrace Industry 4.0 (smart industry) and a further digitalisation of the economy and society, these local ICT capabilities and expertise could empower this transition. In doing so, the ICT sector may have an opportunity to develop some of the capabilities necessary for upgrading its position within global value chains.

In the future, the following reconfigurations in the production system would support a successful transition in terms of addressing Bulgaria's current socio-economic challenges:

- Stronger business interactions between the different segments of the sectors in the examined industrial domain, in particular between ICT service companies and manufacturing companies relying on mechatronics and in need of digitalisation;
- A more internationalised research and innovation system, supported by cross-border partnerships, particularly those that tap into knowledge crucial for contesting the high-end of value chains;
- Enhanced capacities for supporting implementation in the intermediaries (such as the Competence Centres, Centres for Excellence and Digital Innovation Hubs, Regional Innovation Centres and Centres for Vocational Excellence) that can support digitalisation, skills, innovation and networking in enterprises;
- Investment in the public R&D capacities, particularly for the universities to leverage (attract) private sector R&D contracts and investment.

Strengthening and steering domestic consumer and public demand, particularly for digital products and services can contribute to a stronger domestic production system

The domestic market for goods and services from the ICT and mechatronics sectors is small and does not demand advanced goods and services. Overall, the low levels of digitalisation in society as well as in the business sector, as shown by most indicators of the European Digital Economy and Society Index (DESI), are currently a barrier for mobilising the domestic markets as an accelerator to commercialise higher value products and services from domestic suppliers. Public procurement for these products is also modest, although the ambitions to expand eGovernment and digitalisation in general could provide opportunities in this respect. It is therefore not surprising that many enterprises in the ICT and mechatronics sector are export oriented, which in many respects is a great strength. It seems that the export patterns for mechatronics are fragmented across quite a number of unrelated product segments, so no dominant niches are prevailing at the moment. Yet export markets provide ample opportunities for companies to move up in international value chains, provided that they improve their absorptive capacity for (digital) innovations and strengthen their innovation and product development competences.

In the future, a consumption and use system that can help drive a successful industrial transition would need to develop along the following lines:

- Stimulate local private consumption of ICT services through tax incentives, and through the delivery of broadband connectivity through recovery funds, in particular for vulnerable and lower income communities.
- The public sector becomes a driver for innovative services and products in the ICT and mechatronics sectors through innovative procurement and better coordination of public procurement in these areas;
- Develop Bulgarian language content in support of soft skills and demand for ICT in education, piloting innovative curricular changes through the available recovery funds, which could then be mainstreamed through national or OP funds after their mid-term performance review in 2024;
- The government could trigger critical partnerships in the private sector to stimulate cross-sectoral learning and push digitalisation through engaging with business clusters and intermediaries and network industries such as banking, telecommunications, etc.
- Export markets to be used to their full potential to deliver products and services of higher added value through targeted public-private efforts to attract strategic investors in ICT and mechatronics.

Support coalitions will have to be developed in the business sector, among the education and training institutions and intermediaries.

Digitalisation is likely to create better paid jobs but at the same time it would require re-skilling and could mean also sectoral branching to new growth areas. The related drive towards automation in industry, which is important for mechatronics, could require the reskilling of up to 1.5 million workers or slightly above half of those currently in employment. Hence, raising awareness of the need to change and about the potential opportunities and creating the drive for skills retooling will require the building of broad support coalitions among many stakeholders. These have emerged naturally in areas of broad public support for the creation of intermediaries, such as cluster initiatives, Digital Innovation Hubs, CoE and CoC. However, one player that has been so far missing from such coalitions is business representatives. A good starting point to attract businesses to such support coalitions is to manage and sustain more actively relations with former or potential recipients of EU funds, which are more likely to respond positively to requests for engagement. Support coalitions can best be developed through engaging stakeholders in the RIS3 redefinition process at all levels. A good example is the inclusion of members of the business sector and the research community in the Council of Ministers Council for Smart Growth. Yet, these formats need to be reinvigorated, providing stakeholders other than the government with the possibility to vote and shape policy and missions. In this respect, there is a need to pull together information and communication resources from different agencies and develop better push technologies for informing stakeholders, e.g. through the open data portal, through the strategy.bg portal or through the eufunds.bg portal.

The Bulgarian government could reduce some of the resistance to re-skilling from companies and at the same time address their needs to retain personnel during the COVID-19 crisis and its aftermath by designing appropriate support schemes. These could foresee the payment of re-training fees and social security and healthcare contributions for workers who undergo digitalisation courses. Alternatively, such support measures could compensate universities for organising digitalisation courses, while at the same time reimbursing companies for lost revenues from staff re-skilling. It is encouraging that business representatives have indicated a strong interest in raising and widening the skills pool in Bulgaria.

Policy experiments, reforms and dedicated policies will be needed across the Bulgarian system to identify context-specific pathways for speeding up industrial transition and broadening its benefits

The proposed policy instruments and experiments concentrate on the major issues relating to the ICT/mechatronics domain, which have been identified in the previous chapters:

- the fragmented governance and funding mechanisms preventing a systemically-planned support of the domain;
- the skills shortages and mismatches;
- the lack of an ecosystem with organisations championing innovation and digitalisation of the mechatronics sector;
- the weak connection with international networks and value chains and particularly European partnerships and competitive funding;

- the low FDI attractiveness, which hampers the inflow of fresh capital for swifter digital transformation of mechatronics.

A policy experiment should be low cost and small scale but with potential to be scaled up quickly if proven successful or to at least yield policy lessons otherwise. The boldest policy experiment proposed is sharply focused in strengthening capacity building at the thematic domain of the review: reinforcing the capacities of existing intermediaries to set up a Digital Manufacturing Research and Innovation Centre. The Centre could combine the development and dissemination of digital production technologies, education and training in ICT and production technology skills, applied research, pilot and demonstration facilities and business services. In order to ensure that all regions have easy access to its services, it would be worth considering launching smaller satellites within the various regional innovation centres that can serve as a first entry point for companies. As this initiative encompasses research, innovation, business support, education and training it should be funded by bundling the Operational Programmes Innovation and Competitiveness, Science and Education for Smart Growth, Human Resource Development and Growth Regions. In addition, the hub could partner with the existing ICT Academies that are set up by the business sector. This would leverage the resources of both the public and private sector and provide important inputs and feedbacks on business needs.

The Centre could constitute additional tasks and matching resources to the Competence Centres, Digital Innovation Hubs and other intermediaries that have already been set up in this domain. Its current set up should be revisited to ensure that its activities are in line with the needs of Bulgarian industry. Partnerships with other Competence Centres, universities and intermediaries that complement the knowledge base and potential services could be envisaged.

The full report makes additional suggestions for useful policy experiments, which the Bulgarian government may want to consider in stimulating the industrial transition. The following Table summarises some of the proposed interventions.

Table A: Recommended policy interventions for industrial transition

What to achieve?	**What gaps will it fill in the system?**	**Which actors to take action?**	**Possible Timeframe**
Develop a well-resourced Secretariat and Intelligence Unit for the Council of Ministers to prepare and coordinate overarching policy strategies	This will reinforce the whole-of-government approach and coordination in policy making and improve orientation and planning as well as resource mobilisation	Deputy prime Minister's office, Minister of Finance and Council of Ministers	2021
Reinforce the Implementation Agencies involved in the continuation of RIS3, and the relevant national strategies related to digitalisation, Industry 4.0 and the RIS3 priority domains	This will contribute to national and regional policy strategies including the RIS3 to be followed up, to strengthen their ability to support capacity building by producers	Deputy prime Minister's office, Agency for Research and Innovation, Minister of Finance, Council of Ministers, Minister of Economy, Minister of Education and Science	2021
Ensure continuation of (financial) support to already established intermediary organisations on the basis of clear objectives and targets that are jointly defined with the stakeholders	This will contribute to national and regional policy strategies including the RIS3 to be followed up, so that resources will be mobilised effectively.	Various Ministries, Centres of Excellence and Centres of Competence, Sofia Tech Park, Digital Innovation Hubs, Cluster organisations	2021
Key intermediaries identify emerging innovators to launch demonstrator R&D	This will increase the absorptive capacity for digital/mechatronics	Ministry of Economy, Intermediaries	2022

What to achieve?	What gaps will it fill in the system?	Which actors to take action?	Possible Timeframe
projects to showcase innovative ICT-mechatronics combinations	innovations and ultimately the productive capacity (and competitiveness) of both ICT and mechatronics businesses.		
Establish an active and effective strategic skills platform, where future skills' needs and investments are discussed with representatives of business, education and government,	This will improve the resource mobilisation subsystem as well as the orientation and planning subsystems in the short to medium term as it will contribute to a better match between skills supply and demand. In the long-term this will improve both the production and consumption subsystems	Ministry of Education and Science, Ministry of Economy, Ministry of Labour and Social Policy, Business leaders from a mix of enterprise segments, trade unions, representatives of educational institutes including HEI and VET, as well as private sector training initiatives. Initiated by government authorities, set up as semi-independent PPP	2021
Strengthening the VET segment of formal education and providing them a role in re-skilling and up-skilling of the current work force in Bulgaria	This will improve the resource mobilisation subsystem in the first instance and will have a positive impact on the production subsystem by raising skills levels	Ministry of Education and Science, VET institutions, future Skills Platform, Ministry of Finance, Ministry of Labour and Social Policy	2025
Setting up a Digital Manufacturing Research and Innovation Centre	This will help raise the absorptive capacity in the production subsystem, to increase skills levels and bridge the gap between public research and industry	Council of Ministers, Ministry of Education and Science, Ministry of Economy	2022
Nurturing and stimulating internationalisation of key actors in the public and private sectors	This will contribute to the competitiveness of the subsystem production as international ties are known to augment the quality of domestic activities in research and innovation. It can also become a conduit for more and more knowledge-intensive FDI.	Ministry of Education and Science, Ministry of Economy, EEN	2021
Developing an action plan for attracting strategic FDIs in mechatronics and ICT stimulating upward movement on the value-added chain.	Closing the private sector capital gap and ensuring new lead actors for digitalisation	Ministry of Economy, Invest Bulgaria Agency, Bulgarian SME Promotion Agency, Ministry of Transport, Information Technology and	2021

What to achieve?	What gaps will it fill in the system?	Which actors to take action?	Possible Timeframe
		Communications, State eGovernment Agency	
Piloting joint OP calls encouraging industrial transformation efforts based on ICT and mechatronics	Ensuring comprehensive horizontal support for industrial transformation pilots	Managing authorities of the OPs and the Central Coordination Unit at the Council of Ministers	2021
Creating virtuous circles of synergies between national (including OPs) and European programmes (Horizon Europe, Interreg, etc.)	Leveraging EU membership to benefit from OPs but also from EU-level support	Agency for Research and Innovation, Ministry of Economy and Ministry of Education and Science, Ministry of regional development and public works	2022
Review of conditions and measures to establish a national digitalisation mission	Stimulating demand for digitalisation through different public policies, such as public procurement, investments, etc.	Council of Ministers, Agency for Public Procurement, Ministry of Finance, Ministry of Economy	2021

1 Introduction

In 2020 the EU and its Member States and regions are facing challenges that can only be rectified by major changes in both production and consumption patterns. These challenges have been exacerbated in many instances by the COVID-19 crisis. COVID-19 has disrupted production chains and consumption patterns, likely resulting into the sharpest global economic decline and unemployment in recorded economic history calling for a global systemic response[1]. The crisis has increased the need for systemic responses to be amplified and accelerated.

The OECD introduced the concept system innovation to illustrate a horizontal policy approach that mobilises technology, market mechanisms, regulations and social innovations to help solve complex societal problems.[2] The global process of industrial transition, sparked by current megatrends such as digitalisation, automation and the need for sustainable production, can be seen as such a complex societal problem that needs a systemic approach. Regions can seize the chances offered by these megatrends and simultaneously face a number of challenges such as a changing demand for skills or loss of economic activity in particular sectors.

The EU response to these megatrends is defined in its European Green Deal[3] and the New Industrial Strategy for Europe[4] as the 'twin ecological and digital transitions'. The EU industrial transition response foresees three interlinked drivers: (i) a globally competitive and world-leading industry; (ii) an industry that paves the way to climate neutrality; and (iii) an industry shaping Europe's digital future.[5] Delivering on these drivers would require system innovation, i.e., changes not just in industry (production) but also in consumption, learning and skills, as well as societal organisation and state governance.

These drivers have been also integrated into the EU's Recovery Package[6], aimed to support Member States and regions in healing their economies from the Covid-19 crisis. The EU's lead and guidance on the transition is particularly important for regions that have seen their relative economic prosperity decline (in terms of GDP) or stay well below the EU average. Bulgaria is among the regions with the lowest GDP per capita in the EU. This report sets out to assist the country to better understand and manage the imminent industrial transition it faces.

Box 1. JRC Working Group Understanding and Managing Industrial Transitions

The JRC within the frame of the project 'RIS3 Support to Lagging Regions' has launched a Working Group on *Understanding and Managing Industrial Transitions*. The Working Group aims to support regional (and where appropriate national) authorities facing major industrial transitions, away from declining sectors and activities and charting actionable paths towards employment-intensive economic growth. Industrial transition in this context is broadly understood as the sum of all long-run trends of structural change in the regional economy that have significant impacts on employment. The Working Group comprises of JRC staff, the partner authorities, an Advisory Board of distinguished experts and experts engaged in reviews of industrial transition, coordinated by Ken Guy (WG Chair) and Prof. Erik Arnold (WG Rapporteur).

At the centre of the approach to transitions adopted in the Working Group is the development of credible positive visions for the future that can be the source of pride and inspiration for the region (or country) and a rallying point for the mobilisation of actors and resources from all levels. The core activity of the Working Group are the reviews of industrial transition following a common methodology (POINT, Projecting Opportunities for INdustrial Transition) that draws on expertise on system innovation/transition management, foresight, industrial policy and innovation governance. The reviews focus on an *industrial theme* of growing global importance suggested by the relevant territorial authorities (for instance, but not confined to: climate change,

[1] See for example, the IMF's Executive Director blog post *A Global Crisis Like No Other, Needs a Global Response Like No Other*. Available online at: https://blogs.imf.org/2020/04/20/a-global-crisis-like-no-other-needs-a-global-response-like-no-other/

[2] OECD (2015), *System Innovation: Synthesis Report*, Directorate of Science, Technology and Innovation. Paris: OECD. Available online at: https://www.innovationpolicyplatform.org/sites/default/files/general/SYSTEMINNOVATION_FINALREPORT_0.pdf

[3] The European Commission (2019). *The European Green Deal Brussels*, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS, 11.12.2019 COM (2019) 640 final

[4] The European Commission (2020). A New Industrial Strategy for Europe, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS, Brussels, 10.3.2020 COM (2020) 102 final

[5] Ibid.

[6] The European Commission (2020). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTE AND THE COMMITTEE OF THE REGIONS Europe's moment: Repair and Prepare for the Next Generation, Brussels, COM/2020/456 final

electrification of transport, circular economy, digitalisation, artificial intelligence) to collect evidence and examine the scope for developing adequate territorial responses that harness cross-portfolio complementarities (e.g. between ministries and between levels of governance) and cross-stakeholder coordination (e.g. between businesses and broad constituencies of consumers/users).

The JRC is conducting four such reviews (Andalucía, Bulgaria, Greece and Romania) in the current phase of the project. The outcomes of the deliberations of the Working Group, including the reviews and other lessons from leading international practice on industrial transitions will be documented into a final Synthesis Report.

Many European regions currently face sharp changes in external conditions that are testing their capacity to respond. These include economic challenges stemming from intensified global competition, technological challenges such as digitalisation and labour-substituting automation and environmental challenges and responses to climate change. The review not only analyses the current situation but also points to alternative future directions for the territory to tackle these challenges. It undertakes a bold systemic innovation approach, aiming to propose a whole of government response that also involves the private sector and civil society stakeholders[7]. Therefore, the focus of the country reviews is on a particular thematic area which holds the potential to leverage change to transform the production and consumption systems.

The Republic of Bulgaria, in particular the Council of Ministers and the Ministry of Economy, expressed interest in taking part in the JRC review and policy pilot on Understanding and Managing Industrial Transitions. The theme of interest, as agreed by the national authorities, is the linkage between mechatronics and the Bulgarian ICT sector that would open up new pathways for digitalisation in society and manufacturing in particular. The theme of interest coincides with the 'twin ecological and digital transitions' as defined by the EU and responds to the country's policy priorities. While this report focuses more on the digitalisation strand, it bears in mind that the two are interrelated and a similar assessment in the future might have a greater focus on clean tech.

The topic of Industrial Transition is closely linked to a number of national policy strategies such as the Innovation Strategy for Smart Specialisation for the Republic of Bulgaria 2014-2020 (RIS3)[8] and the more recent Concept for Digital Transformation of the Bulgarian Industry (Industry 4.0)[9]. The review is based on literature and policy documents, interviews with key actors, the analysis of data on the Bulgarian economy, the country's ICT and R&I performance and assets, employment trends and other fact-finding activities. In addition, a dedicated stakeholder consultation meeting took place in Sofia, Bulgaria on December 6, 2019, eliciting the views and experiences of participants from across the Bulgarian research and innovation eco-system. A second stakeholder meeting was held on 1 June 2020, using electronic meeting facilities, to chart out possible visions for the future of the system and potential pathways for transformation.

Chapter 1 elaborates the rationale for transition in Bulgaria and the thematic coverage of the review. It defines the boundaries of the thematic area under review and its basic system components. As the review is focused on future changes, the last part of this first chapter provides a vision for a potential endpoint for the transitions and some headline targets to be reached as a result of a change in direction by key stakeholders. Chapter 2 describes the current system in terms of actors, mechanisms, relations and framework conditions related to the thematic area on the linkage between mechatronics and the Bulgarian ICT sector. Inspired by the transition policy literature, the review of the system is structured along dimensions relating to resource mobilisation, planning, production and consumption/use and their relations. Chapter 3 uses this same structure but, rather than describing the current system, it sketches the desired system based on inputs from a wide variety of key stakeholders and actors involved in the transition. Finally, chapter 4 discusses how to accelerate the transition, including the identification of potential leverage points and the needs for changes in the governance of government. It also considers some of the processes that will be necessary, such as building support coalitions and managing resistance to change. The chapter also provides suggestions for policy experiments, reforms and possible policies and instruments to accelerate the transition. The first two chapters were written at the end of 2019 and the first half of 2020, relying on available data at the time of their writing. Chapters three and four were prepared in the second half of 2020.

[7] OECD (2015), *System Innovation: Synthesis Report*, Directorate of Science, Technology and Innovation. Paris: OECD. Available online at: https://www.innovationpolicyplatform.org/sites/default/files/general/SYSTEMINNOVATION_FINALREPORT_0.pdf

[8] Innovation Strategy for Smart Specialisation of the Republic of Bulgaria 2014-2020, version 27.06.2017

[9] Ministry of Economy (2019). Concept for Digital Transformation of the Bulgarian Industry (Industry 4.0). Sofia: Ministry of Economy. Available online at: https://www.mi.government.bg/files/useruploads/files/ip/kontseptsia_industria_4.0.pdf

1.1 Rationale for Transition

Bulgaria faces a number of socio-economic challenges that underpin the need for an industrial transition:

- Low labour productivity and related low levels of income;
- Low share of high-tech production in the economy;
- A demographic crisis which leads to a shortage of labour and skills;
- The need to provide a high quality and healthy life for its citizens.

The 2019 European Semester Report on Bulgaria[10] observes a strong economic growth momentum, with annual growth levels above 3% in 2018 and expected to remain above 3% in 2019. Despite strong growth, levels of poverty, social exclusion and income inequality are among the highest in Europe and remain unaffected or have worsened since 2013.

Convergence with the EU has been slow. GDP per capita has grown faster than the EU average since 2011, but it had reached only 53% of the EU average in purchasing power parity by 2019. Regional disparities are growing and hampering the competitiveness of the country. The 2019 European Semester Report also concludes that insufficient investment in skills, social cohesion infrastructure and research and innovation is holding back the modernisation of the economy. Bulgaria's considerable labour and skills shortages warrant investments in training and reskilling; addressing the lack of digital skills; improving the quality and inclusiveness of education and aligning it to the needs of the labour market; and improving the capacity of public employment services. Of the 27 EU Member States in the European Innovation Scoreboard 2020, Bulgaria ranked 26th in terms of innovation performance and is still categorised as a modest innovator, falling short of the country's RIS3 ambition to become moderate innovator by 2020. Its performance level is below 50% of the EU average. Bulgaria's lowest indicator scores are on R&D expenditure in the public sector, most cited publications and lifelong learning. Regarding progress towards its national targets under the Europe 2020 strategy, Bulgaria is expected to achieve its target for reducing greenhouse gas emissions and increasing the share of renewable energy.[11]

These findings have been confirmed in the European Commission Country Report Bulgaria 2020[12], which was issued just before the COVID crisis unfolded in Europe. The EC notes that Bulgaria's growth prospects remain strong but there is scope to further strengthen the competitiveness and the resilience of the economy. In particular, insufficient investment is holding back the modernisation of the economy. The report further acknowledges that identifying investment needs and securing adequate funding will be key to shaping a new growth model. This would also require more and better targeted investment in digitalisation and in R&D though attention needs to be paid to the governance and performance of the funded projects. The report also states that Bulgaria faces considerable social challenges, such as the highest rates of poverty and income inequality in the EU, as well as limited access to healthcare due to an uneven distribution of scarce resources and low health insurance coverage. These are likely to constrain Bulgaria's capabilities to respond to impulses for industrial transformation. At the same time, Bulgaria faces considerable challenges and huge potential benefits in making use of the new EU green transition instruments. Inadequately addressed environmental challenges in Bulgaria present a major obstacle to long-term sustainable growth. Bulgaria remains by far the most energy and green-house gas intensive country in the EU.[13]

The European Commission's 2020 Autumn Economic Forecast[14] notes that Bulgaria has experienced considerable adverse effects by the COVID-19 crisis, and economic activity is unlikely to return to its long-term growth trajectory before 2022. The forecast notes that this return would hinge on the quality and speed of government action to alleviate the effects of the crisis through deficit budget spending and the EU's Recovery and Resilience Plan.

[10] European Commission, (2019) Country Report Bulgaria, Accompanying document to 2019 European Semester, SWD (2019) 1001 final/2

[11] Ibid, pages 5-8.

[12] European Commission (2020), *Country Report Bulgaria 2020* COMMISSION STAFF WORKING DOCUMENT Accompanying the document COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN CENTRAL BANK AND THE EUROGROUP 2020 European Semester: Assessment of progress on structural reforms, prevention and correction of macroeconomic imbalances, and results of in-depth reviews under Regulation (EU) No 1176/2011 {COM(2020) 150 final}

[13] Ibid, pages 4-6.

[14] European Commission, (2020) European Economic Forecast: Autumn 2020, Institutional Paper 136, November 2020, Directorate General Economic and Financial Affairs, European Commission, Luxembourg: Publications Office of the European Union, 2020.

So, Bulgaria faces the same global challenges as the EU and needs to act on them accordingly. These have been exacerbated by the COVID-19 global pandemic. At the same time, the EU is likely to provide the bulk of the resources for Bulgaria to be able to address these global impulses and benefit from the transformation. In fact, the country's policy documents describing the reasons for transition have been mostly related to requirements related to access to funding from the EU. Given the ubiquity of the twin challenges of ecological and digital transition, it seems only reasonable for Bulgaria to focus in the short to medium-term on the digital aspects, while linking them to longer-term ecological transition. The policy focus on digital transformation has also begun earlier in time[15]. And the COVID-19 crisis has further underscored the need to speed up digital transformation policy implementation. As enabling technologies, digital services and mechatronics can help Bulgaria build up its capacity for change and increase economic resilience in the future.

Well-coordinated, planned and timely government policy, developed in a spirit of consensus with workers and industry and with the backing of considerable EU funds, can support the transition towards a better performing manufacturing sector that applies and embraces digital and other industry 4.0 technologies and state-of-the-art mechatronics. As mechatronics is an enabling technology that is integrated in many industrial sectors, the size of the global markets is difficult to measure. The global digital service sector, one of the fastest growing sectors in the Bulgarian economy, is estimated to reach 853 billion U.S. dollars by 2021, up from 737 billion U.S. dollars in 2017.[16] The OECD Digital Economy Outlook 2017 has seen the value of OECD exports in ICT services increase by 40% in the period 2010-2016. The leading world exporter of IT services is Ireland, with an export value of over 70 billion U.S. dollars in 2016 and a global market share larger than the US, China and India.[17] So there are ample opportunities, also, for smaller European countries.

If successful, Bulgaria stands to:

- Prepare workers for the professions of the future and empower disadvantaged and vulnerable social groups, provided that adequate attention is paid to education, vocational skills and industry-driven training, backed by wider stakeholder engagement, new business models and community-driven initiatives.
- On account of improved labour productivity, be able to provide better wages and higher living standards to Bulgarian employees and indirectly slow down the diaspora of skilled people to other EU countries;
- Be better prepared to benefit from opportunities in the growing global markets for digitalised goods and services, and improve the manufacturing sector's position in global markets in the manufacturing industries;
- Encourage and support increasing investments in innovation and allow for companies to explore new product niches using state-of-the-art technologies.
- Will contribute to improving Bulgaria's position in global value chains. It could benefit from the near-shoring trends away from China that are likely to emerge following the COVID-19 crisis.

1.2 System definition and boundaries

1.2.1 Demarcation of the thematic area

The thematic focus of the Bulgarian Industrial Transition review concerns the linkage between Mechatronics and the Bulgarian ICT sector in order to open up new pathways for digitalisation in manufacturing and society. The reinforcement of this linkage can play a role to boost economic performance and create a platform for wider digitalisation in other areas such as green tech, telemedicine and tele-education. The government strategies that particularly impact these thematic areas and can trigger necessary transitions are the closely related digitalisation, Industry 4.0 and education policies. Mechatronics is a priority area of the Bulgarian RIS3 strategy, which has four priority areas that are described in more detail in section 2.1. below. The national Industry 4.0 Strategy of 2019 also covers the digitalisation of manufacturing, which in part contains

[15] The focus on digitalisation is also in keeping with the EU Digital Strategy, published in early 2020 (European Commission (2020), Shaping Europe's digital future, COM(2020) 67 final, https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_3.pdf)

[16] Data from Statista, retrieved 7 April 2020: https://www.statista.com/markets/418/topic/483/it-services/

[17] OECD (2017), *OECD Digital Economy Outlook 2017*, OECD Publishing, Paris, https://doi.org/10.1787/9789264276284-en.

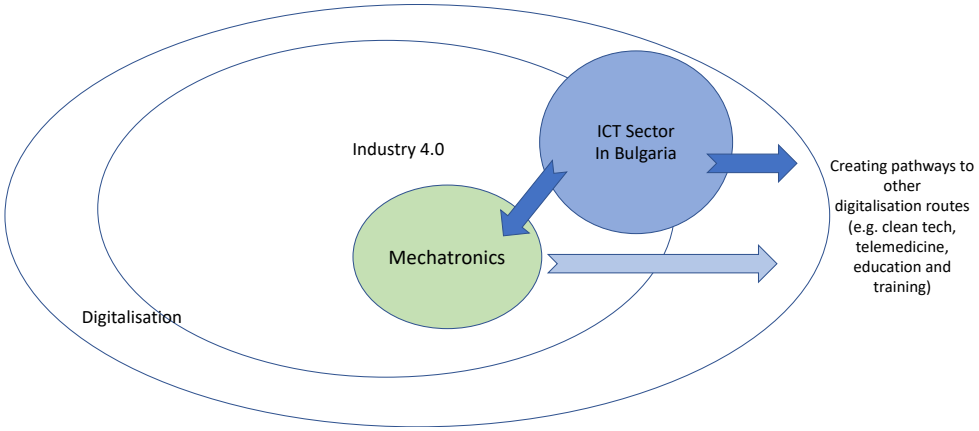
mechatronics. Thus, the thematic focus of the POINT review is at the heart of government and business priorities in Bulgaria[18].

According to the international journal Mechatronics, 'Mechatronics is the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes. It relates to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control'.[19] With the advancement of technology, the technological demarcation of the concept has broadened and can include the combination of robotics, electronics, telecommunications, system controls and computer sciences. The Factories of the Future multi-annual roadmap states that mechatronic systems do not only interface with materials, parts and products, they also cooperate safely with factory workers and communicate with other systems in the factory. Also, they connect to manufacturing execution and monitoring systems on a higher factory and management level. Hence manufacturing systems are becoming smarter in order to generate high value (quality, productivity) while consuming less energy and generating less waste.[20]

Thus, mechatronics is not a business sector with a clearly defined NACE codes, but rather a technology domain that has an impact on multiple sectors. Nevertheless, there are a number of manufacturing sectors that predominantly rely on mechatronics, in Bulgaria and elsewhere. Research, innovation and upgrading production to higher levels of productivity in these domains are closely linked to Industry 4.0 technology development as well as further digitalisation. International reports on Industry 4.0[21] take quite a wide and varied definition of Industry 4.0 and approach it from a technological perspective mostly, not a sectoral one. Also used for industrial innovation policy strategies are the terms Industrial Modernisation, Industrial Digitalisation and Factories of the Future. In recent years, the elements of environmentally sustainable production and skills development have become a prerequisite for such industrial strategies, which are captured in the Industrial Modernisation concept. Today the concept of mechatronics is often used by Higher Education Institutions, demarcating fields of study for their graduates.

The following figure depicts the interaction of the chosen thematic priorities in this Industrial Transition review. The focus is on Mechatronics and the drivers for transition come from the Bulgarian ICT sector and the government's Industry 4.0 and digitalisation strategies.

Figure 1 Potential pathways for desired industrial transition



[18] In the early phase, the Bulgarian Industrial Transition review started off with a broader thematic focus which also included cleantech, the digitalisation of Agriculture as well Healthy living and biotechnology. As these involve quite different stakeholders and value chains, it was agreed to narrow down the focus of the review to Mechatronics and its interaction with digitalisation. Nevertheless, key challenges that all these thematic areas face are similar: an insufficient quality of education, low levels of digitalisation and a shortage of (skilled) labour (see section 1.4).

[19] https://www.journals.elsevier.com/mechatronics

[20] EFFRA, (2013), Factories of the Future, Multi-annual roadmap for the contractual PPP under Horizon 2020, European Commission, Brussels.

[21] See for instance OECD (2017), *The Next Production Revolution: Implications for Governments and Business*, OECD Publishing, Paris, https://doi.org/10.1787/9789264271036-en; EU Automation (2018), 4.0 Sight, Digital Industry around the World, www.euautomation.com; World Economic Forum, (2018), The Readiness for the Future of Production, Geneva, Switzerland; Plattform Industrie 4.0, (2019), Industrie 4.0 gestalten. Souverän. Interoperabel. Nachhaltig., BMWI, Fortgangsbericht 2019.

1.2.2 The thematic area in Bulgaria

The Bulgarian RIS 3 defines mechatronics as including the following two-digit NACE codes: 26. Manufacture of computer, electronic and optical products; 27. Manufacture of electrical equipment; 28. Manufacture of machinery and equipment n.e.c.; 29. Manufacture of motor vehicles, trailers and semi-trailers; 30. Manufacture of other transport equipment; 62. Computer programming, consultancy and related activities; 63. Information service activities; 72. Scientific research and development. Two of the sub-sectors actually coincide with ICT (NACE codes 62 and 63, as well as 72). After a review of NACE four-digit codes, this analysis has included in mechatronics the Manufacture of other transport equipment sector (NACE code: 30), which could utilise mechatronics within its manufacturing process, but also in the goods that it produces. At the same time, the analysis excludes Architectural and engineering activities; technical testing and analysis (NACE code 71), due to the focus on the provision of services and consultancy closer to the architectural field rather than the mechatronics sector (**Table 1**).

Table 1 A snapshot of the Mechatronics and the ICT sectors in Bulgaria

Scientific Fields	Technological Fields (Relevant Patents Classes)	Products Artefacts and or Services	Market Actors (Relevant NACE codes)	State Actors
Mechatronics Physical sciences, Chemical sciences Electrical engineering, electronic engineering, information engineering, Mechanical engineering, Chemical engineering, Materials engineering, Nano technology	G02, G03, G04, G06, G08, G11, H04 F01, F02, F21, F24, F26, G05, H01, H03, H05 A62, B04, B30, F03, F04, F23, F25	Electronic components and boards Consumer electronics Measuring, testing and navigating equipment; watches and clocks Irradiation, electromedical and electrotherapeutic equipment Optical instruments and photographic equipment Magnetic and optical media Electric motors, generators, transformers and electricity distribution and control apparatus Batteries and accumulators Wiring and wiring devices Electric lighting equipment Domestic appliances Other electrical equipment	2611 - Manufacture of electronic components 2612 - Manufacture of loaded electronic boards 2620 - Manufacture of computers and peripheral equipment 2630 - Manufacture of communication equipment 2640 - Manufacture of consumer electronics 265 - Manufacture of instruments and appliances for measuring, testing and navigation; watches and clock 266 - Manufacture of irradiation, electromedical and electrotherapeutic equipment 2670 - Manufacture of optical instruments and photographic equipment 268 - Manufacture of magnetic and optical media 2711 - Manufacture of electric motors, generators and transformers 2712 - Manufacture of electricity distribution and control apparatus 272 - Manufacture of batteries and accumulators 273 - Manufacture of wiring and wiring devices 274 - Manufacture of electric lighting equipment 2751 - Manufacture of electric domestic appliances 2752 - Manufacture of non-electric domestic appliances 2790 - Manufacture of other electrical equipment 28 - Manufacture of machinery and equipment nec 29 - Manufacture of motor vehicles, trailers and semi-trailers 3011 - Building of ships and floating structures 3012 - Building of pleasure and sporting boats	**Government ministries and agencies**: Council of Ministers, Council for Smart Growth Ministry of Economy, General Directorate "European Funds for Competitiveness", Bulgarian SME Promotion Agency Ministry of Education and Science, Executive Agency Operational Programme 'Science and Education for Smart Growth' Ministry of Transport, Information Technology and Communications The Ministry of Regional Development and Public Works Ministry of Finance Ministry of Environment and Water Ministry of Labour and Social Policy **Finance**: Operational Programme 'Innovation and Competitiveness' Operational Programme 'Science and Education for Smart Growth' Operative Programme Transport and Transport Infrastructure

			302 - Manufacture of railway locomotives and rolling stock 303 - Manufacture of air and spacecraft and related machinery 309 - Manufacture of transport equipment nec 331 - Repair of fabricated metal products, machinery and equipment 6201 - Computer programming activities 6202 - Computer consultancy activities 6203 - Computer facilities management activities 6311 - Data processing, hosting and related activities 7219 - Other research and experimental development on natural sciences and engineering	National Science Fund National Innovation Fund Fund Manager of Financial Instruments in Bulgaria Horizon Europe EIB EBRD BDB Green Deal Investment Plan Centres for Vocational Excellence Just Transition Fund Recovery and Resilience Plan **Public Research**: BAS, AA, Sofia University, Sofia Technical University **Clusters and Innovation Infrastructure**: Enterprise Europe Network, BESCO, BASSCOM Cluster Mechatronics and Automation Automotive Cluster Bulgaria
ICT- Manufacturing Mathematics, Computer and information sciences	A44, A46, A61(без A61K), A63, G01, G07, G09, G12, G10, B02, B03, B06, B07, B08, B81, B82	Computers and peripheral equipment Communication equipment	3000 – Office, accounting and computing machinery 3130 – Insulated wire and cable 3210 – Electronic valves and tubes and other electronic components 3220 – Television and radio transmitters and apparatus for line telephony and line telegraphy 3230 – Television and radio receivers, sound or video recording or reproducing apparatus, and associated goods 3312 – Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment 3313 – Industrial process equipment	

ICT-Services Mathematics, Computer and information sciences	B64	Motion picture, video and television programme production services, sound recording and music publishing Programming and broadcasting services Telecommunications services Computer programming, consultancy and related services Information services	5151 – Wholesale of computers, computer peripheral equipment and software 5152 - Wholesale of electronic and telecommunications parts and equipment 6420 – Telecommunications 7123 - Renting of office machinery and equipment (including computers) 72 - Computer and related activities	Green Synergy Cluster Cluster Green Transport Cleantech Bulgaria Cluster for Horizontally Integrated Technologies and Systems Digital National Alliance ICT Cluster Industrial Cluster Srednogorie **Higher Education and Vocational Training** Technical Universities in Sofia and in the Country Sofia University Bulgarian Academy of Sciences Private educational and vocational training institutions and academies

In order to create employment with higher added value and greater labour productivity, the manufacturing industries in Bulgaria need to modernise and invest in digitalisation in particular. While Bulgaria has a relatively strong and growing ICT services sector (see below), other Bulgarian sectors that need ICT as an enabling technology have hardly benefited from this.

Sectors that have shown a potential for growth in more high value segments of the Bulgarian economy are ICT-related sectors. The strongest growth is seen in the sub-sector of Computer Programming, consultancy and other IT services.[22] However, in the stakeholder consultations a picture emerged that this sub-sector is predominantly reliant on the outsourcing of basic IT-coding work for foreign companies, for which companies often recruit university students before finalising their first degrees. The sustainability of IT services relying on cost-driven outsourcing is often questioned, as in the long-run services of this type can easily move to lower cost locations. However, this pool of IT firms provides a fertile ground for a growing number of spin-offs that can emerge as strong export hubs and develop links with other sectors of the local economy. Aiding this transition might be a viable path that could move Bulgarian industry up the value chain.

The ICT sub-sector *Manufacture of computer, electronic and optical products* tripled in revenue between 2010 and 2018. This signifies a positive trend in ICT and increased recognition of Bulgaria as a location for development of R&D-intensive and innovative technologies, not only in software but also in hardware.[23]

The ambition is to mobilise the ICT service assets in Bulgarian companies and public institutions to support the connection between software with electronic engineering knowledge and skills, in value chains that have a high dependency on mechatronics, now and in the future.

The total number of registered companies falling within the sector Mechatronics, as defined in this study[24], in Bulgaria is 17,000[25]. However, data spanning at least a three-year period from 2014-18 is only available for some 8,355 of these companies[26]. For the period 2014-2018, the operating revenue for the Manufacture of machinery and equipment n.e.c. is highest in the Mechatronics sector (EUR 1.8 billion), followed by the Manufacture of machinery and equipment sector (EUR 1.6 billion.). The smallest sectors in terms of operating revenue are Information service activities (EUR 168 million) and Scientific research and development (EUR 231 million.).

The geographical scope of this review is predominantly national, covering all regions of Bulgaria. Both mechatronics and the ICT service sector are mostly concentrated in the capital of Sofia. However, manufacturing companies are more widely spread throughout the country. In terms of policy impact on this thematic area, improvements and modernisation and a transition to a new production mode rely mostly on national policies covering digitalisation, R&I support and education and skills, driven by EU funding and programmes.

Bulgaria has considerable regional imbalances, which are evident in the allocation of R&D funding in the country. This situation has shown a worsening trend for most regions in Bulgaria according to the 2019 Regional Innovation Index. While improving the rate of digitalisation can have an impact on the entire Bulgarian society across all regions, the focus on boosting manufacturing sectors will mostly benefit regions with a manufacturing base and skill pool.

According to the Bulgarian S3, Mechatronics has been designated as the primary priority area for the North West, North Central and North East regions of the country. It has been a key thematic area also in the South Central and South East regions. Even though companies in the sector are widely dispersed across the country, the sector is concentrated in Sofia in terms of operating revenue. The Sofia city alone represented 44% of the turnover of the entire mechatronics sector in 2018 (EUR 3.9 billion.).

[22] ARC Fund, Innovation BG, Innovation and Economic Growth, Sofia, 2019, pages 53-56

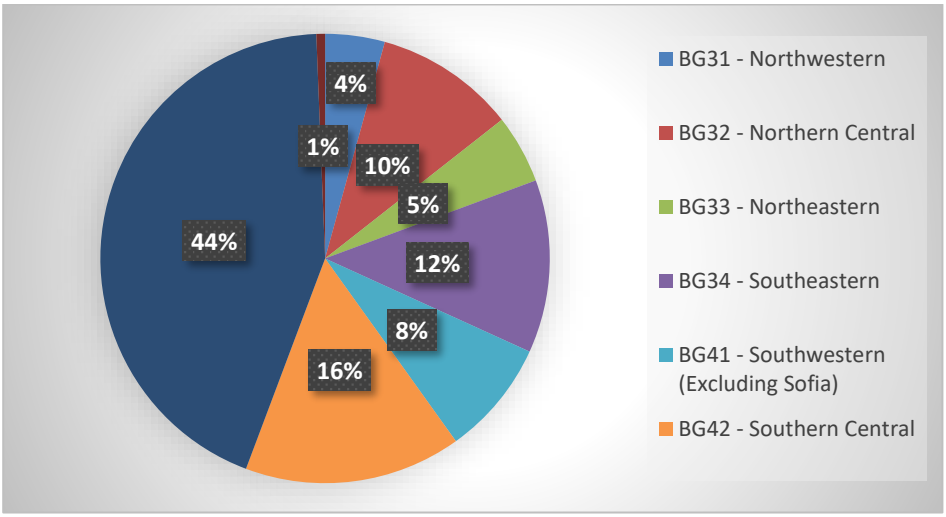
[23] ARC Fund, Innovation BG, Innovation and Economic Growth, Sofia, 2019

[24] For the needs of this review mechatronics has been defined to include the following NACE 2 sub-sectors: 26. Manufacture of computer, electronic and optical products; 27. Manufacture of electrical equipment; 28. Manufacture of machinery and equipment n.e.c.; 29. Manufacture of motor vehicles, trailers and semi-trailers; 30. Manufacture of other transport equipment; 62. Computer programming, consultancy and related activities; 63. Information service activities; 72. Scientific research and development.

[25] As provided in the Orbis database of Bureau van Dijk.

[26] This selection allows for more accurate estimation of the size of the sector. The selection process has also included review if key industrial players are excluded from the selection.

Figure 2 Operating Revenue of the Mechatronics sector in 2018 by NUTS 2 Region in Bulgaria



Source: Authors' calculations based on data from the Orbis database of Bureau van Dijk.

1.2.3 Bulgaria's current position in the thematic area

Despite its relatively strong ICT sector, which is concentrated in the capital city region of Sofia, overall digitalisation in Bulgaria is at a very low level according to the Digital Economy and Society Index (DESI) produced by the European Commission[27]. The low level of digitalisation in Bulgaria has negative effects on the position of mechatronics as it is highly dependent on the digitalisation of its companies, its overall competitiveness (e.g., ability to take advantage of digital commerce) and its work force.

Bulgaria has initiated many policy initiatives and strategies in the area of ICT and Industry 4.0, as the following (non-comprehensive) list indicates, but there seems to be no overarching goal interlinking all of the documents, yet:

- National Broadband Development Strategy 2012 - 2020 and Connect Bulgaria: Updated National Broadband Infrastructure Plan for Next Generation Access (NGA)[28]
- National Digital Bulgaria 2015 Programme and Action Plan, the implementation of which has led to significant progress in the development and widespread use of information and communication technologies (ICT)[29]
- The Digital Bulgaria 2025 Programme and Roadmap[30]
- Strategy for Digitalisation of Agriculture and Rural Areas of the Republic of Bulgaria[31]

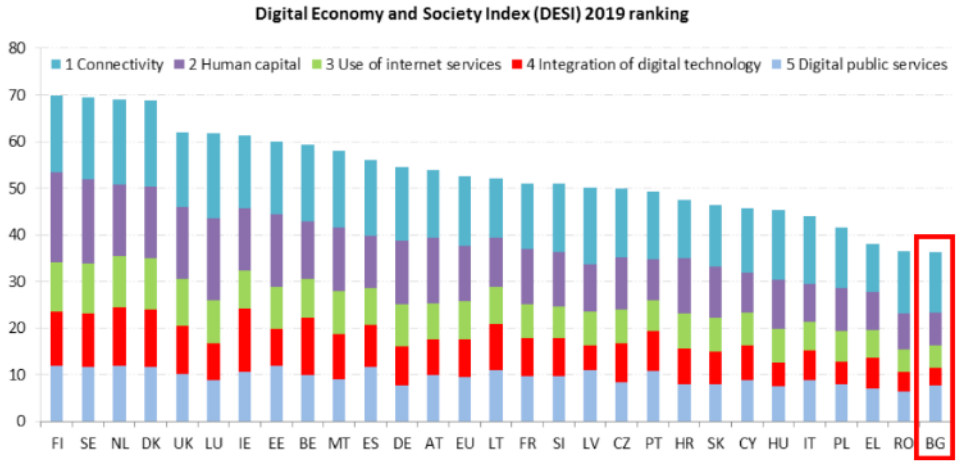
Nevertheless, the country has a very low rank in terms of the main indicators of the DESI index and ranked 28th, the lowest position of all EU countries in 2019.[32] In 2018, Bulgaria occupied 26th position on this same scoreboard. The scores related to connectivity and digital public services were relatively better but still low. Bulgaria scored very low on indicators related to human capital, the use of internet services and the integration of digital technologies. The latter topic is closely related to the present study.

According to the DESI country profile for Bulgaria, companies struggle to take advantage of the opportunities offered by online commerce: 6 % of SMEs sell online (against an EU average of 17 %), 3 % of all SMEs sell across borders, and only 2 % of their turnover comes from the online segment. Although Bulgarians use social media intensively for personal use, only 9 % of companies use it to promote their business, against an EU average of 21 %. Finally, the number of companies with a high-intensity index (using 7-9 technologies of the

[27] European Commission, 2019, Digital Economy and Society Index (DESI), 2019 Country Report Bulgaria. Bulgaria scored last in the EU on the overall Digital Economy and Society Index, as well as in the Integration of Digital Technology sub-index. DESI is a composite index that summarises relevant indicators on Europe's digital performance and track the evolution of EU member states.
[28] Connect Bulgaria: Updated National Broadband Infrastructure Plan for Next Generation Access (NGA), Decision No. 555, 06.08.2020, Council of Ministers, Sofia 2020. [Available in Bulgarian and English]
[29] Adopted by Council of Ministers, Decision No. 953, 16.11.2012. [Available in Bulgarian and in English]
[30] Adopted by Council of Ministers, Decision No. 730, 05.12.2019. [Available in Bulgarian and in English]
[31] Decision No 247 of the Council of Ministers of 02.05.2019
[32] Ibid.

digital scoreboard) account only for 7.81 % of all companies. On a more positive note, 23 % of businesses share information online, against an EU average of 34 %.

Figure 3. Digital economy and society index 2019

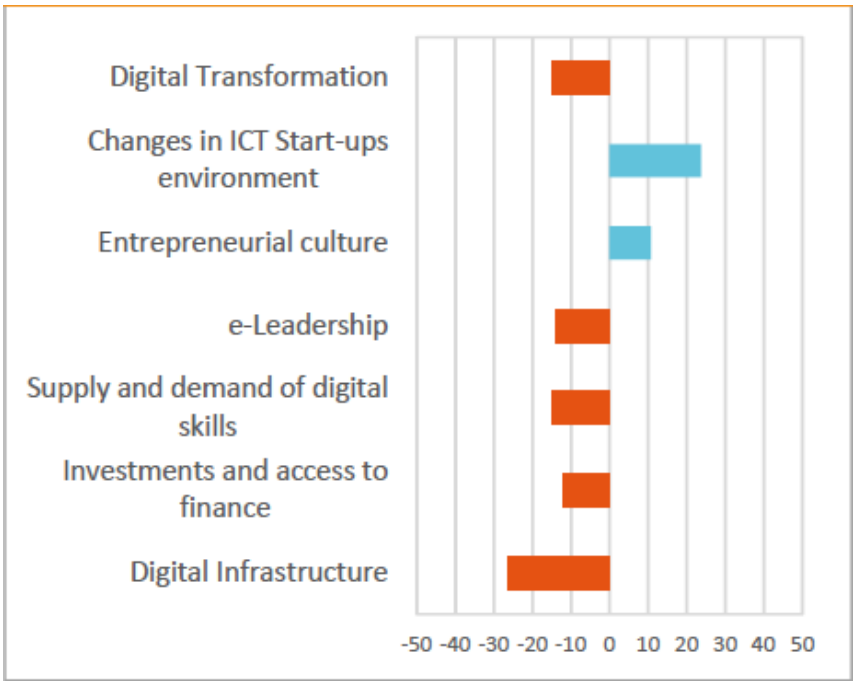


Source: European Commission.

The EU Digital Transformation Scoreboard zooms in on the use of digital technologies that impact competitiveness and industry. This 2018 report showed that a large majority of EU countries had started initiatives to support industrial transition to Industry 4.0. Neither the Bulgaria Industry 4.0 initiative nor any of the other Bulgarian initiatives mentioned above were listed in the 2018 report. Overall, Bulgaria performed below the EU average in five out of seven dimensions, especially digital infrastructure.

In terms of framework conditions for digital transition, Bulgaria has improved its performance in entrepreneurial culture and e-leadership (i.e., training and education available to facilitate the acquisition of digital skills), which is likely to encourage the further development of Bulgaria's thriving ICT start-up environment. But overall, there is need for improvement across all framework conditions.

Figure 4. Bulgaria's performance vs EU average in Digital Transformation Scoreboard, 2018



Source: European Commission.

The World Economic Forum (WEF) Readiness of the Future of Production Report 201833 documents the challenges and opportunities stemming from the interconnection of new technologies. It stresses the importance of the integration of the digital and physical worlds. This challenge is truly global and will affect countries of different industrial development:

'Technologies are transcending the computing capabilities associated with the digital revolution, transforming the physical world through robotics and new methods of production; enhancing human beings physically, mentally, and experientially; and permeating the environment to facilitate greater interconnectivity, monitoring, and efficiency of resource use.' (WEF, page v). Further, recent changes put the competitiveness paradigm of low-cost manufacturing exports as a means for growth and development at risk. (WEF, page vii).

Thus, this is extremely relevant for Bulgaria as its competitiveness at this moment is mostly based on cost-competitiveness (also in the ICT services sector) and is characterised by a broad divide between the physical production sectors and the digital service and production sectors. The WEF distinguishes Leading Countries, Legacy Countries, High Potential Countries/Economies and Nascent Countries. Bulgaria is considered a nascent country and is ranked 40th out of a total of 100 countries in terms of the structure of production (this is, for instance, better than the score for Australia, New Zealand and Ukraine) and 44th in terms of the score for drivers of production. Bulgaria has a relatively good score for sustainable resources (a score of 6.9 out of 10) and the complexity of the structure of production, but very low scores for technology and innovation (4.8), the demand environment (4.3) and the scale of production (3.7).[34]

1.3 Transition endpoint and headline target

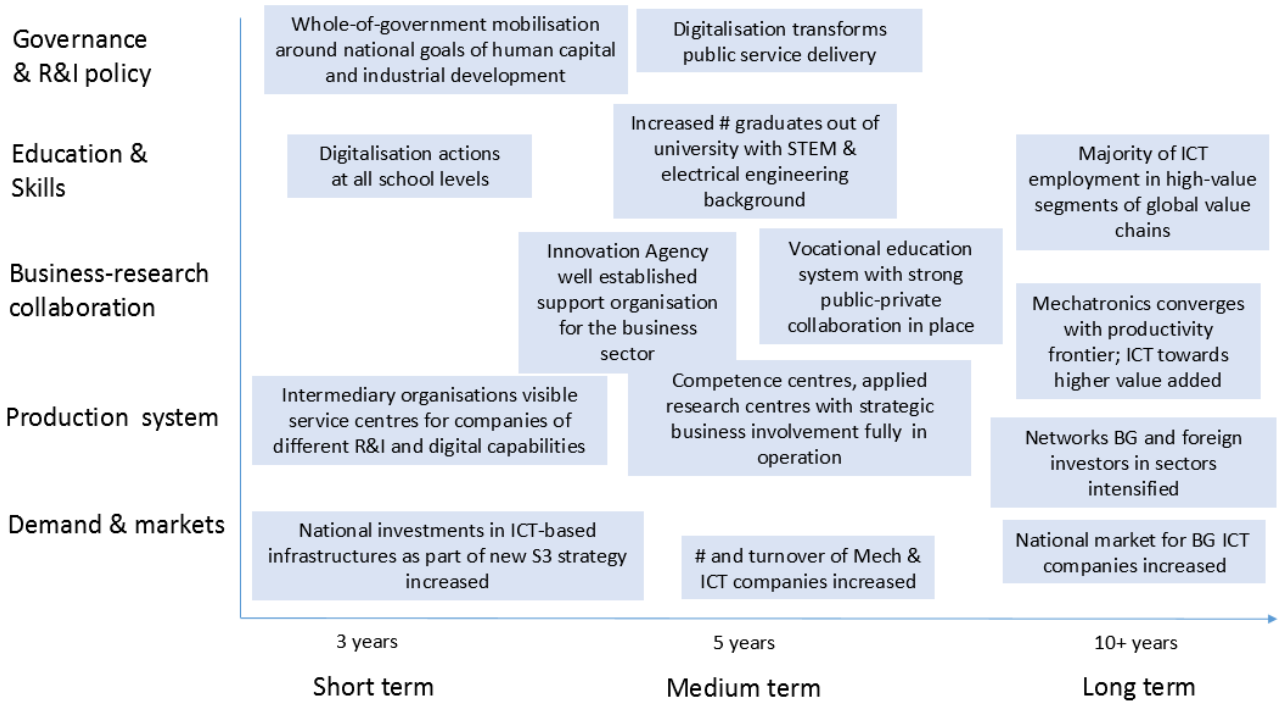
The thematic topic for this review is broad and has implications for several elements of the Bulgarian production and consumption systems. The levels at which ambitions could be formulated at the start of the review were:

1. Governance and policy level with better-aligned policies across portfolios resulting in an overall increase of the public and private funding resources dedicated to the transition and coherent framework conditions, including, where necessary, targeted regulatory changes.
2. Education and skills level: as the shortage of human resources and inadequate levels of skills and education are a major bottleneck, ambitions could be formulated to improve this situation.
3. Businesses: improving productivity, investing in digitalisation, value chain collaboration, entrepreneurship and so on are essentially tasks for the private sector. Ambitions need to be defined in quantitative and qualitative terms for the mechatronics dependent business sectors.
4. Business-to-business and business-to-public research collaboration: as this is at a very low level today, ambitions could be set to intensify those that are beneficial for the mechatronics sector and its digitalisation.
5. Overall, stakeholder coordination across the system needs to be intensified.
6. Demand side: public sector investment and procurement in digital infrastructures, and infrastructures that support green and sustainable growth can play a mobilising role.

The following Figure 5 is a short summary of the possible ambitions in the short, medium and long term, which Bulgarian stakeholders could use to formulate their initial and later update levels of ambition. The Bulgarian government and other stakeholders could in particular use the findings of this POINT review to plan their interventions under the next Multiannual Financial Framework 2021 – 2027, as well as under the Recovery and Resilience Plan.

[33] World Economic Forum, (2018), The Readiness for the Future of Production, Geneva, Switzerland.
[34] See WEF 2018 Country profile for Bulgaria, page 80.

Figure 5. Tentative level of ambition of Bulgaria's industrial transition



Source: Authors

2 Understanding the current state of the system[35]

As noted in the first chapter, the report focuses on the sectors of mechatronics and ICT as trailblazers of the further digitalisation of the Bulgarian economy and society in Europe. Hence, the examined system's geographic boundary coincides with the territorial boundary of Bulgaria. In this chapter the report identifies the key actors in the industrial system within which mechatronics and ICT are embedded, key relations, and the framework conditions within which they operate. It looks into four broad sub-systems (or "functions" that have to be delivered for a functioning industrial system), namely *orientation and planning* (including mostly government functions and key business stakeholders), *resource mobilisation* (with a focus on key knowledge providers and financing instruments), *production* (of goods, services and knowledge) and *consumption or use* (specifically those actors who what is produced in the extant Bulgarian system). The findings in this chapter are based on desk research, in-depth interviews and a stakeholder meeting in Sofia, which involved key actors in Mechatronics and ICT from the public sector, business, intermediaries and consumption[36].

The review, following the POINT methodology, takes a system innovation horizontal policy approach but also zooms in on science, technology and innovation and education issues, as these are core elements of the economy's capacity for change. It builds upon the insights of the current RIS3 of Bulgaria but goes further by using the framing provided by OECD (2015) and Schot and Steinmueller (2018), to map the key departing points for system-wide, transformative change, including changes to the existing knowledge base and technical capabilities, consumer practices and markets, and infrastructure and skills.

2.1 Orientation and Planning

Key factors for transition

There are many factors that influence Bulgaria's orientation and planning capacity but three in particular deserve mention as a framework for better understanding the specific elements presented below:

i. the demands of EU integration and access to EU funds related to the implementation and review of RIS3 and Industry 4.0 in particular have been driving the Bulgarian government's work on orientation and planning. RIS 3, for example, is the first comprehensive innovation strategy at a national level that has included public consultations and specialised input in its development;

ii. the current Bulgarian government's drive towards eGovernment, which has most recently been exemplified by the development of a single cross-governmental working group on digitalisation. The COVID-19 crisis has also underscored the need for more and better digital services throughout government, the economy and society;

iii. the leadership of entrepreneurs and business figures from ICT and mechatronics, who have been at the forefront of market development but have also taken up public positions in, for example, the Council for Smart Growth or the Sofia Tech Park. In addition, there is the external pull of the European market and the desire of Bulgarian companies to gradually move up the value chain in ICT and mechatronics and to participate in clean tech. Bulgaria's economy is highly open, with exports and imports representing more than two-thirds of GDP. More than 60% of Bulgaria's trade has been with the Eurozone members of the EU[37].

Bulgaria is a country with a highly centralised public administration (four-fifths of the public administration employment is in the central government) and a low level of public expenditure (ranking 22nd in the EU), both of which impact orientation and planning capacity. Bulgaria also performs considerably below the EU average in terms of the World Bank's Worldwide Governance Indicators.[38]

[35] The bulk of Chapter 2 was completed in the first half of 2020 and relies on the latest available data then, which often refers to 2018. In the second half of 2020 new data for 2019 appeared, which generally showed further positive developments in all four systems under consideration. However, this new data has not altered the validity of the findings of the analysis.

[36] The meeting was held on 6th of December 2019 in Sofia and was titled *Review of Industrial Transition of Bulgaria: Fact-finding and stakeholder consultation meetings*. The meeting gathered key stakeholders in the Mechatronics and Cleantech, ICT and the Health and Life sectors as defined by the Bulgarian national RIS3.

[37] European Commission (2018), Convergence report 2018. Available online at: https://ec.europa.eu/info/sites/info/files/economy-finance/ip078_en.pdf

[38] European Commission (2018), Public administration characteristics and performance in EU28: Bulgaria, DG Employment, Social Affairs and Inclusion.

Public players and policies

As a parliamentary democracy the ultimate power over public policy in Bulgaria rests with the National Assembly. Yet it is the Council of Ministers, the highest decision-making authority in the executive power, and the separate ministries, which are in the driver's seat when it comes to planning and orientation. Central roles in the governance of industrial transition in Bulgaria in the selected domain for this POINT review would potentially be played by the following authorities (see Figure 6 below):

The **Council of Ministers** (CoM) is responsible for the overall coordination of policies and in particular for smart specialisation through the Council on Smart Growth. The Council of Ministers is also responsible for coordinating the digitalisation inter-ministerial coordination working group. The CoM hosts the Deputy-Prime Minister in charge of all EU funds coordination (including recovery and resilience, just transition, etc.), who oversees also the Unified Management Information System on all operational programmes active in the country. In 2020, the Bulgarian government further strengthened the CoM's role in coordinating the national RIS3 policies by creating the **Agency for Research and Innovation**. The Agency, meant to fulfil one of the enabling conditions of the EC, is intended to oversee the next RIS3 implementation in Bulgaria and will pull together research and innovation resources under a new OP. The OP would aim to support the building of missing and the strengthening of existing horizontal linkages between public and private stakeholders, as well as between national and regional actors.

The **Ministry of Economy** (ME) develops, organises, coordinates and controls the implementation of the state policy in the field of the economy and defines the national innovation policy. It develops and participates in the implementation of the Innovation Strategy for Smart Specialisation 2014-2020, including the coordination of the implementation of the entrepreneurial discovery process as well as the monitoring of the implementation of the strategy. In addition, the Ministry defines the SME, entrepreneurship and cluster policy. It also coordinates the development of the Industry 4.0 strategy. Within the Ministry of Economy, the General Directorate 'European Funds for Competitiveness' is the Managing Authority of **OP 'Innovation and Competitiveness'** (OP IC) and **OP 'SME Initiative 2014-2020'** (SMEI), the two main programmes funding innovation, entrepreneurship and competitiveness of the business sector in Bulgaria. The Ministry of Economy provides national funding predominantly to private enterprises for applied research through the **National Innovation Fund** (NIF), implemented by the **Bulgarian SME Promotion Agency** (BSMEPA).

The **Ministry of Education and Science** (MES) functions as a regulator of the national education system and designs and carries out national science and research policy. The Science and Education for Smart Growth Executive Agency, under the ministry, performs the functions of a Managing Authority of **OP 'Science and Education for Smart Growth'** (OP SESG). MES oversees the functioning of the **National Science Fund** (NSF) which is the main national funding instrument for R&D in scientific organisations and universities. It also supports the research of young scientists, Bulgarian scientific periodicals, and bilateral cooperation with other countries.

The **Ministry of Transport, Information Technology and Communications** (MTITC) is responsible for the Digital Agenda, IT and Communications Policy. It is the managing authority of OP 'Transport and Transport Infrastructure'. The ministry was also responsible for e-government, through its Executive Agency 'Electronic Communication Networks and Information Systems' (EA ECNIS), which successor since 2016 has been the State eGovernment Agency (SEGA). SEGA is also responsible for electronic identification, certification and security, as well as the public information infrastructure and public sector open source code.

Three other ministries could play important roles in orientation and planning related to digitalisation, mechatronics and ICT. The Ministry of Labour and Social Policy manages the Operational Programme Human Resources Development, which supports re-skilling and re-training of the labour force. The Ministry of Agriculture, Food and Forestry is in charge of the Operational Programme Rural Development, as well as the implementation of the Common Agricultural Policy in Bulgaria. OP Rural Development has been instrumental to digitalisation and broadband penetration in rural areas. The Ministry of Regional Development and Public Works manages Operational Programme Growth Regions, as well as the different Interreg programmes, which support Bulgaria's regions.

The **Ministry of Finance** is responsible for the financial oversight of structural fund programmes, through the Directorate 'National Fund', which acts as the Certifying Authority and the Executive Agency 'Audit of European Union Funds', which acts as the Audit Authority. Additionally, the ministry is responsible for the preparing and overseeing the country's budget and for the tax and state aid policy, including in the area of innovation.

The abovementioned institutions are involved in setting up the national strategic and programmatic framework for development of the fields of mechatronics, clean technologies and ICT. The key elements of this framework are presented in Table 2.

Table 2 Linking objectives of current strategies and policy mapping

Strategy /Programme	Responsible institution	Specific goals (as mentioned in the strategy)	Quantitative Targets	Monitoring and Evaluation
Europe 2020: National Reform Program Updated annually as part of the European Semester Process. The latest available edition is of 2019	Ministry of Finance	Developing innovation infrastructure and improving science-business relations and enterprise innovation Improving innovative infrastructure and promoting innovation in enterprises	Impact indicators with current and target values are provided. These are the Europe 2020 Programme targets. Some of the more relevant are: Reducing unemployment rates among youth (aged 15-29) to 7%; Increasing Investments in R&D as % of GDP to 1.5%; Increasing the share of 30-34-year olds with completed tertiary education to 36%.	There is annual monitoring and evaluation within the European Semester framework, in which the Government of Bulgaria responds to the recommendations from the European Commission and the Council.
Bulgaria 2030: National Development Programme	Ministry of Finance	The document sets out three strategic goals - accelerated economic development, demographic boom and reduction of inequalities, for which targeted policies and interventions are envisaged, grouped in five interconnected and integrated development axes - Innovative and Intelligent Bulgaria; Green and Sustainable Bulgaria; Connected and integrated Bulgaria; Responsive and fair Bulgaria; Spiritual and Vital Bulgaria.	Description of the quantitative indicators. Target levels are presented for all indicators. The relevant for this review include: GDP per capita in PPS relative to the EU average, %, baseline 51.2 -> target 75; Digital Economy and Society Index (DESI), 36.2 -> 52.2; Variation in GDP per capita (in PPS) by region, %, 37.5 -> 34; Population (aged 25-64) participating in education and training, %, 2.5 -> 7; Share of low performers in the Programme for International Student Assessment (PISA) (average for the three subjects of the study) 46 -> 25; R&D expenditure, % of GDP 0.8 -> 2.5; Integration of Digital Technology, DESI, %, 18.1 -> 50; Share of high-tech exports in total export, %, 5.9 -> 15; Ultra-fast broadband take-up, DESI, %, 9.7 -> 40;	Same as above. The framework of the European Semester will apply.

Strategy /Programme	Responsible institution	Specific goals (as mentioned in the strategy)	Quantitative Targets	Monitoring and Evaluation
			5G readiness, DESI, %, 0 -> 80.	
Digital Transformation of Bulgaria for the period 2020-2030.	Ministry of Transport, Information Technology and Communications	Vision: By 2030 Bulgaria must have a competitive digital economy and a high standard of citizens, based on knowledge and smart growth. Specific objectives: 1. Deployment of secure digital infrastructure 2. Providing access to adequate technological knowledge and digital skills. 3. Strengthen research and innovation capacity. 4. Unlock data potential. 5. Digitization in favour of a circular low-carbon economy. Improving the efficiency of public administration and the quality of public services.	No quantitative targets set in the strategic document.	No established monitoring and evaluation in the strategic document.
National Strategy for Development of Scientific Research of the Republic of Bulgaria 2017-2030	Ministry of Education and Science	Development, maintenance and effective use of modern scientific infrastructure, balanced by thematic areas and regions, and providing the necessary access to European and international scientific infrastructure Enhancing applied research Thematic Priority Areas for Research include: modern energy sources and energy-efficient technologies; **mechatronics** and clean technology; Health and quality of life. Prevention, early diagnosis and therapy, green, blue and eco-technology, biotechnology, eco-food; Environmental protection. Environmental monitoring. Utilisation of raw materials and bioresources. Purifying and non-waste technologies; **Material science, nano and quantum technologies; Information and communication technologies**; National identity and development. Socio-economic development and management; Promoting applied research and **focusing it on RIS3 priority areas** Encouraging private investment in science	Quantitative indicators for the implementation of the strategy at the three different stages of implementation are provided with baseline in 2015 and targets in 2022, 2025 and 2030 respectively, including: R&D expenditure, % of GDP 0.96 -> 2.40 -> 3.00 -> 3.30; R&D personnel in FTE, % of the labour force: 0.6 -> 0.8 -> 1.0 -> 1.5; number of PhD graduates in the respective year 1442 -> 1600 -> 2000 -> 2200; attracted resources from the EU framework programmes for RTDI per capita, EUR: 1.4 -> 3 -> 7 -> 15.	The implementation of the strategy is monitored by the National Assembly and the International Control Board for the implementation of the strategy. Monitoring and evaluation is linked to the Bulgarian S3, as some of the indicators coincide. An International Supervisory Board is established for specialised oversight over the implementation of the strategy.

Strategy /Programme	Responsible institution	Specific goals (as mentioned in the strategy)	Quantitative Targets	Monitoring and Evaluation
		Significant intensification of the links between science and education, business, government and society in general		
Innovation Strategy for Smart Specialisation 2014-2020	Ministry of Economy	Increase investment in science and research up to 1.5% of GDP Focusing investments to develop innovation potential in identified thematic areas **Support for accelerated absorption of technologies, methods, etc., improving resource efficiency and implementation of ICT in enterprises across the industry** Science-business collaboration Entrepreneurship development **Support for clusters and innovative infrastructure** Internationalisation Creating an adequate business environment conducive to innovation Thematic priority areas for innovation and export-oriented economy: **Information and communication technologies and informatics** **Mechatronics and Clean Technology** Healthy living and biotechnology New technologies in the creative and entertainment industries	The key target and progress indicators have been focused on the European Innovation Scoreboard. The overall goal is for Bulgaria to move from the group of modest to the group of moderate innovators. In relation to this the S3 defines indicative growth rates in the sub-indicators of the EIS. These are then further disaggregated into a detailed monitoring plan.	For monitoring purposes, monitoring is envisaged by means of a report, which is summarised by the ME each year, in conjunction with the partner networks at central and regional level, as well as a summary of the received proposals from ISIS stakeholders. Initially, the report is submitted to the National Innovation Council and the National Research and Innovation Council for discussion by all stakeholders. After discussing and clarifying whether or not there is a need for changes in ISIS, the Minister of Economy submits the report for consideration by the Council for Smart Growth.
National Strategy for the Promotion of Small and Medium-Sized Enterprises 2014-2020 There is a draft National Strategy	Ministry of Economy	Provide an appropriate regulatory and administrative framework for SMEs by applying the "Think Small First" principle Establishing a responsive public administration that is most responsive to the needs of SMEs	Quantitative indicators are provided for every aspect of the Small Business Act. Some of the relevant indicators by 2020 include for example: Additional 102 000 SMEs start training of their personnel; Additional 2400 SMEs start online sales of their products.	No procedure for M&E is present in the current and in the draft SME strategy.

Strategy /Programme	Responsible institution	Specific goals (as mentioned in the strategy)	Quantitative Targets	Monitoring and Evaluation
for Small and Medium-Sized Enterprises for 2021 - 2027		Facilitating SMEs' access to public procurement Improving SMEs' access to finance Ensuring and maintaining a legal and economic environment that facilitates timely payments on commercial transactions Opportunity ("second chance") for entrepreneurs in difficulty to finish their old business and start a new business The draft Strategy for SMEs 2021 – 2027 has three goals (competitiveness, specialisation in high-tech production and knowledge-intensive services, and regional cohesion) and six areas of intervention (entrepreneurship, access to markets, access to financing, digitalisation and skills, better regulation, and green industry)	The draft strategy contains key indicators under each of its three strategic priorities.	
Strategy for Digitalisation of Agriculture and Rural Areas of the Republic of Bulgaria	Ministry of Agriculture and Foods	**Collaboration between farmers, universities, research organisations, ICT businesses**, state and local authorities Support for **start-ups and entrepreneurs in the ICT sector and in agriculture and agri-food businesses** Development of existing **digital innovation hubs** in agriculture that provide a full range of services tailored to the real needs of the concerned hub stakeholder The total estimate of the necessary financial resources for the development of the research activity and stimulation of the partnership between science and business is about 22 million BGN.	Only description of the quantitative indicators	The implementation of the Strategy is a commitment of the Ministry of Agriculture, Food and Forestry. The implementation of the Strategy will be implemented through detailed three-year plans with specific actions, financial parameters, timelines and indicators.
Concept for digital transformation of the Bulgarian industry (Industry 4.0)	Ministry of Economy	Areas of intervention: business digitalisation, export orientation and competitiveness Strengthening the link between science and business in the country and accelerated integration of Bulgaria into European and international programmes, initiatives and networks related to the	Only description of the quantitative indicators is provided. The key suggested indicators are from the Digital Economy and Society Index (DESI) and the World Economic Forum Competitiveness Index.	No procedures for M&E

Strategy /Programme	Responsible institution	Specific goals (as mentioned in the strategy)	Quantitative Targets	Monitoring and Evaluation
		development and implementation of Industry 4.0.		
Strategy for Effective Implementation of Information and Communication Technologies in Education and Science in the Republic of Bulgaria (2014-2020)	Ministry of Education and Science	Modernisation and transformation of the fields of education and science through the means of ICT Developing a single modern ICT environment for education, science and innovation Introducing integrated digital governance in all fields of education and science and automating the administrative work of teachers, scholars and teachers Priority development of publicly accessible, universal and compatible (standardised) electronic content Introducing a national external assessment of students 'digital competencies in completing primary education and certification of students' IT skills	Description of the quantitative indicators is provided but without a timeline for achievement.	Not explicitly developed.
The concept for promoting the training of software professionals	Ministry of Education and Science	To create suitable conditions for training of about 30,000 software specialists additionally in the public universities offering the highest quality of education in this field	The only indicator is as follows: increase of the number of software professionals trained at the level of higher education, VET and informal education	The Ministry of Education and Science organises, coordinates, monitors and controls the implementation of the concept. The Minister of Education and Science will submit a progress report annually to the Council of Ministers. In order to improve communication between stakeholders in software education - employers, higher education institutions, secondary schools and central and local administrations with the Minister of Education and Science, it is recommended to establish an advisory body - the Software Education Council.
Strategy for Development of Higher Education in the Republic of Bulgaria 2014 - 2020	Ministry of Education and Science	Built-up a sustainable and effective **link between higher education and the labour market, and achieved dynamic compliance of demand and supply of specialists** with higher education	The expected results are described without any quantification or a period for achievement. The Action Plan consists of a list of indicators measuring the achievement of objectives, deadlines and source of funding.	No procedure for M&E

Strategy /Programme	Responsible institution	Specific goals (as mentioned in the strategy)	Quantitative Targets	Monitoring and Evaluation
		Promoted **research activities in HEI** and the development of innovation-oriented towards the market economy Expanded and strengthened network **for lifelong learning; broad application of the various electronic forms for distance learning**		
Strategy for the Development of Vocational Education and Training in the Republic of Bulgaria 2015-2020	Ministry of Education and Science Ministry for Labour and Social Policy	Optimising the school network Defining "protected" professions Increasing the attractiveness of vocational education and training Ensuring the quality and efficiency of vocational education and training Improving access to vocational education and training Increasing the involvement of all stakeholders in the vocational education and training system	Only a set of qualitative indicators is provided. Apart from the Strategy, the Action Plan 2015-2017 consists of both quantitative and qualitative indicators.	A National Strategic Group is set up to monitor, control and report on the implementation of the VET Strategy.
National strategy for lifelong learning 2014 – 2020	Ministry of Education and Science	A step forward to a new educational approach and innovations in education and training Increasing the quality of education and training Ensuring the educational environment for equal access to lifelong learning and for active social inclusion and active citizen participation Promoting education and training aligned to the needs of the economy and changes in the labour market	Bulgaria 2020 targets are provided for every quantitative indicator by area of impact.	The procedure for M&E and the role of the administrative bodies involved are presented
National Roadmap for Scientific Infrastructure 2017-2023	Ministry of Education and Science	Development of research Sustainable development of scientific infrastructures by 2023 Diagnostic examination of scientific infrastructures and equipment Identification of methodology and procedures for the evaluation of all existing and future scientific infrastructures seeking access to the National Roadmap Research Excellence	No quantitative indicators	The main implementation of the Roadmap will be subject to ongoing national and international monitoring and evaluation. It will include a general overview of policy implementation at national level, as well as corrective actions and opportunities to introduce new tools and schemes. The NSF will organise an independent external evaluation every two years, incl. surveys and cost-benefit analysis of the regional and national economy.

Strategy /Programme	Responsible institution	Specific goals (as mentioned in the strategy)	Quantitative Targets	Monitoring and Evaluation
		Integration of scientific infrastructure into the European one Thematic Areas: -Physics, Materials Science and Engineering -Medical and agro-biological sciences -Social Sciences and Humanities - E-infrastructure for multidisciplinary research.		A new Standing Committee will be set up for joint monitoring as an advisory body to the Minister of Education and Science
National scientific programmes	Ministry of Education and Science	The National Science Programmes aim to create conditions for seeking solutions to current and significant societal challenges related to environmental, technological, cultural-historical, ethical, health, economic and other challenges, as well as stimulating young scientists in the country. The programmes have been developed in line with the sectoral policies of a number of ministries. The scientific activities are determined after agreement has been reached between the higher education institutions and the scientific organisations in Bulgaria for the joint implementation of the goals set in the programmes. National Science Programmes: 'Information and Communication Technologies for a Digital Single Market in Science, Education and Security' 'Low Carbon Energy for Transport and Household' (EPLUS) 'Environmental Protection and Reduction of the Risk of Adverse Events and Natural Disasters' 'Healthy foods for a strong bioeconomy and quality of life' "Cultural and Historical Heritage, National Memory and Social Development" 'eHealth in Bulgaria' (eHealth) "Reproductive biotechnology in animal husbandry in Bulgaria"	Some of the programmes include quantitative indicators; in others, only a description of the results is provided	No procedure for M&E

Strategy /Programme	Responsible institution	Specific goals (as mentioned in the strategy)	Quantitative Targets	Monitoring and Evaluation
		"Development of methodology for the introduction of NAT technology for the diagnosis of donated blood in the transfusion system of the Republic of Bulgaria" Peter Beron-Science and Innovation with Europe " "High-level Research and People for the Development of European Science" (VIHRN) "Young Scientists and Postdoctoral Fellows"		
National Strategy for Active Life of the Elderly in Bulgaria (2019-2030)	Ministry of Labour and Social Policy	The National Strategy for the Active Life of the Elderly should address the challenges facing the aging population and support policy-making, action and social programming in related fields, including digital literacy and ICT penetration.	Only description of the quantitative indicators The Action Plan provides target values for some of the indicators	An evaluation will be carried out every four years from the planned period (2019 - 2030) A final report on the implementation of the Strategy will be prepared by the MLSP at the end of the planning period in order to take into account the achievement of the objectives set.
eGovernment Development Strategy in the Republic of Bulgaria 2019 - 2023	Ministry of Transport, Information Technology and Communications	1. Providing quality, efficient and easily accessible electronic services for citizens and businesses; 2. Transforming administration into digital administration by integrating information processes; 3. Promotion, access and participation.	Only description of the quantitative indicators	The procedure for M&E and the role of the administrative bodies involved are presented

Source: Applied Research and Communications Fund based on a review of the official documents

Most of the relevant policy documents have been geared towards the adoption in Bulgaria of different EU policy priorities, very often lacking strong local support capacity. Many consulted stakeholders have noted that Bulgarian strategies often remain on paper, as ministries and government agencies struggle to provide sufficient capacity and resources to effectively implement them. This is further exacerbated by the lack of a strong evaluation framework and culture outside of the obligatory monitoring and evaluation related to the implementation of operational programmes. This has led to a natural concentration of focus among the different strategic and programmatic documents towards the funding priorities of EU operational programmes. In fact, the only regular policy monitoring exercise is the National Reform Programme, which is updated annually as part of the European Semester mechanism. Consequently, such concentration has led to the overlapping of governance structures of strategic documents as they have sought to converge under the leadership of the Council of Ministers. Thus, for example, after many years of the decentralised development of often competing or unrelated eGovernment and digitalisation initiatives under different government bodies, the Council of Minsters convened an all-encompassing working group on digitalisation in the second half of 2019.

At a national level, Mechatronics and IT/ICT have been defined as thematic or vertical priorities within the RIS3 strategy set out for 2014-2020. RIS3 also prioritises digitalisation as a horizontal priority for all sectors. RIS3 has four thematic priority areas:

- Mechatronics and Clean Technologies
- Informatics & ICT
- Industry for healthy life-style and bio-technologies
- New Technologies in the creative and recreational industries

The first priority area in particular coincides with the thematic area of this POINT review, albeit the focus of this review is on Mechatronics, with the potential to create a new technological pathway towards Clean Technologies in the future.

A recent review of the progress of the RIS3 in Bulgaria showed that, in terms of the implementation of the RIS3 strategy up to 2018, the largest share of the funding is dedicated to the thematic area '*Mechatronics and Clean Technologies*' (38%), followed by *Informatics and ICT* (26%), *Healthy Living and Biotechnology Industries* (22%) and finally *New Technologies in the Creative and Recreational Industries* (14%).[39]

The broader theme of digitalisation is a key theme in Bulgaria's new Industry 4.0 Strategy. This Industry 4.0 strategy document seems to take a different direction than the RIS3 strategy and its priorities. It is surprising, however, that while the strategy shows a good understanding of the key topics in the international discussion on Industry 4.0, the subsequent elaboration of the strategy seems to focus solely on the digital side of the equation, and less so on the physical engineering side. This might have something to do with the recent policy push to prioritise digitalisation as a national strategy across all government bodies. The Bulgarian government has established a digitalisation policy working group, which is coordinated by the Council of Ministers.

Box 2. Industry 4.0 and digitalisation in Bulgaria

Industry 4.0 is a concept launched around 2010 in Germany as part of the government's High-Tech Strategy, a long-term strategy to boost research and innovation (see https://www.bmwi.de/Redaktion/EN/Dossier/industrie-40.html) for the German economy and society. Industry 4.0 entails the closer inter-connection of automation and data exchange (digital technologies) with manufacturing technologies and processes, leading to cyber-physical systems that can enhance the productivity and functionalities of products and services. In its early years the concept was mostly used to describe the technological challenges and opportunities of bringing together these digital and mechanical production systems. In later years the social and societal implications of Industry 4.0 are more to the foreground.

The concept took off outside Germany and gradually widened its scope and labelled as smart (or advanced) manufacturing or referring to the location of production: smart factories. European Industry Platforms such as the European Factories of the Future Research Association (EFFRA) were set up to bring together businesses and develop joint research and innovation agendas to foster innovative manufacturing. In the UK the related strategy for Industry 4.0 was labelled as the Made Smarter initiative (see https://www.madesmarter.uk). The

[39] S3 Annual Implementation Report 2018. The Ministry of Economy has provided the report upon request. The report is not publicly available.

last few years efforts to support Industry 4.0 and smart manufacturing are inseparable from ensuring environmentally sustainable production processes for the future.

There are many different ways to list the technologies that are included in the Industry 4.0 concept and this list is expanded as new technologies are introduced. EU Automation[40] lists the 'big nine' technologies in Industry 4.0 as social media; big data & analytics, cloud technologies, Internet of Things, mobile devices, robots and automated machinery, cyber security solutions, 3D printing and Artificial intelligence. The UK Made Smarter review of 2017 identified the group of Industrial Digital Technology families as follows[41]:

* Artificial intelligence, machine learning and data analytics,

* Additive manufacturing,

* Robotics and automation,

* Virtual reality and augmented reality,

* The Industrial Internet of Things (IIoT) and connectivity (5G, LPWAN, etc.)

This national review expects that these technologies will impact all possible sectors and has elaborated extensive impact studies for UK's largest industries: construction, food and drink, pharmaceuticals and aerospace.

While Industry 4.0 focuses on manufacturing, digitalisation is a much more inclusive concept as it encompasses all aspects of economy and society (e.g., education and health care), including the government sector and civil society.

Source: Authors

The Industry 4.0 Strategy document of the Ministry of Economy of Bulgaria sets out to promote:

- Artificial Intelligence in industry, inspired by the 2018 European Commission AI Strategy;
- Setting up of Digital Innovation Hubs;
- Providing tax credits for companies to invest in R&D (equipment);
- Supporting human development in ICT (e.g., National IT career training programme).

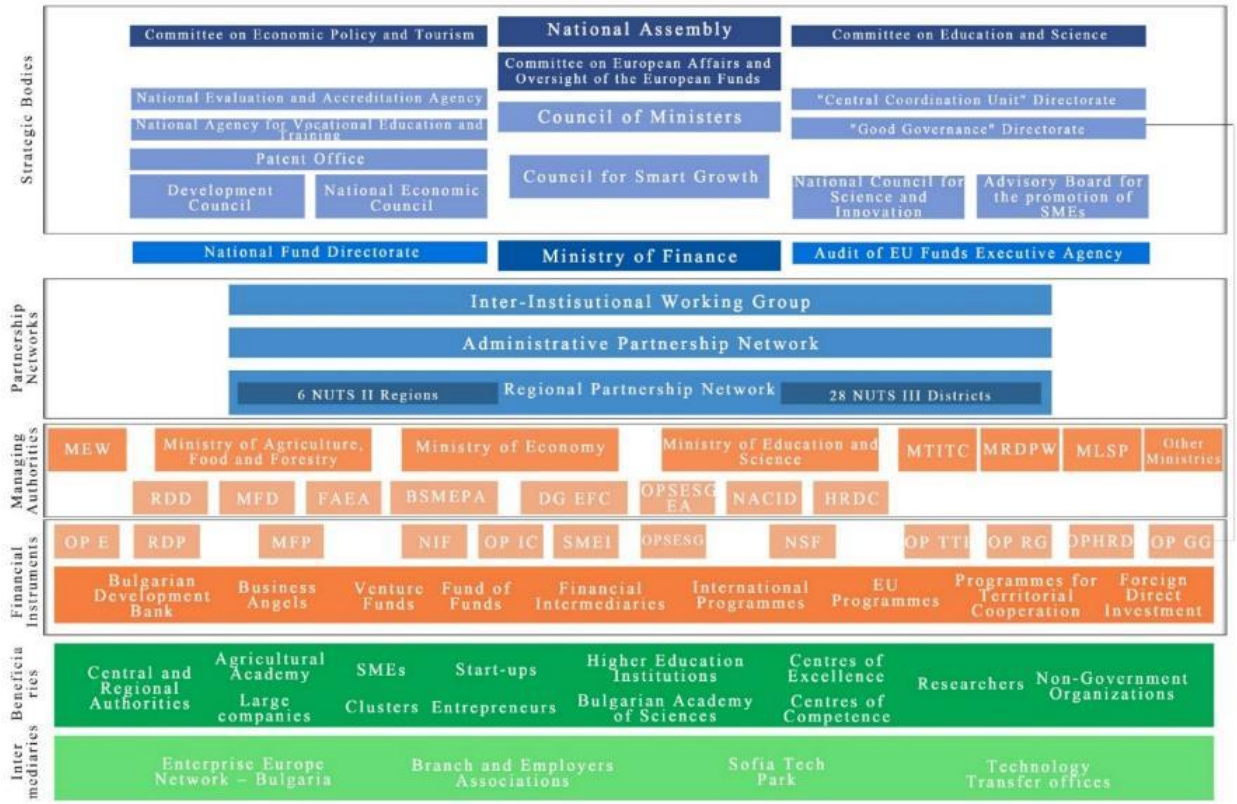
Digitalisation is indeed an important driver for further modernisation of the manufacturing sector so the Industry 4.0 provides a good basis to support digitalisation across the entire society.

However, as the stakeholder consultations for this POINT review clearly demonstrated, a parallel and integrated strategy from the side of social and educational policies is essential to realise ambitions in the thematic area, as this will involve tackling bottlenecks to the development of human resources and increasing efforts to raise the quality of education in general and in the digital and engineering domains of further and higher education in particular.

[40] 4.0 Sight, Digital Industry around the World, www.euautomation.com

[41] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/655570/20171027_MadeSmarter_FINAL_DIGITAL.pdf

Figure 6. STI Governance Structure in Bulgaria



Source: Based on the official versions of Bulgarian Institutions' websites (design by ARC Consulting EOOD)

The EU is an important pull factor in the area of orientation and planning in Bulgaria, which is also related to the provision of resources. This is most clearly exemplified by the fact that the two operational programmes run by the Ministry of Economy and Ministry of Education and Science provide the most funding for R&D in Bulgaria. Hence, it is important to account for the long-term institutions created through OPIC and OPSESG funding in the country. OPIC had planned to fund the creation of some dozen Regional Innovation Centres in the first half of 2020, before the COVID-19 crisis prompted the government to defer the creation of the Centres until the next programming period[42]. The Centres are supposed to support the business – science links in the regions in the areas of RIS3, including links in the domains of mechatronics, clean tech and digitalisation.

Similarly, in 2018/2019, all but one of the Centres of Excellence and Centres of Competence established under the OP SESG pursue objectives in the identified area for industrial transformation in Bulgaria. (Tables 3, 4) Among the other budget lines, eligible expenses include expenditure on wages and salaries of CoE/CoC staff with scientific or technical expertise, including doctoral students, young scholars, leading researchers and the highly qualified specialists needed for the conducting of top-level research, as well as engineers, laboratory and other technicians, and other maintenance staff needed for the implementation of project activities. CoEs and CoCs will also be eligible to conduct specialised training as needs arise.

[42] BG16RFOP002-1.027 - Establishment and development of Regional Innovation Centres (RIC)

Table 3 List of contracts signed under BG05M2OP001-1.001 'Creation and development of Centres of Excellence'[43]

№	Identification number	Beneficiary	Title of project	Total budget in BGN [EUR]*
Component 1. "MECHATRONICS AND CLEAN TECHNOLOGY"				
1.	BG05M2OP001-1.001-0008	Institute of General and Inorganic Chemistry-Bulgarian Academy of Sciences	National Centre for Clean Technology and Mechatronics	69,184,530 [€35,373,489]
Component 2. 'INFORMATICS AND INFORMATION AND COMMUNICATION TECHNOLOGIES'				
1.	BG05M2OP001-1.001-0004	Sofia University "St. Kliment Ohridski"	Universities for Science, Informatics and Technology in Society (UNITe)	29,78,882 [€15,227234]
2.	BG05M2OP001-1.001-0003	Institute of Information and Communication Technologies – Bulgarian Academy of Sciences	Centre of Excellence in Informatics and Information and Communication Technologies	29,355,861 [€15009413]

Source: OPSESG * exchange rate 20 May 2020

Table 4 List of contracts signed under BG05M2OP001-1.002 "Creation and development of Centres of Competence'[44]

№	Identification number	Beneficiary	Title of project	Total budget in BGN
Component 1. "Mechatronics and clean technology"				
1.	BG05M2OP001-1.002-0019	Sofia University "St. Kliment Ohridski"	Clean Technologies for Sustainable Environment – Water, Waste, Energy for Circular Economy	23,667,926 [€12,101,218]
2.	BG05M2OP001-1.002-0023	Technical University -Gabrovo	CoC "Smart Mechatronic, Eco- and Energy Saving Systems and Technologies"	23,569,719 [€12,051,006]
3.	BG05M2OP001-1.002-0014	Institute of Electrochemistry and Energy Systems	Centre of Competence HITMOBIL–Technologies and Systems for Generation, Storage and Utilisation of Clean Energy	21,709,196 [€11,099,736]
4.	BG05M2OP001-1.002-0011	Institute of Mechanics (BAS)	Centre of Competence MIRACle – Mechatronics, Innovation, Robotics, Automation, Clean Technologies	22,570,752 [€11,540,242]
Component 2. "Informatics and information and communication technologies"				
1.	BG05M2OP001-1.002-0002	University of National and World Economy	Digitalisation of the Economy in an Environment of Big data (DEBD)	13,333,869 [€6,817,499]
2.	BG05M2OP001-1.002-0006	Institute for Robotics (BAS)	Creation and Development of CoC Quasar	13,500,000 [€6,902,440]
Component 3. "Industry for a healthy life and bio-technologies"				

[43] BG05M2OP001-1.001 – Creation and development of Centres of Excellence
[44] BG05M2OP001-1.002 Creation and development of Centres of Competence

4.	BG05M2OP001-1.002-0010	Medical University - Pleven	Centre of Competence in the Field of Personalised Medicine, 3D and Telemedicine, Robotic-Assisted and Minimally Invasive Surgery	23,695,179 [€12,115,153]

Source: OPSESG

In terms of orientation and planning actors, the discussion in this section demonstrates that there are many governmental bodies that could be engaged in a successful transformation. But their capacity to develop and implement, let alone lead, indigenous transformation remains limited. There are silos between the different governmental entities and missing links between the national and regional level. Bulgaria also fairs worse that most of its EU peers in terms of governance and the appropriate framework conditions for transformation. In the first two programming periods after Bulgaria's entry into the EU, the country has focused on simultaneously building capacity, supporting the main production and consumption actors, and establishing the links between them and creating the necessary infrastructure for growth. This multitude of priorities has ultimately resulted in lack of critical mass for specialisation in any one area. Bulgaria could benefit a lot from analysing and assessing whether and how its legal, tax, regulatory and other policy instruments could complement public financing to incentivise consumers, producers, knowledge providers, policy makers, etc. to seek opportunities for industrial transformation. One of the critical components of improved collaboration is the necessary increase in the level of trust between different players, which hinges critically on improving policy predictability and the rule of law in the country.

Similarly, there are many relevant national strategies to the chosen thematic priorities of industrial transition but these seem geared primarily towards meeting EU guidance and requirements and lack sold locally developed content. In addition, while the coordination between the different strategies has been improving, they still remain largely uncoordinated. There are even more notable gaps in the coordination of national strategies with European (Horizon 2020) or regional (Interreg) strategies. An outward orientation towards opportunities presented by European and other cross-border policy strategies, business investments and initiatives could provide an additional boost (more financial resources, wider reach, greater diversity of actors, etc.) to national efforts.

Table 5 SWOT on Orientation and Planning

Strengths of Orientation and Planning	Weaknesses of Orientation and Planning
• Strategic documents converging on EU priorities and on the chosen industrial transition theme of mechatronics, clean tech and digitalisation. • Established STI and RIS3 national governance structure. • Clear leadership of the Council of Ministers together with the Ministry of Economy and Ministry of Education and Science. • Improved capacity of the Managing Authorities responsible for the main funding mechanisms, the operational programmes for innovation and for science and smart growth.	• Lack of independent national political leadership and tradition in industrial policy constrain transformation planning and orientation. • Persisting silos between Ministry of Economy and Ministry of Education and Science, as well as between them and other relevant ministries. • Low implementation capacity of the public administration across all levels (but in particular in the regions) and functions. Lack of monitoring and evaluation frameworks. • Weak overall governance performance and quality of public institutions.
Opportunities of Orientation and Planning	**Threats of Orientation and Planning**
• Adoption of a whole-of-government approach to industrial transformation. • The continuing stability of EU policy and funds' framework, including the focus on RIS3. • Increase in the available resources for technical assistance and the entering in the third planning cycle of EU funds.	• Slow decision-making due to continuous negotiations with the EU on OP implementation. Overwhelmed public planning capacity, which could result in superfluous and inefficient planning and investment of augmented recovery and resilience funds. • Reversal of globalisation trends, resulting in abrupt changes in export demand for the

• Involvement of more private sector leaders and stakeholders. • Creation of regional orientation and planning capacity around the Regional Innovation Centres, Centres of Excellence and Centres of Competence.	mechatronics, clean tech and ICT sectors. Global geopolitical rivalry. • Political instability or stale-mate in the face of the lack of common understanding on priorities among parliamentary political parties.

2.2 Resource Mobilisation

Bulgaria faces a considerable investment shortfall, both in terms of financial and human resources. Moreover, the UN projects that Bulgaria would be among the countries with the fastest shrinking population between 2019 and 2050[45].

Bulgaria had an average gross fixed capital formation (investments) of 20.9% of GDP over the past decade, which is around the EU average. Yet, it declined sharply following the financial crisis of 2009, reaching only 18.3% in 2019, one of the lowest values in the EU. This translates into an average annual investment of € 9 472 million, which is comparable to that of Croatia and almost twice smaller than that of Slovakia, both countries with a smaller population than Bulgaria. Getting a credit in Bulgaria is still more difficult than in Central Europe and Asia according to the World Bank Doing Business Report 2020[46]. Credit activity in Bulgaria recovered in 2017 – 2019 following a steep decline in the wake of the 2008 financial crisis. Non-financial corporations received on average €550 million new loans annually, with households receiving an additional €263 million. In 2018, the latest year for which data are available for Bulgaria, non-financial corporations received €1289 million and households €1283[47]. However, non-performing loans remain relatively high, although steadily decreasing. The NPL ratio has been on a downward trend across individual banks and segments, declining to 6.9% at the end of Q2 2019. But it remains one of the highest in the EU (with the EU average of just below 3%). Non-performing loans by non-financial corporations stood at 11.1% in 2019 and were even higher for domestically owned banks (at 19.4%). In addition, the access of companies to financial market funding, especially the use of listed shares and debt securities, remains very limited. Financial literacy among households is also very low, limiting the financial services' capacity to provide longer-term financing.[48] At 157% of GDP in 2018, financial intermediation in Bulgaria is on par with other East European member states but remains more than twice as low as in West European members[49]. At the same time, at 95% of GDP, private sector debt remains higher in Bulgaria than among its new member state peers from Eastern Europe, signalling a ceiling to further growth.

Fiscal performance in Bulgaria remains robust, with recurring budget surpluses and declining public debt. At 20.4% of GDP, general government debt in Bulgaria is the second-lowest in Europe.[50] Yet, at 38.5% of GDP in 2018, the latest available data, Bulgaria's general government revenue was also among the lowest in the EU apart from Ireland, Lithuania and Romania.[51]. In terms of expenditure, on average some 83% of the Bulgarian general government budget was spent on current expenditure in the period 2014 - 2018.[52] The total capital spending and reserves of the Bulgarian government for the same period was on average €2538 million annually. At the same time, the Bulgarian consolidated fiscal accounts show Bulgaria received on average €1341 million annually in grants and donations, which primarily constituted EU funds. If the country's contribution to the EU budget is discounted, then Bulgaria received annually on average a net €857 million from the EU. The country's reliance on EU funds for development is even higher if the total EU financing for Bulgaria

[45] United Nations, World Population Prospects 2019 Highlights, United Nations. New York 2019 https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf

[46] World Bank (2020), Economy Profile: Bulgaria, Doing Business 2020. Available online at: https://www.doingbusiness.org/content/dam/doingBusiness/country/b/bulgaria/BGR.pdf

[47] All data is from Eurostat database, Private sector credit flow: loans by sectors, consolidated - million units of national currency [TIPSPC26], extracted on 24 April 2020.

[48] European Commission (2020), *Country Report Bulgaria 2020* COMMISSION STAFF WORKING DOCUMENT Accompanying the document COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN CENTRAL BANK AND THE EUROGROUP 2020 European Semester: Assessment of progress on structural reforms, prevention and correction of macroeconomic imbalances, and results of in-depth reviews under Regulation (EU) No 1176/2011 {COM (2020) 150 final}

[49] As measured by Total financial sector liabilities, by sub-sectors, consolidated - % of GDP [TIPSFS31], Eurostat data, extracted on 24 April 2020.

[50] Eurostat, General government gross debt (EDP concept), consolidated - annual data (online data code: TIPSGO10), downloaded on 24 April 2020.

[51] Eurostat, General government revenue, gov_10a_main, downloaded on 24 April 2020.

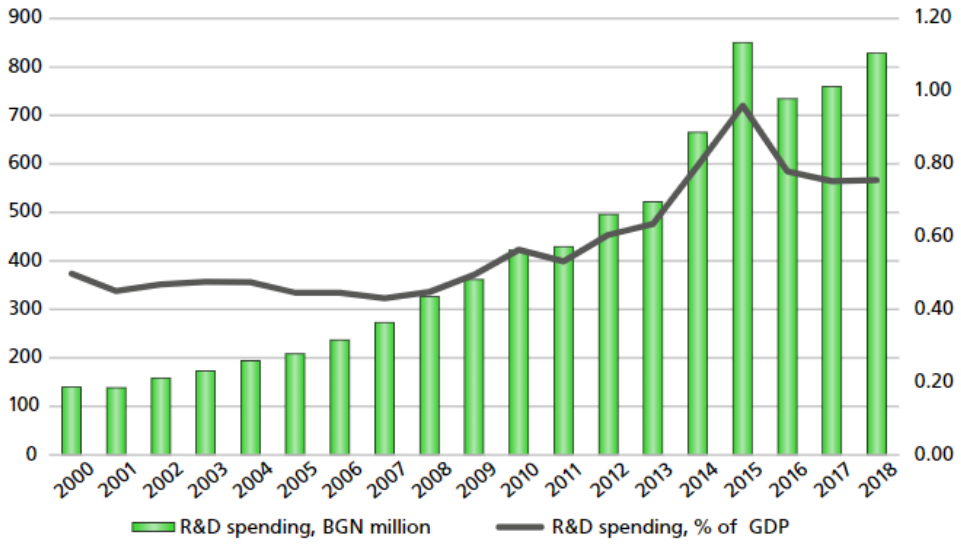
[52] According to the latest available data on the consolidated fiscal programme from the Bulgarian Ministry of Finance.

is considered, including direct payments for agriculture and grants under EU programmes run from Brussels. In the period 2014 – 2018, Bulgaria received from the EU financing equal on average to 4.91% of the country's Gross National Income. This is among the top 5 levels among all the EU countries. In 2018, the latest year, for which data is available, Bulgaria received €1670 million from the EU, net of its national contribution and own resources.[53] This amounted to just above 3% of Gross National Income, the third highest level among the EU-27 countries. The total gross EU financing in Bulgaria in 2018 amounted to €2169 million, which was on par, though a bit lower than, the total amount of credit received by the private sector in the country for the same year. This further underscores the importance of the EU in planning and orientation and in resource mobilisation in the country.

The Bulgarian RIS3 foresees a total of €1352 million for financing its implementation, including support for the vertical priorities, mechatronics and ICT, and the horizontal priority of digitalisation. The strategy foresees that the bulk of the resources (more than € 1 billion) be provided through the Operational Programme 'Innovation and competitiveness' and Operational Programme 'Science and Education for Smart Growth'. The RIS3 further shows that the government has foreseen that other operational programmes, such as 'Good Governance' and 'Human Resources Development', as well as EU programmes, such as Horizon 2020, play a more limited role. This seems to indicate the government's focus on more traditional science, technology and innovation understanding and frameworks for economic transformation, rather than on systemic innovation transformation (Schot and Steimueller, 2018). Hence, the following discussion is also more specifically focused on R&D.

In terms of capacity building for systemic change, it is important to zoom in on R&D spending in Bulgaria. In 2018, R&D spending in Bulgaria reached BGN 827.6 (€423.2) million[54], which was more than a two-fold increase over the 8% of the past decade (Figure 7). However, the ratio of R&D spending to GDP remained at 0.75%, or exactly half the national 2020 target of 1.5%. Bulgaria has relied on EU funds and its business sector (often matching the EU funds' contribution) to provide the resources for R&D. Funds from abroad, primarily EU funds, account for more than half of the sources for R&D funding in Bulgaria. This might explain the peak of R&D spending in the year following the last year of the 2007 – 2014 Multiannual Financial Framework of the EU. At 0.17%, government spending on R&D as a share of GDP in 2018 recorded its lowest level for the whole period after 2000. It was also the lowest in the EU. In 2018, enterprises in Bulgaria spent a total of BGN 594.8 (€304.1) million on R&D, equivalent to 0.54% of GDP. Compared to the other institutional sectors, only the increase in the business sector spending on R&D was able to outpace GDP growth.

Figure 7. R&D Spending in Bulgaria, 2000-2018



Source: ARC Fund based on National Statistical Institute, 2019.

Financing Industrial Transition

[53] All figures pertaining to EU contributions discussed in this paragraph come from DG Budget data on EU expenditure and revenue 2014 – 2020, available online at: https://ec.europa.eu/budget/graphs/revenue_expediture.html

[54] The Bulgarian lev (BGN) is pegged to the euro (€) at an exchange rate of EUR 1 = BGN 1.95583

The key instruments for research and innovation funding in Bulgaria are the EU operational programmes. In the first programming period of Bulgaria's EU membership, 2007 – 2014, Bulgaria had one stand-alone operational programme on competitiveness, which primarily funded projects for the technological upgrading of Bulgarian companies. The country had a science component within the operational programme on human resources. In the next programming period 2014 – 2020, there have been two OP's supporting innovation: OP 'Innovation and Competitiveness' (OP IC) and OP 'Science and Education for Smart Growth' (OP SESG), governed by managing authorities under the Ministry of Economy and the Ministry of Education and Science respectively.

The two operational programmes OP IC and OP SESG sought to fund new technologies in four thematic areas of Bulgaria's first RIS3: mechatronics and clean technologies; informatics and information and communication technologies; industry for a healthy life and bio-technology; new technologies in creative and recreational industries. In addition, RIS3 outlines two horizontal priorities: the mainstreaming of digital technologies (or the further digitalisation of industry) and the development of resource effective technologies. Hence, the current POINT review could also be seen as a continuation of the RIS3 focus as it concerns two of the technological thematic areas and both horizontal priorities. These seem to have been mainstreamed also regionally in all Bulgarian NUTS II regions (Table 6 & 7).

Table 6 Thematic priorities for smart specialisation in Bulgaria by NUTS 2

North West Region (NWR)	**North Central Region (NCR)**	**North East Region (NER)**
Mechatronic and clean technologies	**Mechatronic and clean technologies**	**Mechatronic and clean technologies**
Industry for healthy life and biotechnologies	Industry for healthy life and biotechnologies	Industry for healthy life and biotechnologies
New technologies in creative and recreational industries	**ICT and informatics**	New technologies in creative and recreational industries
South West Region (SWR)	**South Central Region (SCR)**	**South East Region (SER)**
ICT and informatics	**ICT and informatics**	New technologies in creative and recreational industries
New technologies in creative and recreational industries	**Mechatronic and clean technologies**	**Mechatronic and clean technologies**
Industry for healthy life and biotechnologies	Industry for healthy life and biotechnologies	Industry for healthy life and biotechnologies

Source: OPIC

Table 7 Project applications under OP IC until 31.05.2018 by thematic priority and by NUTS II region

Thematic priorities	NUTS II REGIONS - PROJECT APPLICATIONS						Applications/ approved	
	NWR	NCR	NER	SWR	SCR	SER	number	%
Industry for a healthy life and bio-technology	**123**	**14**	**33**	**143**	**63**	**20**	396/76	19%
Mechatronics and clean technologies	**273**	**40**	**67**	**142**	**90**	**67**	679/208	31%
New technologies in creative and recreational industries	**161**	**7**	**33**	**91**	**9**	**9**	310/77	25%
Informatics and information and communication technologies	**38**	**34**	**28**	**475**	**63**	**25**	663/130	20%
Total	**595**	**95**	**161**	**851**	**225**	**121**	2048/491	24%

Note: * Cells in green correspond to thematic priorities in the region.
Source: Ministry of Economy

Thematic priorities 'mechatronics and clean technologies' and 'informatics and ICT' received almost twice as many project proposals and approved projects as the remaining two priorities, perhaps due to the much broader (horizontal) application of the products and services in these fields. Furthermore, there are significant differences in terms of project proposals under each thematic priority. Under **'mechatronics and clean technologies'** the most popular sub-priorities have been related to clean technologies and machine building in the energy and transport sectors, production of basic mechanical elements and 'smart home' systems. Under '**informatics and ICT'** over 70% of the proposal were either in the field of web applications or 3D, big data, grid and cloud technologies. The actual impact of these projects on the country's industrial transformation has not yet been studied as RIS 3 has not been evaluated. It is also unclear how well they relate to the transformation outside the funded projects. The purpose of the funding has been focused on promoting innovation among businesses in Bulgaria, but also the increased cooperation between enterprises and research institutes. The projects that the OP funds have aimed to support enterprises during: 1) pre-project, 2) industrial research and 3) pre-market development. The aim of the OP has also been the increase the employment of researchers and highly qualified technicians. It has supported enterprises in hiring researchers and other R&D professionals to carry out their own research projects within industrial settings.

For the funding period 2014-2020, the total funding amount provided by OPIC was EUR 1.05 million[55]. Some 2131 companies in Bulgaria received funding from OPIC. Of these, 469 companies were from the Mechatronics sector (including some ICT sub-sectors)[56] and have received funding, estimated at EUR 320.8 million through 894 projects. Out of the Mechatronics companies that received funding, the highest concentration is in manufacturing of machinery and equipment (163), electrical equipment (63) and computers (52). Companies from the ICT sector that received funding numbered 108, while the enterprises engaged in the conduct of scientific research numbered 33. In terms of operating revenue, the companies that received funding from OPIC had significantly higher operating revenues than the average for the companies in the Mechatronics sector. The average operating revenue for companies that received funding from OPIC was 3.8 times higher than those that did not. This seems to show that OPIC interventions had very limited impact on innovation development of Mechatronics outside the capital region. There is a need for deeper evaluation of the results to be able to pinpoint whether the better results of companies are because of their OPIC participation or whether the results (also) reflect selection effects, i.e., companies were chosen for funding because they were doing well already. To better account for these two possible causes, Bulgaria might consider differentiating its public support clearly

[55] According to data from the Unified Management Information System for the management of EU funds. Data downloaded as of the end of March 2020.
[56] As defined in NACE codes for this review. See Table 1 for details.

between R&D and non-R&D innovation investments, such as non-R&D engineering (e.g., improvements in routine installation, service and maintenance), investments in IT (e.g., programming custom solutions, IT infrastructure, databases), design, marketing, training and management. These non-R&D investments should not, as a rule, be promoted at the expense of R&D, but ideally additional to it.[57]

In comparison to the previous programme period, there has been a much greater emphasis on intermediary bodies and collaboration between business and research in 2014 - 2020, including the completion of the Sofia Tech Park, funded under OP IC, and the newly established ten Centres of Competence (CoCs) and four Centres of Excellence (CoEs), funded under OP SESG and also covering the thematic priorities of RIS 3 (Tables 6 & 7) plus two more CoE, funded by Horizon2020 and co-financed by OPSESG with 15 million euro. These are meant to provide a concentration of a critical mass of high-quality research personnel and cutting-edge technology and research infrastructures in their areas of thematic focus, which, with the exception of one CoC, are all in mechatronics, clean tech and ICT.

Box 3. Business Models of Centres of Excellence and Centres of Competence Established in Bulgaria.

The created CoE and CoC in Bulgaria follow three different business models, distributed almost equally:

Centralised model, where one (leading) partner holds significant share of the financial resources and equipment. Substantial part of the infrastructure is installed at the premises of the leading partner. The leading partner is also responsible for the implementation of the procurement procedures. The leading partner employs most of the staff. Due to the fact that the process of decision-making is concentrated in one body, strong institutional support is ensured together with a clear vision and mission. The main risk of this business model is associated with the lack of synergy between partners and incomplete usage of the capacity of most of the organisations involved.

Example: CoE Centre of Excellence in Informatics and Information and Communication Technologies

Almost 100 % of the infrastructure is located in IICT-BAS as a leading partner. The main criterion for the selection of partners is to build complex capacity at the highest level. The planned activities are in line with the priorities in the thematic area Informatics and ICT of the Innovation Strategy for Smart Specialisation of the Republic of Bulgaria for the period 2014-2020. CoE in Informatics and ICT aims at developing a research centre where research in Informatics and ICT will be carried out in line with the best world standards and practices by a sufficient number of top-level scientists, within a well-defined organisational structure, following the centre's own research programme related to the priorities of S3.

In contrast, the **decentralised model** provides an opportunity for establishing equity/proportionality between partners in terms of allocation of budget and distribution of equipment. Infrastructure is installed at the premises of the relevant partner according to their financial share. Each partner conducts independent procurement and contracts. The risks in this model are related to the high level of fragmentation in implementing different project activities and vague vision and mission for the future development. The centres applying this business model are exposed to the risk of the partnership falling apart after the completion of the projects.

Example: CoC Creation and development of Centre of Competence in Mechatronics and clean technologies MIRACle (Mechatronics, Innovation, Robotics, Automation, Clean technologies)

The overall objective of the MIRACle project is to create a Centre of Competence in the S3 Priority Thematic Area of Mechatronics and Clean Technologies, consisting of a critical mass of leading scientists and talented, successful researchers and inventors in all scientific fields in the thematic area, with a state-of-the-art research infrastructure, a well-defined organisational structure and its own research and innovation programmes. The specific objectives of the project are as follows: Ensuring the reproduction of scientific and research staff in the specified thematic area, including by attracting leading scientists and researchers (from home and abroad) to conduct research and to provide specialisation of high-level researchers and innovators; Creation and introduction of new training and educational methods and programmes in the field of mechatronics and clean technologies, including for researchers and business representatives; Creating favourable and attractive conditions for the development of highly qualified young researchers, specialisation of high-level researchers and innovators in the field of mechatronics and clean technologies, as well as for continuity of knowledge and experience of different generations of researchers; Creating strategic partnerships with leading technology research organisations and companies in Europe to initiate research projects funded by the EU Framework

[57] See: Bell, M. (2009), 'Innovation Capabilities and Directions for Development', STEPS Working Paper 33, Brighton: STEPS Centre.

Programmes; Achieve effective closure of the science-education-business knowledge triangle at the MIRACle Competence Centre.

The **mixed (hybrid) model** can be described as a combination of the first two models, where two main partners exist. Both of them are jointly responsible for the project management and the allocation of resources. The procurement and project implementation are also a shared duty. In one or another aspect, the hybrid model can be affected by the advantages and disadvantages of the first two models.

Example: CoE National centre of mechatronics and clean technologies

The main objective of the project is to construct a modern National Centre of Excellence in mechatronics and clean technologies, which will have an added value to the Programme for sustainable and intelligent economic growth of Bulgaria. The Centre will have leading functions for the country in the scientific area of 'Mechatronics and clean technologies'. The specific goals are related to the following: To differentiate three scientific research campuses, equipped with modern scientific facilities, which will ensure the execution of high level of scientific research in the area of 'Mechatronics and clean technologies'; Implementation of modern long term scientific plan in the area of „Mechatronics and clean technologies', based on the competence of the partner organisations which will be in compliance with the needs of the Bulgarian industry; Maintaining of a highly qualified scientific team; To establish the conditions for effective technological transfer. The centre is in line with S3 'Mechatronics and Clean Technologies' thematic area.

In accordance with the programme, modern and competitive scientific complexes will be built at the highest level, equipped with unique for the country and concentrated in certain places scientific equipment. These complexes will provide opportunities for high quality research in accordance with best standards and practices. It is envisaged that the main activities will be carried out in close cooperation with the Centres of Competence in the field of mechatronics and clean technologies, as well as with the ITC in the field of information and communication technologies. The high level of scientific activity will be assisted, as associate partners, by foreign scientific institutions. For better relations with the business will rely on the associated partners - representatives of the Bulgarian business / industry.

The activities provided for in the training and qualification programme will ensure the quality of research and ensure continuity and sustainability of the topics. The creation of highly qualified specialists for the needs of modern science will help to improve the quality of engineering education, increase the number of students in engineering majors, and reverse the increasing age of employees working in the mechatronics and clean technologies sector. The long-term results of the training programme and advanced training of scientists will have a positive impact on the country's significant socio-economic challenges, such as low labour productivity and low share of high-tech production

Source: Ministry of Science and Education, OPSESG.

In order to counterbalance the concentration of CoC's and CoE's in Sofia[58] and in an attempt to stimulate cooperation between business and research at a regional level, giving a leading role to the private sector, the government has transferred BGN 100 million from OP SESG to OP IC to manage a procedure for the establishment of **Regional Innovation Centres (RICs)[59]**. The intention was to create at least one centre for each RIS3 thematic priority in every one of the six planning regions in Bulgaria. RICs are meant to ensure the most up to date testing laboratory equipment for businesses in the region and serve as a centre for the regional innovation systems, linking businesses to the other participants regionally, nationally and internationally. Due to the COVID-19 crisis, though, the Government of Bulgaria has taken the decision to postpone the establishment of the RICs until the next programming period in 2021 – 2027, redirecting the resources to help SMEs during the pandemic instead.

Box 4. The concept for the establishment of Regional Innovation Centres in Bulgaria

The main objective of the procedure for support of Regional Innovation Centres is to build and develop modern research and innovation infrastructure and expertise for carrying out applied open-ended research and development activities, facilitating the accelerated economic and social development of the Bulgarian regions. The research infrastructure will be part of the scientific and innovation system of Bulgaria in the priority areas of the Innovation Strategy for Smart Specialisation.

[58] The CoCs and the CoEs include in their consortia many of the country's top universities but are coordinated almost exclusively by institutions based in the capital Sofia. Only two CoCs are coordinated by universities based in Gabrovo and Pleven in North Bulgaria.
[59] As of February 2020, the project proposals for establishing RICs are under evaluation. The call for RICs has been closed on January 21, 2020.

The competitive call will support joint projects initiated by several enterprises with high innovative potential in cooperation with research organisation/s and will result in the creation of research and innovation capacity to support and develop the local economy according to the regional specialisation priorities of the RIS3 strategy. The main focus of the procedure is to explore and further develop the R & D potential of the research organisations as part of the RIC in cooperation with regional businesses for the creation of new products, services and processes.

Supporting the creation and development of regional research and innovation infrastructures and capacities will enhance synergies and knowledge sharing both within and outside the grouping, and in particular between research organisations and businesses, building on a common long-term development programme and establishing a common communication language between them. Investment in open and shared science and innovation infrastructures will be supported in order to strengthen cooperation, networking and knowledge transfer, including through technology transfer offices.

The total budget of the procedure is BGN 115.6 millions of European and national funding with the minimum and maximum amount of the grant of BGN 1 500 000 and BGN 7 000 000 respectively.

The total budget will be distributed equally among the 6 regions at NUTS 2 level, excluding Sofia-city. Projects that do not receive funding in the respective region will participate in a common national ranking and will be funded in case of any remaining regional budget.

The projects in the respective areas of regional specialisation defined in RIS3 in the priority areas for the specialisation of the respective region will bring additional points to the applicants.

The following activities are allowed for funding under this procedure:

1. Building new or expanding and modernising existing research and development infrastructures according to regional specialisation of RIS3

2. Acquisition of tangible assets (research and test equipment) - production equipment (including technological lines) and intangible assets (specialised software, platforms, etc.)

3. Transfer and widespread popularisation of knowledge and research results. Creating mobile apps with access rights, free webinar, virtual conferencing, etc.

4. Carrying out studies and analyses (including foreign best practices)

5. Limited construction works are allowed only for on-going repairs for the needs of the research infrastructure

6. Support capacity building of the research and development team

7. Stimulate the internationalisation and marketing of the grouping

8. Building the administrative body

The procedure has been developed and implemented under the Priority Axis 1 "Technological Development and Innovation", Investment Priority 1.1 "Technological Development and Innovation" of OPIC

Source: OPIC.

According to the ongoing debates about the next Multiannual Financial Framework 2021 – 2027 and the Next Generation EU budget aimed at supporting Member States, Recovery and Resilience Plans, Bulgaria would be among the recipients with the highest contribution as a share of GDP. Hence, in 2021 – 2027 Bulgaria will have almost double the EU resources it had at its disposal in the 2014 – 2020 period, signalling considerable opportunities for financing industrial transition pilots and mainstreaming.

As already mentioned, Bulgaria has devoted very limited national public resources to R&D. Almost all of these are in the form of direct institutional subsidies for the Bulgarian Academy of Sciences, universities and the Bulgarian Agricultural Academy. **National competitive funding for R&D** has been miniscule and concentrated in two instruments: the National Science Fund, which funds only research organisations, and the National Innovation Fund, which funds businesses. Both instruments operate only on the basis of national financing and the amount of their budgets is an object of negotiation as part of the approval of the state budget on an annual basis. The **National Innovation Fund** (NIF) has been the smaller of the two and has also followed the RIS3 priorities. Between 2005 and 2015, NIF funded 457 projects with a total grant amount of BGN 39.8 (€ 20.3) million. In addition, NIF has suffered from weak administrative capacity, which has resulted in several unsuccessful funding procedures. The majority of the projects have fallen under six main sectors, with no more than 45 projects in each: ICT, electronics, optics; metal products; motor vehicles and trailers; chemicals;

pharmaceuticals; food production. There has been no evaluation carried out of the market impact of the fund or its contribution to the RIS 3 objectives.

In addition to the European and own public resources of OPs, Bulgaria has also had access to **Europe-wide programmes for R&D and innovation**. While improving, Bulgaria's participation rate in such programmes has remained below potential, with private not-for-profit and for-profit entities contributing proportionately per researcher more than the publicly funded bodies.

As of September 2019, Bulgaria's participation in **Horizon 2020** comprised involvement in 583 projects, worth € 106.4 million. This corresponds to a success rate of 10.2%, measured as a percentage of the total number of project proposals that had passed the administrative threshold, which is close to but below the EU average of 11.98%. Participants in projects funded under Horizon 2020 Programme are distributed in 19 NUTS 3 districts of the country. The leading district is Sofia-city, which accounts for almost 78% of the beneficiaries and 75% of the received funding. Next is the Plovdiv district, where 7% of the beneficiaries are located with a 14% share of the contracted funds. With an equal share of 5% on both indicators, Varna is in third place. These districts host the three largest cities in Bulgaria.

Bulgaria has 13 successful **SME Instrument** projects, ranking the country 21st by number of projects within the EU 27 and 24th in terms of funding received, with € 1.81 million. So far, only one project from Bulgaria has met the requirements of Phase 2 of the SME Instrument, which finances innovation development and innovation demonstration activities. The remaining twelve projects were submitted only under Phase 1, which evaluated the feasibility of innovative projects. The breakdown of the 13 projects by topic area is as follows: **ICT – one project, Phase 2, with funding of EUR 1.21 million**; Agriculture and Fisheries - two projects, Phase 1, with funding of EUR 100 thousand; Construction and transport networks - two projects, Phase 1, with funding of EUR 100 thousand. In the areas of Biomarkers and Diagnostic Medical Devices, Consumer Products and Services, Eco-innovation and Raw Materials, Energy, Food and Drinks, Health, Nanotechnology and Security, one project, Phase 1 has been registered in each area, with a funding of EUR 50,000 per project[60].

Human Capital

With an aging population and continuing net migration, Bulgaria's workforce is bound to be shrinking, with projections showing that the trend is likely to continue until 2050. Reversing the demographic decline in Bulgaria, from the current -6.6% is among the top three priorities of the Bulgaria 2030 National Development Programme. Over the past decade, the Bulgarian population shrank by more than 450 thousand to just above 7 million as of January 1, 2019 (or 1.6% of the total EU-27 population). All NUTS II regions in Bulgaria lost population between 2009 and 2019, with the North West region losing close to 20% of its population. In fact, the only NUTSIII level region that gained population during this decade was Sofia-city, which added 54 thousand people. Thanks to an increase in the retirement age and to a gradual but stable rise in employment, Bulgaria has been able to keep the rate of decline in its active population and the number of employed to more moderate levels than the decline in the overall population. Over the past decade, the active population declined by 165 thousand to 3276 thousand. At the same time, total employment declined by 'only' 69 thousand to 3136 thousand in 2019. This occurred because the share of the employed in the total population increased from 63% in 2009 to 70% in 2019[61].

In terms of educational attainment in 2017, the latest available year for which data are available, Bulgaria produced 48 281 upper secondary education graduates, of which 16 138 vocational education graduates; and 56 851 tertiary education graduates, of which 1423 PhDs. The trend is downwards for all forms but has been particularly pronounced in vocational education, which produced half the graduates it produced back in 2005. In 2017, some 1307 vocational training graduates were in information and communication technology with another 6134 in engineering, manufacturing and construction. From the tertiary education graduates in 2017, some 2127 were in ICT and 7652 in engineering, manufacturing and construction. In terms of graduates in tertiary education in science, mathematics, computing, engineering, manufacturing and construction per 1000 of population aged 20 – 29, at 14.3% Bulgaria is among the countries with the lowest shares in the EU.[62] In

[60] http://sme.easme-web.eu

[61] All data in this paragraph is Eurostat data and refers to the active population and employed in the age group 15 – 64. The indicators included are: Population change - Demographic balance and crude rates at national level [demo_gind]; Employment and activity by sex and age - annual data [lfsi_emp_a]; and Population change - Demographic balance and crude rates at regional level (NUTS 3) [demo_r_gind3]. Downloaded on 24 April 2020.

[62] All data in this paragraph is Eurostat data and refers to the following indicators: Graduates by education level, programme orientation, completion, sex and age [educ_uoe_grad01], Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02], Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction, by sex - per 1000 of population aged 20-29 [educ_uoe_grad04]. Downloaded on 24 April 2020.

addition to the across-the-board decline in the quantity of educational output, there have been signs that quality has also stagnated at a low level. According to the OECD's PISA survey, Bulgaria has been the worst performer in science and the second to worst in mathematics in the EU-27. According to the 2018 survey, some 46.5% and 44.4% of the 15-year olds in Bulgaria underperformed in science and mathematics respectively.

Stakeholders at the POINT review exploratory meeting in Sofia in December 2019 were unanimous that the quantity and quality of the available human capital for innovation in Bulgaria is insufficient. Hence, businesses, especially in the area of ICT, have gradually started developing their own education and training institutions and teaming up with existing universities. Yet, these are primarily geared towards meeting the rapidly rising demand for outsourcing services for export, with little capacity for deeper ICT engineering skills. Still, ICT has become by far the most popular discipline in secondary schools and universities, but the uptake of digitalisation in non-ICT majors remains limited.

Box 5. TechnoLogica internship programme

TechnoLogica is a leading Bulgarian software company, which since 1990 has been developing a comprehensive range of information technology services.

TechnoLogica's internship programme was started in 1993 and provides an opportunity for students from Sofia University St. Kliment Ohridski, the Sofia Technical University and the University for National and World Economy to be employed over the summer period as paid interns at the company. Interns receive certificates and some stay on as full-time employees. In 2012, sixteen students, chosen through a selection process that included an interview and, for some positions, an exam joined the company team for three months. At the beginning, interns are trained in the high-tech and information systems used at TechnoLogica, and then join specific project teams. Each intern is assigned an experienced mentor who provides guidance and supervision of the intern's work.

In 2012, in addition to the internship opportunities in IT, the programme provided training in consultancy on ERP, HR and BPM systems.

"The challenge is not only to provide paid internship which shows students that integrity and innovation could be combined in a business in Bulgaria, that there are good career opportunities and allows them to study the work process in a company … The challenge is to train and motivate mentors and to use tasks from actual projects that would be both interesting and correspond to the skills of interns", says Mr. Ognian Trajanov, CEO of TechnoLogica.

Source: TechnoLogica, 2020.

Box 6. The business in support of employability: Software University experience

The Software University (SoftUni) was established in 2013 by Dr. Svetlin Nakov, university teacher and software engineer with over 15 years of professional experience, and Hristo Tenchev, CEO and founder of XS Software, a Bulgarian company for development of online games.

SoftUni was created to address the need of sufficient number of qualified professionals for the IT industry in Bulgaria. SoftUni estimates that while the sector needs 40,000 qualified professionals, Bulgaria has only about 17,000. The aim of the innovation education centre is to prepare specialists for the software industry in support of entrepreneurship through the learning by doing model (training in programming, IT majors, combined with practical experience). For Svetlin Nakov the aim is to enable Bulgaria to develop its potential of a Silicon Valley in Europe through development and support of talent in the ICT sector.

The educational programmes of SoftUni are a combination of programming courses and IT technology in conjunction with most recent trends in the subjects, so as to obtain fundamental knowledge and develop logical and algorithmic thinking of students. The university has a faculty of own teachers and visiting lecturers.

Two forms of study are available – attendance and online. The places in the attendance form of education are limited and are allocated based on performance. The best students in the attendance form are exempt from payment of a fee for the next module with a scholarship for excellent performance. All students of SoftUni receive a package of licenses for software products, provided by the university's partners. It offers an opportunity to its best students to become part of a paid internship programme. The students receive a diploma for software engineer-practitioner. The diploma is not recognised by the state but is valued highly by employer software companies. The software university has built successful partnerships with several accredited Bulgarian universities – MTM College, the Varna Free University, the Bourgas Free University, the Higher School

of Telecommunications and Posts. After successful graduation from a SoftUni partner university the students obtain a state recognised diploma of higher education.

For the period 2014 – 2015, 28,000 students of the Software University made their first steps in the programming basics courses and over 4,000 candidates passed successfully admission tests in programming for 4 majors. The number of alumni in the SoftUni network reached over 120,000 persons, and those starting a career after obtaining a profession exceed 1,000. Most of the students are male, 44 % of the students are Bulgarian. 92 % of graduates have been employed by IT companies.

SoftUni runs over 60 open courses in software, hardware, digital marketing and design, which have attracted more than 20,000 participants. The seminars exceed 225. In October 2016, the university launched SoftUni Digital, the first full programme for education in digital marketing in Bulgaria. About 500 selected applicants are expected to study in it for 7 months. Since the autumn of 2016, SoftUniKids has started teaching children aged 7 -12 the basics of programming for a period of 8 months.

SoftUni organises hackathons, Softuniada (Olympiad in programming and technologies), technological conferences and provides free video lessons (with over 1.2 million views). It maintains partnerships with more than 60 companies and sectoral associations and NGOs.

Source: SoftUni. 2020.

Box 7. Innovative business models for education and skills development: From Bulgarian problems to exportable solutions

"The need for quality education is fundamental in our times. There is always a need for education in one form or another. The challenge is because the people in the system and in the business are afraid of a scenario where they are incompetent and unable to cope with the school and do not offer the required high quality of service. You need to take the risk" says Polly Yankova, co-founder of Mind Hub, a chain of programming for children and adolescents in over 30 schools in Bulgaria, Romania, Estonia, North Macedonia, Denmark and Finland.

"When we started developing the platform in 2013, the idea was to provide flexibility in the Bulgarian education market. Neither the people nor the organisations were ready. In 2015, we created an online school in Bulgaria called "Proznaniya" for additional training from 1st to 12th grade, as well as for Bulgarian students abroad. We have further developed the software and decided to go outside where there are established habits for using technology in education" says Svetlana Savova, Director of Partnerships and Sales at VEDAMO, a web-based distance learning platform. VEDAMO has customers on 6 continents, mostly in the USA, Europe, Asia and Latin America.

SoftUni has the most recent international start in outsourcing destinations that have a hunger for developers and need for IT education. The company tries first in the Philippines and Malaysia, where cultural differences are most challenging. "1.5 years ago, we chose a strategy to develop in many markets simultaneously, in an online environment. We focused on markets where the English language is official, but it turned out that the basic education level is low there and the attitudes are different. We have managed to validate that through online marketing from Bulgaria we manage to enrol many people, but it is difficult to retain them", explains Svetlin Nakov, co-founder of SoftUni. Adaptation of the business model is required, as for Romania SoftUni creates a new product in Romanian language based on their own methodology. The most important thing is to create a brand without the support of local partners for the time being.

All three cases are ahead of the moment and are already breaking into the international market. Their benefits are universal - they rely on technological solutions that are objective and measured in quality, 'sell' universal knowledge, and develop skills for the future. At the same time, they are looking for a place in local markets and a business model, according to them, right partners, fighting for sustainability, in competition with sufficiently strong national alternatives. But the risk is not unjustified. According to a study by Holon IQ, global spending on governments, parents, and education and training businesses will reach $ 10 trillion by 2030.

MindHub prefers a franchise. "We have a strict selection of franchise partners. Some centres have to make more changes to the product and courses than others. The choice of markets consists of a number of factors - the presence of a stable IT sector in the country, the level of digitalisation of education, interest at the national level to small and medium-sized businesses, as well as the ability to travel to the state, the level of English, etc. The test period continues several months after the opening of a centre, and we consider a centre that grows to our standards 2 calendar years,' explains Poli Yankova.

VEDAMO is making a breakthrough abroad after successfully obtaining competitive funding from the European Commission - Ready2Go, which provides assistance in entering new markets. The team participates in an accelerator programme in Silicon Valley, USA. “After a month in the US, we began to build a solid network of contacts. This was followed by educational events in the US where we introduced our platform. We have partnered with leading distance learning leaders - Canvas, Moodle, Schoology, D2L - Brightspace, Google for Education, Global Grid for Learning, The Consortium for School Networking (CoSN) and more. We have put in place a detailed study of competition, bringing our advantages over the rest, traveling ...”, explains Svetlana Savova.

Despite the three different approaches to the goal, having and validating your own methodology and platform is key to success. SoftUni is changing its business models for its markets outside, but it relies on the same programmes, teacher selection and community management as in Bulgaria. Validation of training and methodology comes from employers who hire their students. "It is important that when people come to study programming, they can succeed, whether the training is on a pre-scheduled schedule or on demand, in what language. The challenge in Romania, which is very similar to our market, comes from not knowing us, but working on the platform. There is no major educational service provider in the market,' he explains.

Svetlana Savova adds that although it initially took about 6 months to research a market and start operating on it, VEDAMO is now a recognisable brand. Marketing mainly in an online environment remains a challenge because "when we are in an external market, we struggle with a lot of advertising / marketing" noise ", and people prefer their (native) products." "I think it is now a turning point in the field of education in every country in the world. In the US, we are our biggest competitors. It was very difficult for an Eastern European company to compete with the big players, but it works, "she said.

Nakov adds that in the future he will also rely on partners - educational institutions to develop the SoftUni network outside, but so far, the operational work is being done entirely in Bulgaria, including marketing. "I believe we will soon be opening online in 20 countries, which is normal when you have a good product," he explains.

Polly Yankova is also optimistic: “We are trying to reach 100 locations by the end of 2020. Our focus is in several markets - Bulgaria, Romania, Scandinavian countries and the Netherlands. Then we will focus on the UK and the US”.

Source: Applied Research Communications Fund, 2020.

ICT in particular, but also mechatronics, have been among the sectors with the highest job growth in Bulgaria in the past decade (Table 8). In addition, the R&D sector has also grown rapidly, doubling the number of employees in the last ten years.

Table 8 Top 10 sectors with job gains in Bulgaria

NACE REV 2		Average annual change (2008-2017)	Change 2017 versus first year available		
Code	Description	Value	Ranking	Value	Ranking
E39	Remediation activities and other waste management services	18,1%	1	260,6%	1
B09	Mining support service activities	16,1%	2	140,0%	7
M72	Scientific research and development	13,9%	3	204,6%	2
N82	Office administrative, office support and other business support activities	12,9%	4	191,7%	3
N78	Employment activities	12,8%	5	172,8%	4
J62	Computer programming, consultancy and related activities	11,2%	6	157,8%	5
J63	Information service activities	11,1%	7	154,8%	6

C29	Manufacture of motor vehicles, trailers and semi-trailers	10,6%	8	132,7%	8
M75	Veterinary activities	9,9%	9	127,0%	9
J59	Motion picture, video and television programme production, sound recording and music publishing activities	9,9%	10	118,4%	10

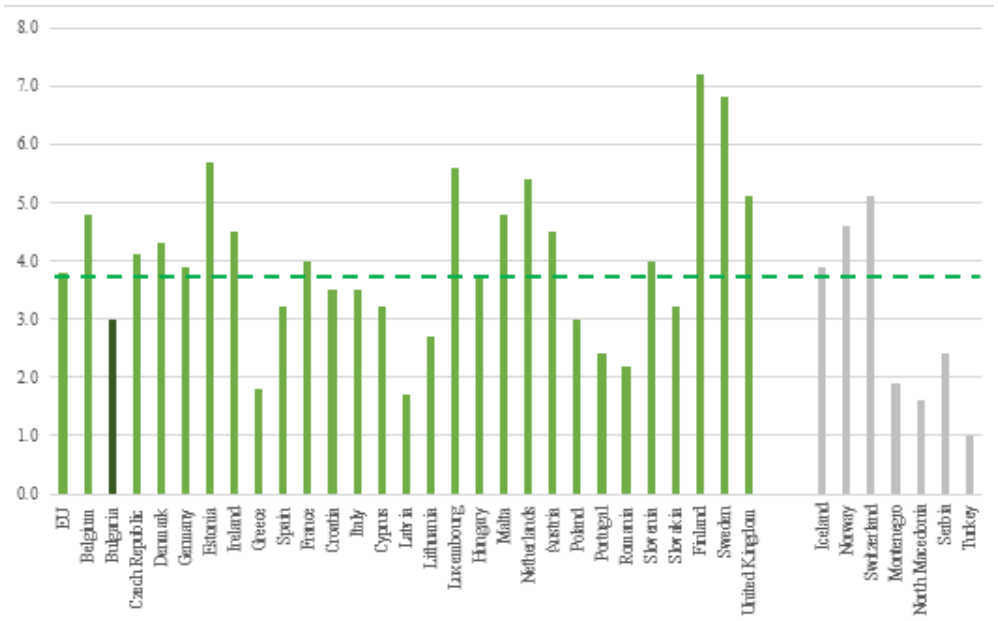
Source: Eurostat Annual Enterprise Statistics.

In 2018[63], the number of R&D employees in Bulgaria grew on an annual basis by over 10% to 34,436. There were over 3,200 newly appointed R&D or first-time enrolees in the annual accounts of Bulgarian enterprises within the 'R&D staff' category. The latter shows an overall positive growth trend, which also reflects businesses' rising awareness and use of this type of reporting data. The business sector has a leading role in the growth of R&D staff. Since 2015, enterprises have been providing more jobs for researchers than the public sector and higher education. In 2018, the share of business in the institutional structure by the indicator reached nearly 46%, compared to 28% in universities and 25% in the government sectors (mostly the two academies' units).

As horizontal technologies whose results may be applied to and help to ensure progress in all other areas of economic and social life, ICT are still one of the most attractive sectors for professional development and career, including young and highly-qualified people. An additional incentive is provided by the numerous policies and financial instruments at the European and national levels.

In 2018 (latest available data), **there were 95,900 ICT experts in Bulgaria,** which was 3% of the overall employment in the country. The change during the five-year period is positive in terms of both the number of people employed and the share in the national employment (73% and 58% respectively). As for the growth in the number of ICT experts, Bulgaria comes in sixth in the EU after Portugal (65%), Estonia (64%), France (58%), Hungary (55%) and Germany (54%). In terms of the growth in 'share in the overall employment', the country is fourth after Portugal (171%), Estonia (156%) and France (152%).

Figure 8. Share of ICT experts in all employed, 2018, %



Source: Eurostat, 2020.

The ICT sector in the EU is male-dominated, with 72% of those employed in the sector in 2018 being male (compared to the share of male workers in the EU as a whole, which stands at a comparatively balanced 54%). **In Bulgaria, the ICT sector has the best balance in terms of gender equality** in the EU, with a slight predominance of men.

[63] Latest available data. Data for 2019 will become available in October 2020.

In 2018, almost 69% of those employed in the ICT industry in Bulgaria had a higher education (given an EU average of 62.7%), which is twice as much as the corresponding percentage for those employed in the economy as a whole (32.4%). Almost half of the ICT specialists (or 50%) are under 35 years of age, given that the share of this group for the whole economy is 27.2%. The high concentration of higher education graduates in the ICT sector seems to be a clear indication that the sector is moving into more knowledge-intensive segments of the value-added chain.

The greatest shortage of personnel with ICT competencies is registered in the Czech Republic, where 66% of the companies have such difficulties. The same holds true for 39% of the Bulgarian companies, which is a little below the European average of 41%.

For the sixth consecutive year, the **Global Talent Competitiveness Index**[64] compares 125 economies in terms of human capital and its contribution to national competitiveness. In the 2019 edition, Bulgaria ranked 54th in the world and 30th in Europe (out of 37 countries from the continent), with an index of 42.72. This has been Bulgaria's best score since 2013. Of the EU member states, only Croatia (55th place) and Romania (69th place) lag behind Bulgaria. The index is composed of a number of sub-indexes, each monitoring different factors that determine the country's attractiveness to talented individuals. Bulgaria ranks relatively better in two of them: (i) enabling factors - legislation and market, which measures the general macroeconomic stability of the country with a strongly performing labour market; the country ranks 27th in Europe, ahead of Romania, Greece and Croatia; (ii) global knowledge skills, including the capacity of high-level professional knowledge, creativity and problem-solving skills, with application in the knowledge-intensive sectors; Bulgaria is 27th in Europe, ahead of Slovakia, Poland, Hungary, Croatia and Romania. While **these two factors could form the basis for a strong industrial transition**, they might also contribute to furthering the strong brain drain the country faces, provided the relative weakness in the rest of the sub-indexes. Bulgaria ranks relatively poorly in all the other sub-factors, including attracting talents (ahead only of Romania and Croatia); growing of talents (ahead only of Romania); (iii) retaining of talents (ahead only of Romania, Greece and Croatia); (iv) vocational and technical skills (only ahead of Romania). While examples of high value-added sectors attracting foreign investment in Bulgaria exist, much effort is still needed to position the country on the global talent immigration map.

Evidence from Eurostat experimental statistics[65] suggests there are vertical and horizontal imbalances in Bulgaria concerning the labour market and the career paths of employees, where vertical imbalances relate to the degree of correspondence between acquired educational degrees and the educational and qualification levels required in the workplace, and horizontal imbalances relate to the degree of correspondence between the area of acquired education of employees and the area of professional realisation. There are **significant vertical imbalances** in Bulgaria. At the national level, the share of overqualified workers amounted to 23.6% in 2018, an increase of 3.4 percentage points over the last ten years. Vertical disparities for Bulgaria are most pronounced in trade, where nearly 49% of the university graduates are in positions that do not require staff with this level of educational attainment. There is also a significant imbalance between educational level and workplace requirements in manufacturing (36.6%), transport (36%), construction (25%) and public administration (19.5%). This seems to show that higher qualified graduates seek higher pay, which has been most pronounced in trade. **Horizontal disparities** in the labour market have also had a negative impact, above all at the individual level, in terms of the inability to capitalise on the time and effort invested during education, and the higher levels of stress due to the lack of competencies suitable for the working place. In addition, such disparities have negative effects for companies because of the higher costs required for adapting employees to the work environment. And for the economy as a whole, horizontal disparities mean an asymmetry between the focus of public spending for education, and the needs of the labour market.

While Bulgaria has managed to perform relatively well on the standard indicators for skills and competences, such as those relating to the level of educational attainment, the adaptability of the labour force and the population to the changing factors of the environment has been lower[66]:

- Some 67% of people aged 16-74 **do not have digital competences**[67], while the EU-28 average share is 41%. This constrains industrial transition as it limits demand for digitalisation, reduces the capacities of companies to operate in the digital world and precludes Bulgaria from benefiting more from the EU's common market in digital services.

[64] INSEAD (2019): The Global Talent Competitiveness Index 2019, Fontainebleau, France.
[65] Experimental statistics, Eurostat, https://ec.europa.eu/eurostat/web/experimental-statistics/skills
[66] A New Skills Agenda for Europe: Working together to strengthen human capital, employability and competitiveness, COM (2016) 381 final; Analytical underpinning for a New Skills Agenda for Europe, SWD (2016) 195 final.
[67] The Digital Competence Framework 2.0, https://ec.europa.eu/jrc/en/digcomp/digital-competence-framework

- Only 2% of the population is engaged in **lifelong learning** versus 11% on average for the EU-28.
- Some 54% of employers in Bulgaria (40% for EU-28) report having **difficulties in finding staff** with the necessary education and competences. Against this background, only 31% of companies (versus 66% for EU-28) fund on-the-job training programmes.
- The three **professions with the highest growth** in Bulgaria are: a) workers in the mining and construction sectors; b) cashiers, bill collectors and bank employees; c) intermediaries in the provision of business services[68].

In conclusion, the preceding discussion on resource mobilisation seems to hint that the opportunities for resource mobilisation for Bulgaria to deliver an industrial transition in mechatronics enhanced by digitalisation would hinge on the Bulgarian government's ability to deliver on three primary pillars:

i. concentrate and mobilise human resources for the better governance and implementation of public and EU financing, especially in the R&D domain;

ii. channel EU funds more effectively to leverage private investments; and

iii. increase, financial intermediation, in particular adding new instruments for non-bank financing, such as equity, venture capital, bonds market, etc. It would also seem reasonable that the Bulgarian government increases its own contribution to R&D funding in the process of upgrading its R&D public governance and delivery system (including public universities, the academy of sciences and the agricultural academy).

Table 9 SWOT on Resource Mobilisation

Strengths of Resource Mobilisation	Weaknesses of Resource Mobilisation
• Bulgaria has low levels of public debt and healthy private finance institutions, which can provide increasing resources to fund a more ambitious systemic industrial transformation programme. • EU funds, the major source of financing of mechatronics, ICT and digitalisation in the country, are likely to continue to increase in 2021 – 2027 and be focused on priorities identified in the RIS3 2014 – 2020. • EU funds will remain concentrated on the key areas of the chosen theme for industrial transition: mechatronics, ICT and digitalisation. • Private education, business-led initiatives have stepped in to fill in the gap left by years of declining quantity and quality of education and education – business needs mismatch. • (Knowledge intensive) Employment in ICT and Mechatronics has been on the rise, increasing the likelihood of sustained growth in the future. Bulgaria has been among the top countries in the EU in terms of the growth of the number of ICT experts and of their share in total employment. • The ICT sector is (rapidly moving to become) knowledge intensive with higher than the EU average share of employment of higher education staff and twice higher than the national average share of young specialists. • The private sector provides more than half of the R&D funding in the country, which in a development setting indicates strong potential for further enticing businesses to co-finance public R&D funding.	• Bulgaria's population is shrinking fast, reducing the available human resources for industrial transition. Overall education results in the secondary and higher education remain below average. • Bulgaria's fixed capital formation has shrunk since 2009 and is now one of the lowest in the EU, hindering transformation potential. • Very limited public resources dedicated to R&D, indicating low capacity for nationally driven transformation and governance capabilities. • Limited non-banking finance culture and practice. • Lack of understanding and coordination of available resources to stimulate systemic transformation. EU funding is concentrated in traditional STI, without drawing in funds for other purposes, like human resources, infrastructure, regional development, etc. • Low capacity for developing digital skills, on-the-job and life-long learning. Vocational training remains limited in view of the high industry demand for higher quality human resources. • Ineffective educational system and shortage of skilled labour (despite the high proportion of university graduates) – vertical and horizontal skills disparities. • Discrepancy between investments in education and labour market demand resulting in rising percent of overqualified workers and increased opportunity costs.
Opportunities of Resource Mobilisation	**Threats of Resource Mobilisation**
• Public funds for systemic change could be increased to leverage more competitive funding from EU programmes and to better target development goals.	• Inability of the newly created CoCs, CoEs, Tech Park and RICs to leverage regional private sector competences and skills to

[68] A NEW SKILLS AGENDA FOR EUROPE: Working together to strengthen human capital, employability and competitiveness, COM (2016) 381 final; Analytical underpinning for a New Skills Agenda for Europe, SWD (2016) 195 final

• The Bulgarian government could broaden the framing of policy action even outside the RIS3, in view of the specific challenges of industrial transition in a development setting. • Strong focus of the secondary and higher education system on ICT and computer science. Emergence of many new schools, including such in close cooperation with businesses. • Leverage the created national and regional institutions for high-quality talent concentration (CoCs, CoEs, Tech Park, RICs). Newly established institutions under RIS3 in 2014 – 2020 (Sofia Tech Park, Centres of Competence and Excellence, Regional innovation Centres) could help underpin strong private sector growth in R&D. • Bulgaria could benefit from investing larger share of its EU and national spending in non-R&D innovation investments, including engineering (e.g., improvements in routine installation, service and maintenance), investments in IT (e.g., programming custom solutions, IT infrastructure, databases), design, marketing, training and management.	meet global demand and gear the economy towards higher value added. • Continuing brain drain and inability to retain highly qualified experts due to the overall less favourable life and work environment. • A possible decline in the quality of allocation of EU funds in the wake of the COVID-19 crisis and away from longer-term transformation paths. • COVID-19 crisis could further divert resources and sway focus away from long-term systemic transformation goals. • COVID-19 could also impact negatively the capacity of businesses to support viable industrial transformation by squeezing or displacing altogether economically viable companies under normal economic conditions. • Continuing deepening of regional disparities in human resources, which could further dampen equitable growth and lead to a vicious circle of relative decline.

2.3 Production

Of the two sectors that are the concern of the current POINT review, ICT has been the better defined and studied in Bulgaria. Mechatronics has emerged as a focus area of industrial transformation in RIS3 and is fairly well-known in the country due to Bulgaria's industrial past and specialisation in electronics. RIS3 has defined mechatronics primarily in terms of robotics. Hence, we look below primarily at production in the ICT sector, including outsourcing trends, and provide only an overview of the mechatronics sector.

The **COVID-19 crisis** is likely to have a deep reaching impact on digitalisation and related production in both the ICT and mechatronics sectors. While it is still too early to discern its effects completely, some have already become visible or can be expected to materialise with a high degree of certainty. For example, the decoupling of the major trading blocks of the US, China and the EU is likely to continue, prompting in particular EU companies to seek an exit from China and possibly relocate to Eastern Europe, including Bulgaria. While this trend is not entirely certain, it does create opportunities for Bulgarian policy-makers to consider. On the other hand, the economic recession will most certainly dampen demand across the economy. The decline is likely to be less pronounced for ICT and mechatronics companies linked to digitalisation, which has been one of the areas of business that has seen growth during the crisis.

In 2018, **mechatronics** covered 8,349 enterprises with a total turnover of € 8.9 billion, employing more than 162 thousand people (**Table 10**). Similar to overall economic activity, mechatronics enterprises have been concentrated in Southern Bulgaria and in the Southwestern region in particular, which hosts the capital Sofia. Some of the large global multinationals in mechatronics have established manufacturing in Bulgaria, including ABB, Schneider, FESTO, Liebherr, EPIQ, Hyundai Heavy Industries, Sparky, AMK, etc. Some of them have entered the country through privatisations or cooperation with existing Bulgarian enterprises. At the same time, local companies have been trying to develop a sectoral governance structure by establishing their own active cluster, which has recently received further support for innovation through OP IC.

Table 10 Business landscape in the field of Mechatronics by NUTS 2

NUTS 2	Legal Entities	Turnover (€)	Employment
BG31 - Northwestern	390	382,781,757.16	7,938
BG32 - Northern Central	745	903,548,781.37	16,809
BG33 - Northeastern	1,015	441,462,460.93	12,983
BG34 - Southeastern	809	1,111,303,310.50	23,596
BG41 - Southwestern	4,160	4,638,398,444.43	76,776

BG42 - Southern Central	1,230	1,394,343,260.68	24,053
Grand Total	**8,349**	**8,927,642,278.92**	**162,764**

Note: For the needs of this study mechatronics has been defined to include the following NACE 2 sub-sectors: 26. Manufacture of computer, electronic and optical products; 27. Manufacture of electrical equipment; 28. Manufacture of machinery and equipment n.e.c.; 29. Manufacture of motor vehicles, trailers and semi-trailers; 30. Manufacture of other transport equipment; 62. Computer programming, consultancy and related activities; 63. Information service activities; 72. Scientific research and development.
Source: Companies' financial data, Orbis Europe database, Bureau van Dijk, 2019, Author's estimations

Sofia is the mechatronics sector epicentre of Bulgaria. In terms of average annual operating revenue (turnover) for the period 2014 – 2018, Sofia outperforms the other regions in 6 of the 9 two-digit NACE sub-sectors (Figure 12). This is particularly true for the three ICT sub-sectors that are also considered to be part of the mechatronics sector: Computer programming (EUR 925 million or 87% of the revenue of the entire sector is concentrated in Sofia); Information service activities (EUR 136 million or 81% of the sector); and the Manufacture of computer, electronic and optical product (EUR 506 million or 67% of the sector)[69]. The highest disproportion between Sofia and the other regions is in the Scientific R&D sector. Some 92% of the sector's annual operating revenues are concentrated in Sofia. In all of the above sectors, Sofia is not only leading by operating revenues but also by concentration of leading companies and by the economic performance of these companies, measured by average operating revenue per worker.

Sofia is also the centre for resource mobilisation as both government funding and private funding are located there. All the recognised resource mobilisation actors in the Mechatronics and ICT sector are located in Sofia. In the capital, the supply side (innovations) and the demand side (user environment) are much more developed than in the other regions. The companies with the highest demand for the development of the material-technical system of the mechatronics and ICT sectors are also concentrated in Sofia. The concentration of intermediaries (NGOs, trade unions, clusters and other interest groups) further facilitates a culture which stimulates the development of the sector. This is something that is absent in the other regions. The already existing advantages of Sofia and the concentration of companies and investment capital attracts further companies, which prefer to be located in the city rather than in other regions of the country. This further exacerbates the gap between Sofia and the rest of the country. Hence, national policies and funding programmes have aimed at narrowing the gap in development between Sofia and the rest of the country.

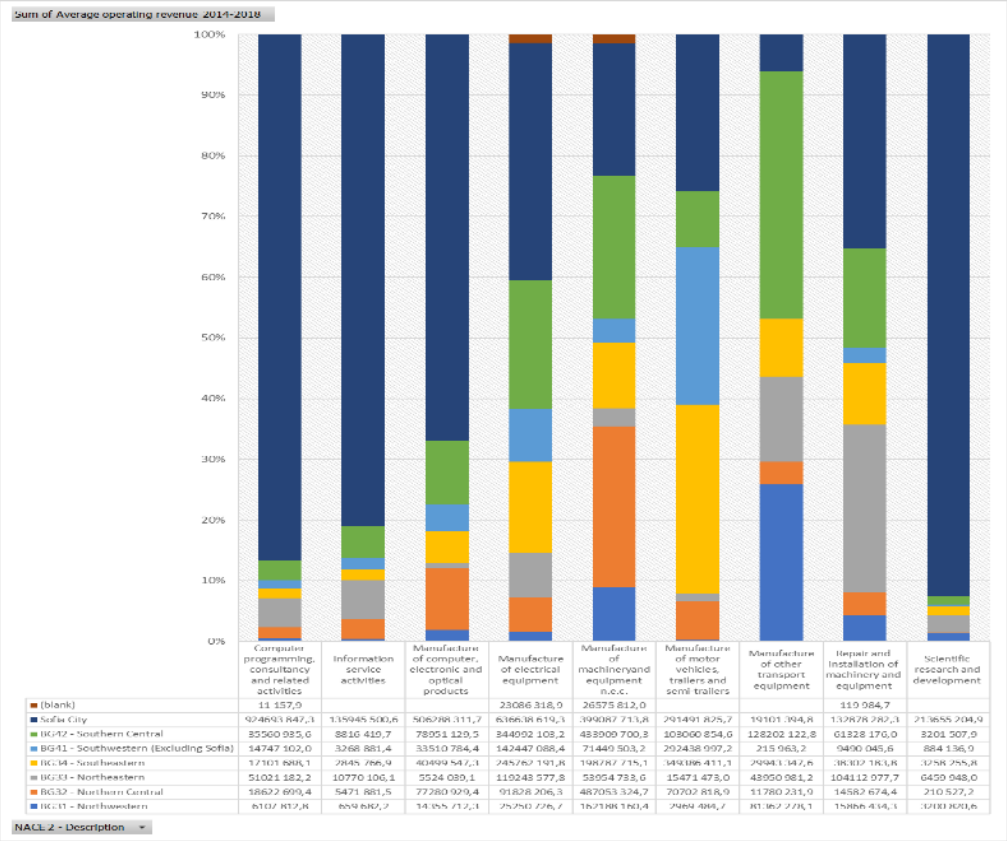
The ICT sector is highly concentrated in Sofia, while the country's other regions underperform. This creates limitations for increasing the interconnectivity between ICT and Mechatronics, particularly the manufacturing of electrical equipment and machinery. The manufacturing elements of Mechatronics constitute a significant presence in each of the southern regions. For example, the South East region has the biggest share of the Manufacture of motor vehicles sector (31%) and the South-Central region leads all other regions, including Sofia, in the manufacturing of other transport equipment (41%). Yet the ICT sector has no significant presence in any of them, which reduces the opportunities for locally developed digitalisation.

Bulgaria's northern regions[70] lag behind the rest when the Mechatronics and ICT sectors are combined. Yet, the repair and installation of machinery and equipment has a significant presence in the North East region (28% of the sector). The manufacture of motor vehicles also has a significant presence (27% of the sector) in the North Central region. Despite this, all three northern regions have minimal market presence in the ICT sector and in research and development. The North West region could be regarded as the region that lags furthest behind, with a minimal presence in all sectors except the Manufacture of other transport equipment. These observations demonstrate that the focus in these regions might better be on non-R&D innovation, seeking further industrial development along established sectoral paths outside Sofia.

[69] Please, note this is based on data from the Orbis database of bureau Van Dijk, which might deviate from the actual statistical data based on data availability and

[70] This includes: North East, North Central and North West regions.

Figure 9. Average operating Revenue by NACE 2 sub-sectors[71].



Source: Authors' calculations based on data from the Orbis database of Bureau van Dijk.

On average, annually between 2016 - 2018, 1654 companies engaged in R&D in Bulgaria[72]. During the same period, a total 824 companies from the Mechatronics sector engaged in R&D. Of these, 485 engaged in R&D every year during that period. This indicates that Mechatronics is the sector of the Bulgarian economy with the highest concentration of companies engaging in R&D. Despite this, R&D in the sector is concentrated in less than 10% of its companies. Less than 6% of the enterprises in the sector conduct regular R&D (i.e., annually). These companies are also characterised by significantly higher operating revenues than others in the sector. The average operating revenue of the companies engaging in R&D was four times greater than those that did not engage, although not all of the largest companies in the mechatronics sectors conducted R&D. Furthermore, the average number of employees engaged in companies investing in R&D is close to four times greater (54 compared to 14), and productivity[73] within these companies is also higher. These observations underscore the notion that a viable strategy for industrial transformation should aim not only to raise R&D intensity levels amongst active R&D performers but also to extend the pool of R&D performing firms in the economy. Pursuing such a development path would require support for initiatives specifically aimed at expanding the pool of R&D-performing companies, while other support measures could be targeted at established R&D performers with good track records (e.g., by supporting their international competitiveness).

The companies engaging in R&D are concentrated in three NACE 2 sectors: Computer programming, consultancy and related activities (270 companies, of which 121 companies engaged in R&D every year); Research and Development (240 companies, of which 182 companies engaged in R&D every year); and Manufacture of machine equipment (124 companies, of which 74 engaged in R&D every year).

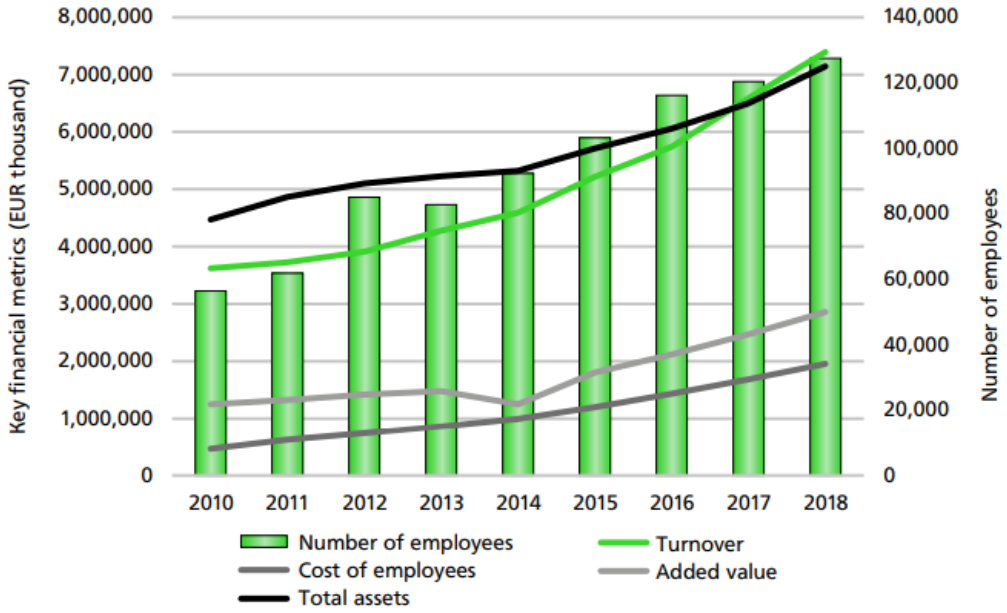
In terms of the geographical distribution of mechatronics companies performing R&D, 506 out of the total of 824 are located in Sofia City. Sofia is followed by the South-Central region (89 companies), with the majority of R&D companies is located in the country's second biggest city Plovdiv (71 companies). Bulgaria's northern regions, all of which have mechatronics as a focus in their S3 specialisation have the lowest number of R&D

[72] Based on data from the National Statistical Institute and the Orbis database of Bureau van Dijk.
[73] Estimated on the basis of operating revenue per employee.

performing mechatronics companies (a total of 142 companies). The North West region hosts the lowest number of such companies of all regions (40).

The Bulgarian ICT[74],[75] sector has experienced steady growth in the last twenty years and this trend continued in 2018. In 2018, the ICT sector generated €7.4 billion annual revenue and provided more than 127 thousand jobs. This represents an increase of 204% in revenues and 226% in number of jobs as compared to 2010, which significantly outpaced the growth of these indicators for the whole economy over the same period (178% and 145% respectively). ICT's added value rose too, but at a slower pace. This might have something to do with the sharp increase in the number and cost of employees in the sector since 2010. In addition, costs have also risen due to the need for on-the-job training to compensate for the lack of capacity in the formal education system.

Figure 10. Key financial metrics and number of employees in the ICT sector 2010-2018



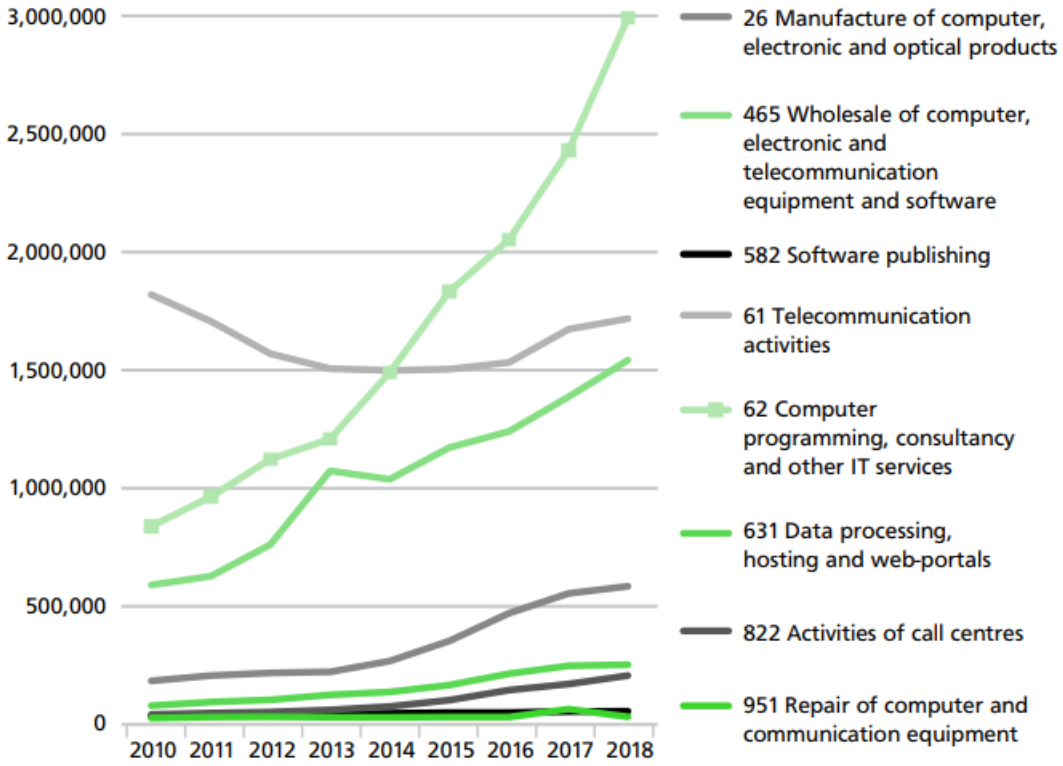
Source: Companies' financial data, Orbis Europe database, Bureau van Dijk, 2019.

Over the whole period, the fastest growing ICT sub-sectors in terms of revenue have been 'Computer programming, consultancy and other ICT services' and 'Wholesale of computer, electronic and telecommunication equipment and software' (Figure 9). The sub-sector of 'Telecommunication activities' fell back to second place after 2014. The revenue of the 'Manufacture of computer, electronic and optical products' sub-sector tripled for the same period. At the same time, multinational leaders in automotive microelectronics and parts, which is related to mechatronics, have set up local production and R&D facilities (e.g., Visteon, Melexis, Integrated Micro-Electronics Bulgaria, Sensata Technologies, Festo Production, etc.). The period witnessed also the fast development of indigenous Bulgarian companies in the areas of microelectronics, sensors, industrial automation, robotics, etc. (e.g., Datecs, Samel-90, Optics, Daisy Technology, etc.).

The same trends – an increasing multinational presence and the gradual development of local leaders – have been even more visible in the area of software development. Since the early 2000s, multinational ICT leaders in software have established R&D centres in the country (e.g., VMWare Bulgaria, Software AG, SAP, Devexperts, Progress, Bosch Software Innovations Sofia, IDT Bulgaria, LeanPlum, etc.), in most cases based on the acquisition of their long-term Bulgarian subcontractors. At the same time, indigenous Bulgarian companies have affirmed themselves as innovative world-leaders in specific market niches (e.g., Chaos Software, Ontotext, Interconsult Bulgaria, Mobile Systems, Software Group Bulgaria, Sirma Medical Systems, etc.).

[74] This section draws heavily from the excellent analysis of ARC Fund's Innovation.bg 2019 report by Todor Yalamov.
[75] For a NACE 2 code definition of ICT sector, please see Table 1 in Section 1.

Figure 11. Annual revenues in the ICT sector 2010-2018 (thousand €)



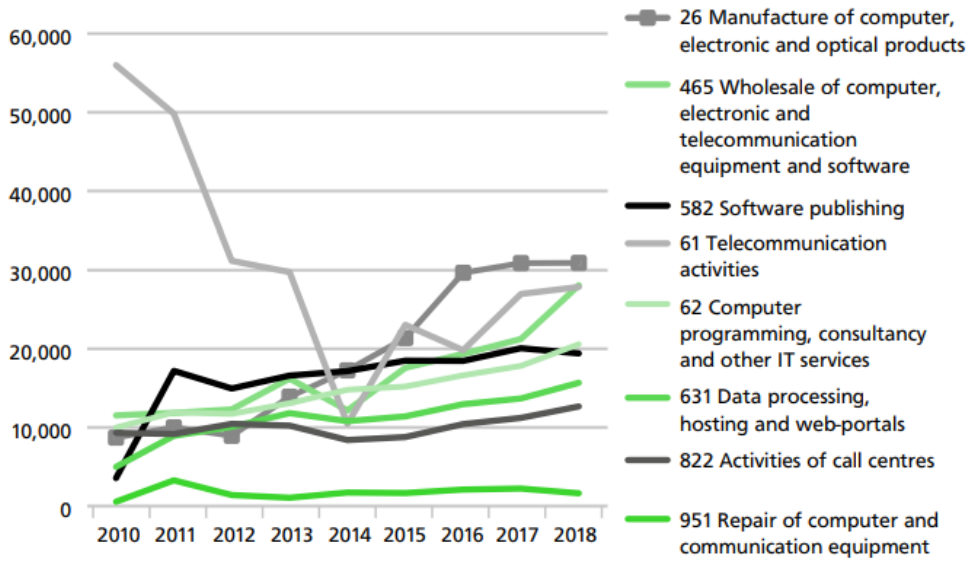
Source: Companies' financial data, Orbis Europe database, Bureau van Dijk, 2019.

By 2018, the sub-sector 'Computer programming, consultancy and other ICT services' was leading in terms of jobs as well as total costs related to employees. However, in terms of labour productivity[76], the leader has been 'Manufacturing of computer, electronic and optical products', followed by telecommunications and wholesale activities. This high upward trend of productivity in hardware manufacturing, measured by the produced added value per employee, might be an indication that the Bulgarian ICT sector is gradually shifting from software-based, low-value-added outsourcing services and sub-contracting to the production of higher-value-added products and integrated platforms (

[76] Labour productivity is defined as added value in euro per employee.

Figure **12**). Alternatively, this could mean that companies are simply assembling more hardware in Bulgaria to benefit from the country's low corporate tax rates and membership in the EU.

Figure 12. Productivity of ICT sub-sectors measured as produced added value per employee 2010-2018 (€ per employee)



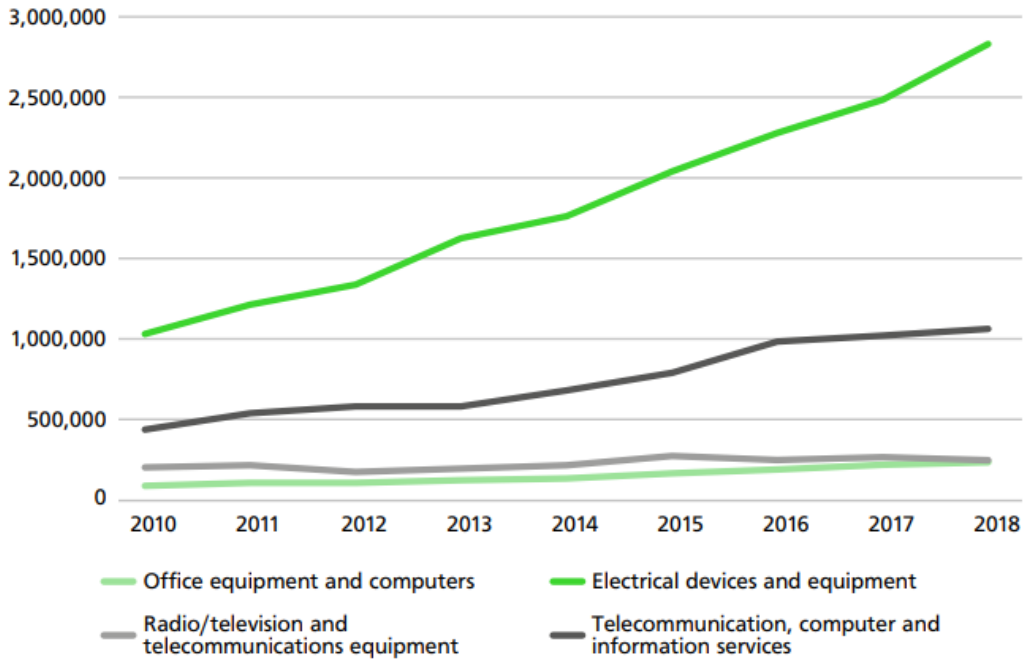
Source: Own calculation, based on companies' financial data, Orbis Europe database, Bureau van Dijk, 2019.

Geographically, the **ICT sector is concentrated in and around the capital Sofia**. In 2018, the Sofia-city (NUTS III level), represented 87% of the revenues, 80% of the jobs, and 91% of the added value of the ICT sector. Sofia-city has seen a stable influx of R&D intensive multinationals in the ICT sector. Examples in addition to those already mentioned include the establishment of Atscale Bulgaria, Nuvolo Technologies Bulgaria, Crayon Bulgaria, and LeanPlum, as well as the acquisition of Fadata by two British companies and of a part of the Smartcom AD team by GlobalFoundries, etc. In recent years, Sofia-city has also seen a growing trend in the creation of new start-ups – mainly in fintech, IoT and data analytics. Often, they are either corporate spin-offs from established ICT companies or their founders have gained experience in leading Bulgarian and multinational companies (e.g., Payhawk, Connectedbin, Phyre, Sirma Medical Systems, Bizportal, ProDron Sys, Sensika Technologies, etc.). An important facilitating factor for the development of the strong innovation-based ICT sector in Sofia City has been the establishment of several private training and education academies and other talent-developing initiatives of leading ICT companies, e.g., Musala, Telerik Academy, SoftUni, LeanPlum, etc.

Beyond Sofia-city, the next top-performing districts in the country with high concentrations of ICT companies, are Plovdiv, Varna, Burgas, Gabrovo, Ruse, Sofia Province, Stara Zagora, Blagoevgrad, and Veliko Tarnovo. Unsurprisingly, the administrative centres of these districts are university cities, while some of them – like Gabrovo, Stara Zagora, and Plovdiv, have been centres of the national computer and microelectronics industry since the 1980s. Each of the districts has its own mix of companies from different ICT sub-sectors. In many cases, specific clusters of firms working in a particular sub-sector have emerged. Such clusters have defined the sub-sector specialisation of the respective district, attracting more and more companies from the same sub-sector. The most well-known example is **Plovdiv** (including the Trakia Economic Zone and the nearby town of Assenovgrad), where companies coming from three sub-sectors have established a dynamic and innovative eco-system. The biggest one in terms of revenues and employment is 'Computer programming, consultancy and other IT services' (€ 96 million annual revenue in 2018), followed by 'Wholesale of computer, electronic and telecommunication equipment and software' (€ 62 million revenue in 2018) and 'Manufacture of electronic components and boards' (€ 30 million revenue in 2018).

The **export of ICT products and services** has increased three times in the past decade and exceeded BGN 10 billion (€ 5.1 billion) for the first time in 2019. The largest exporters in the sector have been Paysafe, Integrated Microelectronics, Datecs, Progress, VMware, SAP Labs, Festo, Visteon Electronics, Melexis and others).

Figure 13. Export of ICT products and services in EUR thousand



Source: Comext and BNB, 2019

The ICT outsourcing industry has made a complex journey from offering mass, low-cost services (coding or calling) to developing unique, multi-channel products/solutions. Increased trust between partners has provided Bulgarian companies with access to specialised infrastructure, while participation in the strategic projects of their clients has allowed them to adopt longer strategic planning horizons. Indicative of the trend away from the provision of low-cost services has been the change in the name of the Bulgarian Outsourcing Association to the Association for Innovation, Business Services and Technology.

As a result of their fast growth and salary increases, ICT companies have contributed to the alleviation of poverty in disadvantaged communities. Automotive electronics factories and other enterprises have transformed some local communities, providing opportunities for many Roma, whose children go to school, to find formal employment and even start a career. Call centres were the first rapidly developing ICT companies with foreign investment in the country. They the gradually expanded their services, evolving to more sophisticated outsourcing of business processes. Some of the first employees of the call centres became entrepreneurs themselves, after saving some of their increasing incomes, and started solving problems they had identified during their previous work. The high income in ICT companies in Bulgaria (on average over BGN 2000) pulled upwards salaries in other sectors and helped retain many young people in the country. About 2% of all people employed in Bulgaria work in the outsourcing industry and generate 8.5% of the working income in the economy (for 2018)[77].

Patent Activity

One confirmation of the transformation of the Bulgarian economy from lower to higher value-added knowledge-related products is provided by the rise in patenting and publication activity. This rise has been mostly driven by the integration of the Bulgarian economy in the EU and by foreign partners. The starting base is low but it provides some backing to the understanding that mechatronics and ICT might be potential drivers of Bulgaria's next industrial transformation.

In 2018, patent activity in the country reached a 20-year peak in terms of the number of granted patents. Patents granted to Bulgarian inventors rose to 171, more than double the total for the previous year. There was also an increase in the number of foreign holders, albeit a modest 2% increase on an annual basis. During the period 2008-2018, the patent activity of Bulgarian inventors remained stable, with an average of 430 patent applications per year filed both with the Patent Office of the Republic of Bulgaria (PORB) and with patent offices outside the country. In 2018, just over 12,000 patents were in force in the country.

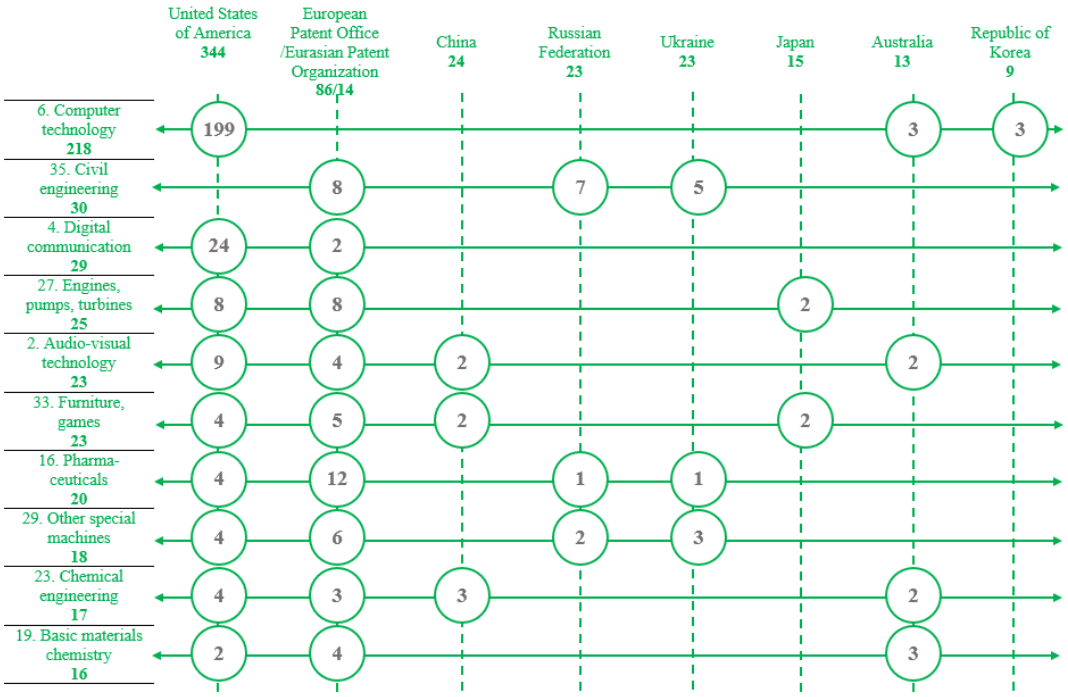
[77] 2019 Annual Report, Association for Innovation, Business Services and Technology.

In 2018, Bulgarian patent holders maintained 705 active patents outside the country. The majority them, over 54%, were obtained for the US market, followed by Switzerland (5%), France and China (3% each). Amongst the 13 new EU member states, Bulgaria maintained its position as one of the leaders with respect to patent activity in the USA. Bulgaria holds fourth place with an overall total of 790 patents granted by the US Patent and Trademark Office (USPTO), trailing Hungary (3649), Poland (1561), and the Czech Republic (1238), which have much bigger economies and populations[78]. The ratio of the number of patents to the number of persons engaged in R&D places Bulgaria as one of the top 3 countries from the former socialist block. With 26.7 patents per 1,000 R&D employees, it trails only Hungary (64.9).

Bulgaria's patent activity at the European Patent Office (EPO) is quite different. Within the group of 13 new EU member states, Bulgaria ranks 11th, with 216 patent applications for the 2008-2017 period, ahead of only Lithuania and Croatia. This position remains unchanged for the indicator 'patent applications per 1 million persons of the country's population'.

The predominant interest of Bulgarian inventors in the US market in the period 2011-2015 is focused in two main fields – **electrical computers** and **digital processing systems and data processing**. At the EPO, 34 out of a total of 77 patents granted (or 44%) for the 2008-2017 period, were in **mechanical engineering**, followed by 31% in the field of chemistry (1/3 of those are in pharmaceuticals). **Civil engineering** ranked third with 13%. Fourth came the sector of **electrical engineering** with 8%, including digital communications, basic communication processes, computer technology, audio-visual technology and electrical machinery, apparatus, energy. (Figure 14)

Figure 14 Patent activity of Bulgarian patent holders in foreign patent offices, Main technological areas, 2008-2017, number



Source: WIPO IP Statistics Data Centre, 2019.

Publication Activity

Over the past 20 years, Bulgarian research units have increased their publication activity, as recorded in the SCOPUS database. In 2019, the annual increase was 20%. This was the first year since 2009 that the country's publication activity rose at a higher pace than the average for the Central and Eastern European region (12%). Yet, Bulgaria's publication activity shows some deficiencies, which might be important to bear in mind in relation to any successful industrial transition:

[78] Data available by 2015.

Publication activity per thousand employees in the field of science and technology in Bulgaria (123) remains far behind the leader in the CEE, Slovakia (404)[79];

The share of publications with international participation remains below 50% in 2018;

Bulgaria ranks last but one in the EU according to the number of international (non-EU) joint scientific publications per 1 million of the population (which tends to correlate with indicators of research quality). At 324, Bulgaria's result is only ahead of Romania (257) and is three times below the EU-28 average of 1070;

In terms of the number of public-private joint publications per 1 million of the population, Bulgaria (16.5) shares the last place with Lithuania (16.4) – five times below the EU-28 average.

Leading scientific areas in Bulgaria in terms of publication activity are:

- Physics and astronomy, with a total of 18,499 scientific publications for the period 1996-2018, H-index 143 and 14.34 citations per document;
- **Engineering sciences**, with a total of 12,212 scientific publications for the period 1996-2018, H-index 95 and 6.76 citations per document;
- Medicine, with a total of 17,599 scientific publications for the period 1996-2018, H-index 152 and 12,88 citations per document.

The results for both patenting and publication activity show, Bulgaria is still likely to rely on imported technology and fundamental knowledge to deliver its industrial transformation. A critical aspect of any such transformation would need to include the upgrading of patenting and publication activity in ICT and mechatronics.

Table 11 SWOT for Production

Strengths of Production	Weaknesses of Production
• Traditions in ICT and mechatronics in Bulgaria date back to the 1980s, creating a solid foundation for growth. • A decade of continuous strong growth in value added, employment and productivity in ICT services and hardware sectors and mechatronics, have created a number of successful examples of local companies and international investors, which can provide models for emulation. • The European Green Deal and Recovery priorities, feature digitalisation and industrial transition prominently, which provides credence that Bulgarian production in both sectors will quickly recover post-COVID-19 recession. • ICT and mechatronics have established cluster initiatives, which allow companies in the country to develop cooperative initiatives, meet demands that outstrip the individual companies' capacity, and agree on common positions. • Both ICT and mechatronics sectors have continued influx of emerging dynamic start-ups, which enrich the competitive environment and the product mix supply.	• Small and fragmented national market. Lack of links between ICT and the other sectors of the economy, including mechatronics. • Shortage of technical and engineering personnel, both in terms of quantity and quality. • Lack of inter-relation between the ICT and mechatronics sub-sectors; they both exist primarily for export with not enough internal collaboration and links. • Unmet capacity in terms of non-R&D innovation, such as internationalisation, modern methods of marketing, and advertising, including further development of organisational-managerial capacity and business models. • Lagging behind in the modernisation of ICT infrastructure in education and science. • Strong concentration of ICT business in Sofia. All other NUTSII&III regions have been losing population in the past decade. This could also be perceived as many opportunities for transformational development outside Sofia.

[79] Eurostat, SCImago (2007). SJR — SCImago Journal & Country Rank. Retrieved October 31, 2019, from http://www.scimagojr.com, Author's calculations.

Opportunities of Production	Threats of Production
• The COVID-19 pandemic is likely to push demand for ICT and mechatronics higher and also prompt EU producers to shift their supply chains closer to home and away from China. • Identification of joint actions of common interest by business associations in mechatronics and ICT, and of regulatory and other interventions that could catalyse the transition. • Using the COVID-19 crisis to push for digitalisation of production (online sales, etc.) across the economy by using the spare capacity of the local ICT and mechatronics companies. Use the established Centres of Excellence and Centres of Competence. • Strengthening science-business collaborations, cluster support, TTO support, etc. good practices. Newly created CoC and CoE are concentrated in ICT and mechatronics and will create new opportunities and support for production • Increasing the local embeddedness of ICT companies in other sectors, including mechatronics and clean tech. • Further integrating digitalisation in the educational process across different majors, thus preparing the economy for the wider use of digital skills.	• Declining number of high-grade specialists, which can deliver more complex R&D tasks, over and above outsourcing. • Stopping or reversing of the pace of globalisation and the inception of trade wars, which can harm the country's growth prospects. • COVD-19 has further disrupted the global supply chains and is likely to accelerate further trade tensions, in particular between Europe and China. • Too quick and formalistic rebalancing of national policies towards green growth agenda without considering the possibility of linkages to digitalisation and to mechatronics and ICT. • Lack of solid local R&D and science based, which reduces the long-term adaptability and capacity of the production system.

2.4 Consumption/Use

The Bulgarian domestic market is one of the smallest in the EU. Bulgaria's per capital GDP is the lowest in the EU. This is reflected in low demand for new technologies, which are typically also related to higher prices. Hence, Bulgaria's systemic transition towards digitalisation based on the integration of ICT in mechatronics is likely to rely on a combination of external market pull as well as public spending to promote demand. The Bulgarian public procurement market is a viable option for early adoption or mainstreaming of new technologies that can aid industrial transformation. In 2018, the public procurement market was worth BGN 8.45 (€ 4.32) billion[80]. Yet, Bulgarian authorities have been shy in using the public procurement instruments at their disposal. There have been no or very few contracts for procuring R&D, which benefit from a special allowance in the legislation. As of 2019, ten years after the instrument was introduced in the EU, the Agency for Public Procurement has only developed guidelines for green public procurement, but no such practices have been introduced in the country[81]. This applies also to ICT public procurement. The Bulgarian government lacks a unified ICT purchasing strategy, which could spur development in the local production and services sectors.

The COVID-19 crisis is likely to hit demand for all industries across the board. Yet, if the crisis turns into a long-term threat, mechatronics and ICT sectors and digitalisation are well placed to rebound quickly, as evidenced by the rise in video-conferencing services, online purchasing and delivery, etc. The business sentiment (or the expectation about future business prospects) in the Bulgarian industry as measured by the EU Flash Consumer

[80] Source: Agency for Public Procurement
[81] http://rop3-app1.aop.bg:7778/portal/page?_pageid=93,1450254&_dad=portal&_schema=PORTAL

Confidence Indicator turned negative already in August 2019 but at much lower level than in the EU and the Eurozone on average. Even as late as March 2020 the sentiment indicator was twice as high as that for the EU as a whole. Service sector sentiment, on the other hand, only turned negative in the EU in March 2020 and remained positive in Bulgaria even then. Similarly, retail trade sentiment in Bulgaria has stayed positive and more confident than in the EU all throughout the period. The only indicator that is consistently negative and much lower than in the EU has been consumer confidence, which correlates with the very low, income levels in the country.[82]

Besides the limiting constraints noted above, Bulgarian consumers have also been known to be conservative in their choices, thus avoiding new or unknown product experiences. There is also a sizable digitalisation gap, which makes transition more challenging in the Bulgarian context. Hence, it is only natural that both mechatronics and ICT rely primarily on export markets for both goods and services.

The latest input-output tables of the National Statistical Institute[83] suggest the B2B market within mechatronics and ICT sectors is limited within one and the same sector or at most between two sectors. One way to gauge the inter-sectoral links between the mechatronics and ICT sectors is to compare the share of intermediate consumption of products developed in the same sectors in the total intermediate consumption of products from mechatronics and ICT. In this respect mechatronics is much more concentrated / closed within itself than ICT. For example, 85% of the intermediate consumption of Manufacture of Electrical Equipment, and 75% of the intermediate consumption of the Manufacture of Computer, Electronic and Optical Equipment are products from the same mechatronics and ICT sector. These numbers are 57% for the Manufacture of Machinery and Equipment, 43% for the Manufacture of Motor Vehicles, Trailers and Semi-Trailers and 50% for Activities in the Field of Information Technology and Information Services. There are two examples of cross-sector B2B cooperation within mechatronics and ICT. The Manufacture of Motor Vehicles, Trailers and Semi-Trailers uses products from the Manufacture of Electrical Equipment. And Activities in the Field of Information Technology and Information Services use Computer, Electronic and Optical Products.

More than half of the product output of most mechatronics sub-sectors is for export and capital consumption (in the case of Machinery and Equipment the share is 80%)[84]. More than 30% of IT and Information Services are destined for exports, while more the 50% are for intermediate consumption. Three sectors consume more than 30% of the IT and Information Services - Activities in the Field of Information Technology and Information Services, Financial Service Activities and Telecommunications. Government – related or subsidised sectors, such as Public Administration, Education and Healthcare consumed another 7% of the IT services[85].

According to the Observatory of Economic Complexity, the economy of Bulgaria has an Economic Complexity Index (ECI) of 0.49, making it the 47th most complex economy in 2018. Bulgaria exports 348 products with revealed comparative advantage[86]. Goods from the mechatronics sector, which fall within these competitive products include: Insulated Wire ($647 million), Electrical Power Accessories ($452 million), Low-Voltage Protection Equipment ($351 million) (see Figure 15).

Bulgaria's product space network (Figure 15), shows that the goods that fall within the mechatronics sector are dispersed into the network, with the exception of some clusters of goods. There are two particular clusters of connected goods from the mechatronics sector within the wider network of exported goods. The first cluster combines the main exported goods of the sector, including five of the key mechatronics exports. The structural node within that cluster is the product group of Electrical Power Accessories. This product group contributes to the increased export of other key goods such as Low-voltage protection equipment (export of $351 million), Electrical Control Boards (export of $325 million) and Vehicle Parts ($211 million). A second cluster that is evident within the Bulgarian product space network is the Mechatronics-ICT cluster of goods (see the ellipse within Figure 15). Within this cluster, specific mechatronics goods that interconnect the two sectors are concentrated. This specific cluster, though, seems to have two disadvantages. On the one hand, the majority of goods within this cluster are not ones in which Bulgaria has a particular advantage on the global market. Only three product groups from this cluster have a significant advantage in global market: Electric Batteries ($201 million), Electrical Resistors ($172 million) and Printed Circuit Boards ($92.4 million). On the other hand, the

[82] Data on consumer confidence is based on the EU Flash Consumer Confidence Indicator, released on 22 April 2020. Available online at: https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/business-and-consumer-surveys/latest-business-and-consumer-surveys_en

[83] The latest available data is for 2014 but we do not expect major changes to have occurred in the meantime in the patterns on consumption and use in the different sectors.

[84] Based on data from the Input-Output tables.

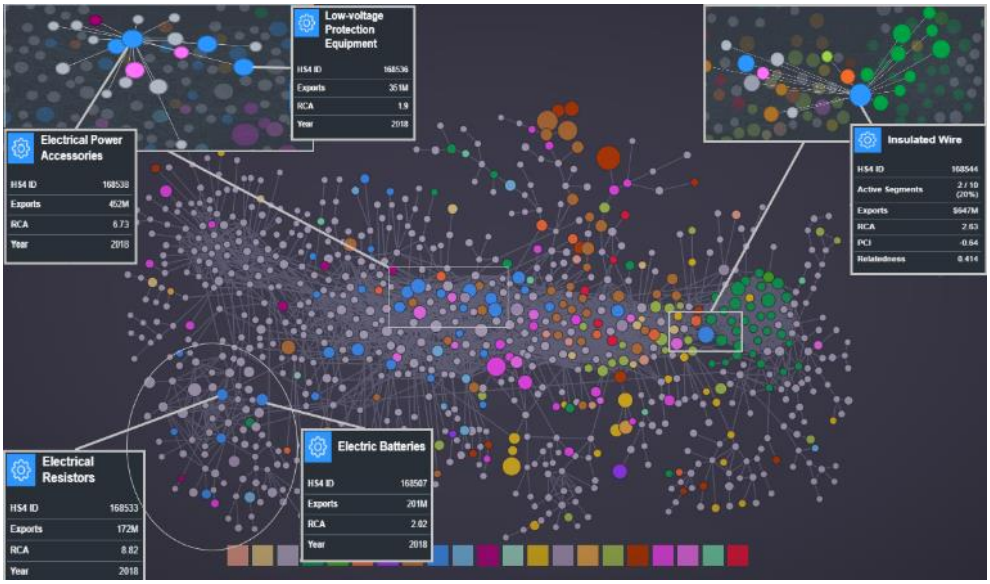
[85] This is like to have increased, provided the considerable investments in e-government, e-justice and e-health after 2014.

[86] Meaning that its share of global exports was larger than what would be expected from the size of its export economy and from the size of a product's global market

cluster has low interconnections between the product groups it contains, with only the most exported goods having strong interconnections. The two clusters seem to show particularly strong exports, but without internal interconnections and a lack of links to other goods in the mechatronics sector (strong dispersal into the product space). More importantly, goods from the mechatronics sector that are particularly competitive are rarely interconnected and co-exported. Increasing the interconnection between goods would occur through greater cooperation and pursuit of common business opportunities between businesses on a national level.

Furthermore, the mechatronics goods that are most competitive on the global market are co-exported with goods in which Bulgaria does not play a major market role. For example, insulated wire exports are more connected to goods in the textile industry than to other goods in the mechatronics sector (see the network in Figure 15). This might be related to the fact that Bulgarian mechatronics companies are part of European value chains, which help them export but does not help them to create links in the local economy. More than 63% of the exports of the Bulgarian industry are destined for the EU, whereas for imports this indicator is about 50%.[87] In addition, 27% and 61% of the exports of the Bulgarian industry to the EU are outputs from the top 10 and top 100 companies. This export concentration is even higher if total exports are considered, with values of 38% and 69% respectively.[88] This implies that very few players control the bulk of the sector, which could warrant a case study approach to an analysis of export behaviour. Future policy and cooperation between the actors in the mechatronics sector could stimulate the strength of the connections between mechatronics goods, which in turn would potentially also help the development of new related industries.

Figure 15. Exporting patterns of Bulgarian goods within the global industry space[89]



Source: Observatory of Economic Complexity.

The data provided by the Observatory of Economic Complexity[90] shows that, for 2018, the latest year for which records are available, total exports from Bulgaria amounted to $34 billion, making it the 63rd largest exporter in the world. In the period 2012-2017, the exports of Bulgaria have increased at an annual rate of 2.8%. In 2018, Bulgaria had a negative trade balance of $4.3 billion. Some $11.4 billion of all imports can be attributed or related to the Mechatronics sector, while the exports from that sector amounted to $8.51B.[91] The most exported goods group from this sector was Insulated Wire, which amounted to $647 million or 6.63% of total exports from Bulgaria in 2018. Forty-one percent of the exports of this goods group went to Turkey ($267

[87] Based on Eurostat data: Concentration of trade by NACE Rev. 2 activity [ext_tec02]. Extracted on 25 April 2020.
[88] Based on Eurostat data: Production in industry - annual data [sts_inpr_a]; Concentration of trade by NACE Rev. 2 activity [ext_tec02]. Extracted on 25 April 2020.
[89] Available online at: https://oec.world/en/visualise/network/hs92/export/bgr/all/show/2017/. The figure shows the connection between all the goods that are co-exported with goods from other sectors. The coloured nodes represent product categories in which Bulgaria is active globally, while the grey nodes show all products that are not. The colour itself shows the sector these products belong to, while the distance between them reflects how related they are in terms of capabilities, assets and/or institutions they draw on.
[90] Observatory of Economic Complexity, (2020). Bulgaria Report. Available online at: https://oec.world/en/profile/country/bgr/
[91] Please, note, the date from the Observatory of Economic Complexity is not comparable to the NACE data used to define mechatronics for the purposes of this study. The sectors as defined within the data visualisation of the observatory is classified according to SITC methodology and assumes that the Mechatronics sector consists of the categories: Machines, Instruments and Transportation.

million). Over the period 2012-2017, the goods group that has grown most significantly in exports is Monolithic Integrated Circuits, Digital, which accounted for 2.4% of total exports in 2017. Its average annual growth rate has been 118%.

Table 12 Exports of goods from the Mechatronics sector[92]

Product	Category of Goods	Export Value (in million US Dollars)	Percent (%) of Total Export
Insulated Wire	Machines	647	6.63
Electrical Power Accessories	Machines	452	4.63
Low-Voltage Protection Equipment	Machines	351	3.6
Electrical Control Boards	Machines	325	3.82
Integrated Circuits	Machines	323	3.8
Cars	Transportation	314	3.69
Electrical Transformers	Machines	271	3.19
Other Engines	Machines	258	3.03
Refrigerators	Machines	256	3.01
Valves	Machines	224	2.63
Vehicle Parts	Transportation	211	2.48
Excavation Machinery	Machines	201	2.36
Electric Batteries	Machines	201	2.36
Electrical Resistors	Machines	172	2.02
Liquid Pumps	Machines	168	1.97
Broadcasting Equipment	Machines	164	1.92
Tractors	Transportation	154	1.81
Bicycles	Transportation	149	1.75
Motorcycles	Transportation	134	1.57
Medical Instruments	Instruments	132	1.55

Source: Observatory of Economic Complexity.

In 2017, the total value of imported goods amounted to $38.3 billion, making Bulgaria the 60th largest importer in the world. In the period 2012-2018, the imports of Bulgaria increased at an annual rate of 0.5%. Total

[92] Available online at: https://oec.world/en/visualise/tree_map/hs92/export/bgr/all/show/2017/

imports in the Mechatronics sector[93] in 2018 amounted to $11.4 billion. The most imported goods group from the sector was Cars, which accounted for $1.36 billion in 2018, some 12% of total imports to Bulgaria. These goods groups are primarily imported from Germany (22.1% - $301 million) and Hungary (20.1% - $151 million), with 85% coming from within Europe. The second most commonly imported goods group from the mechatronics sector is Broadcasting equipment, amounting to $601 million or 5.28% of total imports. The primary import sources for Broadcasting Equipment are Slovakia (23% - $62.2 million), The Netherlands (22% - $121 million) and The Czech Republic (9.68% - $53 million.), and 95% of imports are from Europe. Over the period 2012-2017, the goods group that has grown the most is Super-Heated Water Boilers (growth of 3000%). The sector itself accounted for 1.3 % of the total imports of Bulgaria in 2017.

Table 13. Imports of goods from the Mechatronics sector[94]

Product	Category of Goods	Export Value (in million US Dollars)	Percent (%) of Total Export
Cars	Transportation	1360	12
Broadcasting Equipment	Machines	601	5.28
Tractors	Transportation	495	4.35
Insulated Wire	Machines	366	3.22
Integrated Circuits	Machines	335	2.94
Vehicle Parts	Transportation	296	2.6
Electrical Power Accessories	Machines	277	2.43
Delivery Trucks	Transportation	269	2.36
Low-voltage Protection Equipment	Machines	245	2.15
Computers	Machines	242	2.13
Video Displays	Machines	218	1.91
Office Machine Parts	Machines	214	1.88
Harvesting Machinery	Machines	208	1.83
Valves	Machines	192	1.69
Machinery Having Individual Functions	Machines	186	1.63
Air Conditioners	Machines	173	1.52
Other Electrical Machinery	Machines	171	1.5
Electrical Transformers	Machines	146	1.28

[93] The sectors as defined within the data visualisation that are considered part of the Mechatronics sector are: Machines, Instruments and Transportation. This is according to the SITC methodology.
[94] Available online at: https://oec.world/en/visualise/tree_map/hs92/import/bgr/all/show/2017/

Product	Category of Goods	Export Value (in million US Dollars)	Percent (%) of Total Export
Liquid Pumps	Machines	134	1.17
Bi-Wheel Vehicle Parts	Transportation	129	1.14
Medical Instruments	Instruments	114	1%

Source: Observatory of Economic Complexity.

Demand for the production of the Bulgarian mechatronics sector rose during the period 2014 – 2018. The operating revenue of the sector grew to EUR 8.927 billion in 2018. Over a period of five years, the sector experienced a growth rate of 50.8% (from EUR 5.921 billion in 2014). The combined profit of the sector also grew steadily, reaching €884 million in 2018, with a healthy profit margin of 23%. These numbers underscore the sector's long-term viability. Looking at the NUTS 2 level, all regions in Bulgaria have experienced growth. The South West region (excluding Sofia) had the highest growth rate for the period 2014-2018 (91.7%), while the North East had the lowest (12.4%). The growth rate in Sofia was 57.8%. Over the period 2014-2018, the share of operating revenue between the NUTS 2 regions in Bulgaria did not shift significantly. Productivity per worker for the period 2014-2018, measured by dividing the average operating revenue by the average number of employees, shows that the most productive companies are located in Sofia, with productivity per worker standing at EUR 40.3 thousand/per worker. In contrast, the least productive companies are in the North Central region (EUR 23.1 thousand). (Table 14).

Table 14 Bulgarian NUTS 2 Regions with thematic priority Mechatronics

	Operating Revenue 2018 (in EUR)	Operating Revenue 2015 (in EUR)	Growth rate (2015-2018)	Change in Share of the Operating Revenue (2015-2018)
BG31 – North West	382 781 757,2	288 455 167,2	32.7%	+0%
BG32 - North Central	903 548 781,4	698 754 568,9	29.3%	+0.2%
BG33 – North East	441 462 460,9	380 159 039,8	16.1%	+0.7%
BG34 – South East	1 111 303 310,5	853 230 850,4	30.2%	+0.1%
BG42 - South Central	1 394 343 260,7	1 102 464 550,5	26.4%	+0.6%

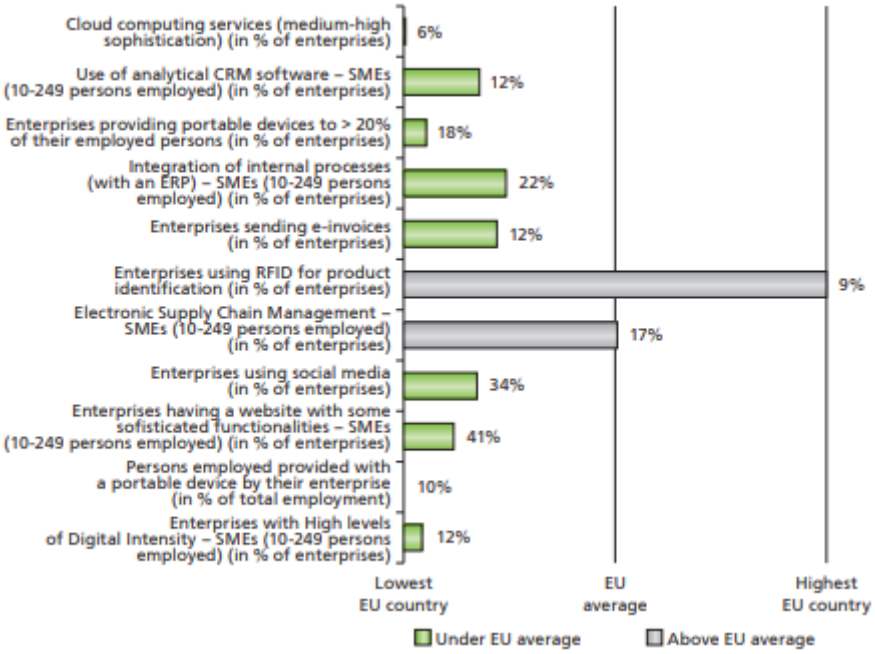
Source: Authors' calculations based on data from the Orbis database of Bureau van Dijk.

Although Bulgaria made progress in terms of many of the indicators for **e-business** development found in the European Digital Scoreboard between 2016 and 2017, the latest year for which figures are available, it was not sufficient to bridge the gap with other EU Member States. Fewer than a fourth of the companies in Bulgaria use resource management systems (ERP), compared to the EU28 average of one third. Much fewer – one eighth – use a system for customer and partner management compared to the average for Europe of one fifth. On the positive side, the share of companies using a supply management system is equal to the average for Europe – 17.6%. This might reflect the better integration of supply processes along the value chain, which usually ends in the EU. Bulgarian exports are mainly directed at the EU and many large exporting companies have suppliers/contractors in the countries to which they are exporting (typical examples are companies in the automotive industry or those involved in the manufacturing of clothing). Hence, companies are under pressure to implement systems for product identification through RFID (Radio Frequency Identification). This segment of

e-business has actually been the most developed in Bulgaria, with 9.18% of the Bulgarian enterprises using RFID (the highest value in EU28). RFID is used across the whole process of labelling, packaging, transportation, entry in the resource management systems of enterprises and final sale to end customers. (

Figure **16**).

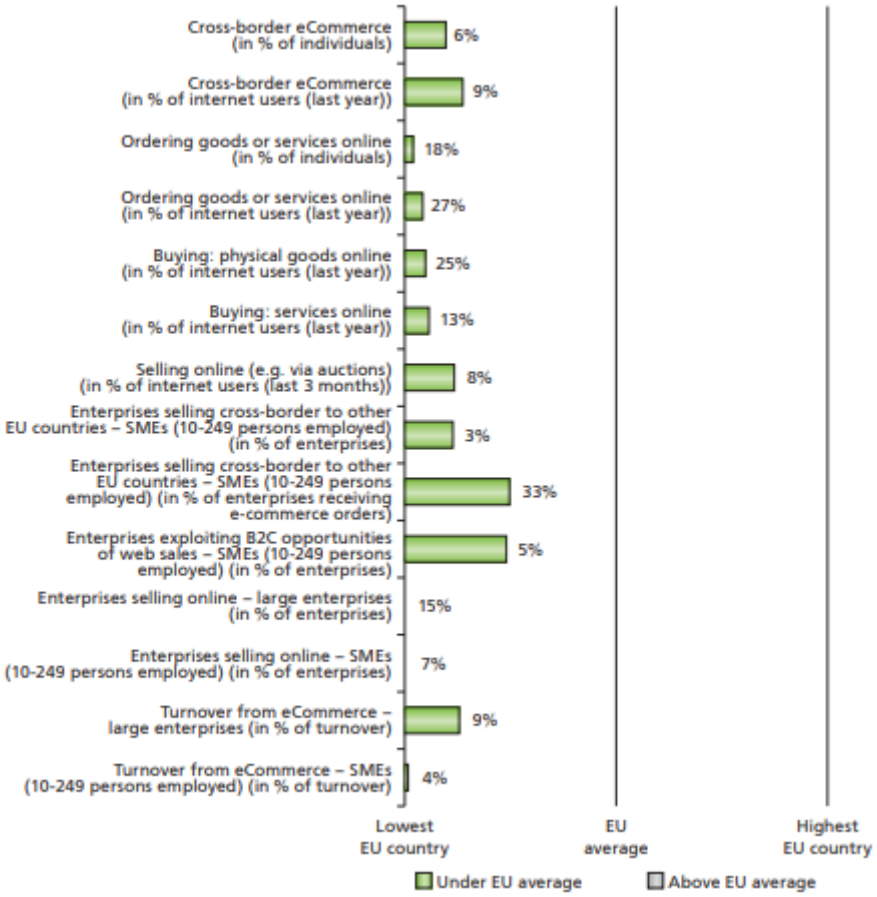
Figure 16. Country profile, e-business indicators



Source: Digital Scoreboard, Innovation.bg 2019

Bulgarian enterprises lag behind their European partners and peers as regards the use of cloud technologies, maintenance of websites, use of social media for business, and the provision of portable devices for staff members. Only Romanian enterprises are performing worse in the EU in terms of websites, and only Latvia and Poland perform worse in terms of social media. The share of Bulgarian enterprises with low digital intensity is the highest in Europe. Still, 8% of enterprises use some kind of cloud technology, and 6% use complex cloud technology (e.g., for the export of data and services), which is sufficient to build capacity for cloud services on the domestic market. Schools comprise an important segment of this domestic market and the need to offer different cloud services, including e-logs, electronic learning content, self-train systems for testing and learning, etc. Provided they are also part of the public funding system, public procurement could be used to pilot and/or mainstream digital products, this increasing domestic demand for ICT solutions.

Figure 17. Country profile, e-commerce indicators



Source: Digital Scoreboard, Innovation.bg 2019

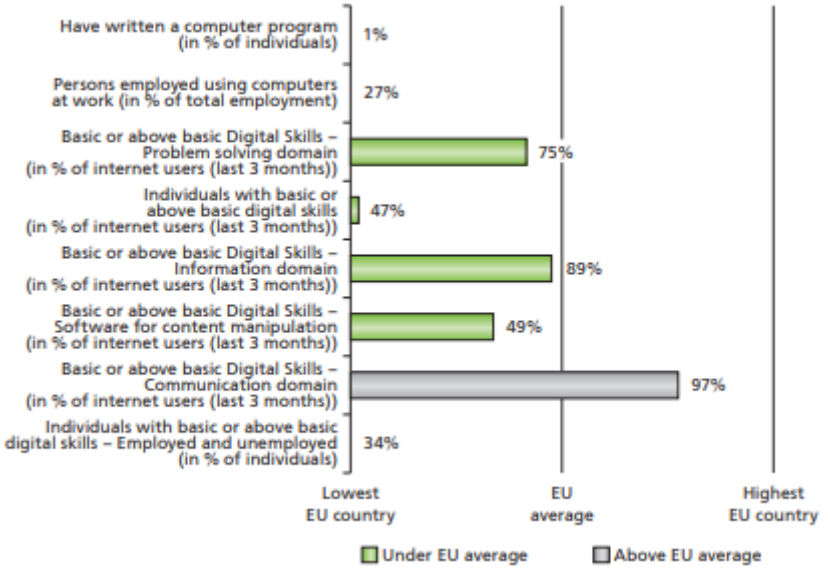
Unsurprisingly, Bulgaria also lags significantly behind in terms of the e-commerce indicators included in the European Digital Scoreboard (Figure 17). Yet, some indicators provide grounds for optimism. The number of Bulgarian enterprises pro-actively seeking opportunities to sell via the internet has increased by 50% annually in recent years. According to the latest available data[95], 15% of large companies (over 250 persons) generate about 9% of their turnover through online orders, while only 7% of small and medium-sized enterprises (from 10 to 249) get 4% of their turnover online.

Individuals appear to be better prepared than businesses for trade online. Some 18% of them did shop online and one third of them did their shopping abroad[96]. Some 8% of individuals stated that they had sold something online (e.g., via OLX, the new shopping functionality of Facebook, or specialised car websites). OLX alone has had over one million installations and about 120,000 active users daily (not necessarily selling or buying). The most popular stores in Bulgaria are Wish, Joom, AliBaba, AliExpress, OLX and eMAG. Due to different problems with supplies from China, those with the highest turnovers from Bulgaria are OLX and eMAG[97].

An important niche of e-trade development in Bulgaria is the growth of courier services. Couriers offer mark-ups to the most popular platforms for e-trade websites, so that when a customer orders a good, the courier can be automatically notified and go to the company, or they offer a service for store management to online merchants. A niche courier specialised in supplies of online orders from abroad is Gabco, which addresses many problems of customers who order supplies to Bulgaria from a non-EU country.

[95] For 2016.
[96] Digital Scoreboard 2019. Data for 2017
[97] Digital Scoreboard 2019

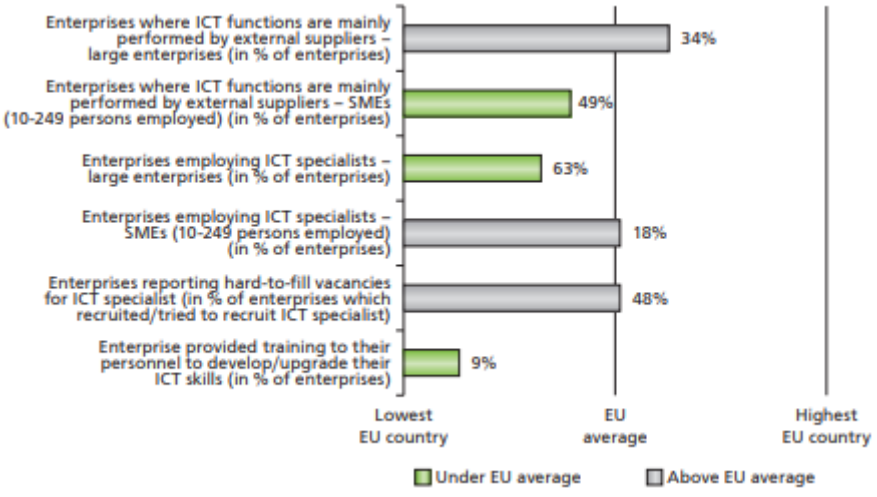
Figure 18. Country profile, digital skills indicators



Source: Digital Scoreboard, Innovation.bg 2019.

Data from the European Digital Scoreboard demonstrate a digital division between the general level of digital competence and that of ICT specialists. The ICT sector has managed to close some skills gaps through training in the popular IT academies (Telerik, the Academy of Imperia online, etc.) and the Software University. Yet, the risk of not being able to find ICT specialists is a bit higher for Bulgaria than the average level for Europe (48%). Bulgarian companies seek to resolve difficulties they experience finding qualified staff by exporting IT activities abroad (34% of Bulgarian enterprises, which is above the average norm for Europe). The main source of resources for addressing this issue - corporate trainings, still account for just 9% in Bulgaria, i.e., much below the average European level.

Figure 19. Country profile, ICT specialists indicators



Source: Digital Scoreboard

There are three different instruments for increasing demand for Industry 4.0 products and the related social and economic transformation, which have so far been largely underused in Bulgaria:

- Transforming university education. Attracting foreign (EU and non-EU) staff to industry must be linked with a requirement that universities develop and widen the coverage of their programmes to the world by teaching in English;

- Using city development. Technologies of industry 4.0 such as 3D scanning and virtual reality should be included in city planning policies and architectural requirements to facilitate the provision of e-services. This has the added value of allowing the public to see in advance what development plans would look like if implemented;
- Increasing e-healthcare services. Bulgarian healthcare service provides should take account of the fact that Bulgarians seek information about their healthcare above the average European levels to introduce and promote more online innovation services. At the same time, companies dealing with artificial intelligence need to be motivated to provide more and better diagnosing tools.

Table 15 SWOT for Consumption / Use

Strengths of Consumption and Use	Weaknesses of Consumption and Use
• EU and national funds for procurement are predictable and can serve as market pull factor. • Bulgaria's access to EU markets is an important factor for demand growth. • High coverage with high-speed broadband for households and enterprises can be used to increase online consumption of goods and services. • Continuing commitment of substantial funds towards the development of e-government. • 100% connectivity of all schools in Bulgaria to the Internet. • High level of use of electronic public services by the business.	• No coordinated government procurement policy in any of the areas: digitalisation, etc. • Low (though rising) domestic intermediate and final demand. • Low level of digital literacy of the population compared to the EU average. • Low level of usage of the internet and internet-based services. • Low implementation and use of ICT by SMEs in other industrial sectors. • Low level of e-commerce development compared to the EU average.
Opportunities of Consumption and Use	**Threats of Consumption and Use**
• Leverage the demand for ICT services of mechatronics to help the local ICT sector climb up the value chain. • Government digitalisation policies can be used to nurture demand for ICT services and hardware, if focused on major challenges for Bulgarian industry/mechatronics. • Though COVID-19 will hurt already low incomes, it could spur a cultural shift towards more online consumption and demand patterns, which might open new opportunities for digitalisation. • Combine EU and national public procurement and define targets for product and services development on national level through procurement policies. • Coordinate eGovernment spending with citizens' digital literacy measures and ICT integration in enterprises. • Work on internationalisation and demand from global growth markets through the provided EU funds.	• Slowdown or reversing of the globalisation, which would decrease demand for Bulgarian goods and services. • Change in the political priorities on EU and subsequently Bulgarian level away from the identified transition areas. • Slowing of demand growth in Bulgaria.

3 The desired state of the system

This chapter provides an overview of the future desired state of the chosen thematic area for industrial transition in Bulgaria along the four systems of the POINT review: orientation and planning, resource mobilisation, production and consumption and use. It also outlines any missing elements or linkages of the systems and proposes possible pathways for reaching their future desired state.

3.1 Orientation and Planning

3.1.1 Current scope and degree of ambition

Bulgaria's vision of the future desired state of digitalisation in the course of industrial transition is elaborated in a number of interrelated strategic documents, which constitute the basis for the understanding of the political will and the agreed headline targets in this area.

- The National Development Programme 2030 provides the overarching perspective for the development of the country in the next decade and will likely guide the government's thinking in implementing the resources from the next Multiannual Financial Framework 2021 – 2027 and the Recovery Package.
- The draft Partnership Agreement (PA) for Bulgaria 2021 – 2027[98], the principal document guiding the management of EU funds and national co-financing in the country, states that the four strategies guiding the interventions related to Bulgaria's "innovative and smart economic transformation", include:
  - the updated Innovation Strategy for Smart Specialisation 2021 – 2027 (not yet available),
  - The National Strategy for Development of Scientific Research of the Republic of Bulgaria 2017-2030,
  - The National Strategy for SMEs in Bulgaria 2021-2027[99], and
  - The strategic document Digital Transformation of Bulgaria for the period 2020 – 2030.

The government's specific goals in the area of ICT, mechatronics and digitalisation are spelled out in greater detail in the strategic document Digital Transformation of Bulgaria for the period 2020 – 2030 and the Concept for Digital Transformation of the Bulgarian Industry (Industry 4.0) 2017 – 2030.

The overall headline goal of Bulgaria's smart specialisation defined in the draft PA is to rise up to the group of moderate innovators in the European Innovation Scoreboard, including all of its regions[100]. The level of ambition has increased to reaching 65% of the EU level by 2028 compared to the current level of 50% by 2020.

The draft PA introduces two new approaches. Firstly, Bulgaria intends to introduce a much stronger regional dimension, including regional RIS3s with higher focus and specialisation, picking up just two of the four national RIS3 thematic priorities. Secondly, the draft PA envisages the introduction of a new governance element, an Agency for Research and Innovation at the Council of Ministers[101]. The main focus of the agency would be ensuring better coordination of fragmented national R&I policies, synergies between different EU funds' programmes, and overall system integration on national and regional level. The agency would also contribute to the systemic adoption of digitalisation in the Bulgarian public administration. The agency would run a newly drafted Operational Programme on Smart Transformation, which aims to (i) enhance the quality, capacity and productivity of the science and innovation system; and (ii) accelerate the digitalisation of public services for the benefit of citizens and businesses.

In a nutshell the consensus strategic vision outlined in the four strategies singled out in the PA can be summarised as 'Bulgaria achieving the average EU level of penetration of digital technologies in the Bulgarian economy and society, so that by 2030 it is recognized as a regional centre of the digital economy through the implementation of products, technologies, business models and processes from Industry 4.0 for modernisation, automation and competitive positioning of the Bulgarian economy in the medium to long run'[102]. The PA focuses on achieving successful digital transformation of Bulgarian SMEs in the framework of Industry 4.0, circular

[98] The draft PA is available in Bulgarian at https://www.eufunds.bg/bg/node/4825.

[99] The draft strategy is available in Bulgarian at: https://mi.government.bg/files/useruploads/files/investment-policy/SME_Strategy_BG_8DEC_2020.pdf

[100] As of 2020 only Bulgaria's South-West Region, which includes the capital of the country Sofia is in the group of the moderate innovators.

[101] The Concept for the creation of the Agency for Research and Innovation has been put to public discussion by August 20, 2020, which can be seen in Bulgarian at: http://www.strategy.bg/PublicConsultations/View.aspx?lang=bg-BG&Id=5333. The Council of Ministers has voted the creation of the Agency in September and it is planned to be operational by the end of 2020.

[102] Strategic document Digital Transformation of Bulgaria for the period 2020 – 2030, p. 8 [Available in Bulgarian and English]

economy and the European Green Deal. It further notes that digitalisation and technological upgrade support would be focused outside the capital Sofia and outside the IT sector, which have received the bulk of financing in the past programming periods.

The PA provides an overview of the different stakeholders or actors related to industrial transformation, including: Bulgarian SMEs, entrepreneurs and entrepreneurial associations, clusters, research and knowledge creation units (CoC, CoE, regional innovation units and research organisations, universities, etc.), Sofia Tech Park, industrial zones and parks, schools, public sector and government organisations, digital innovation hubs, technology transfer offices, European networks of technology transfer and business development (such as Enterprise Europe Network), etc.

The priorities of the PA seem to have been closely mirrored in the draft National Recovery and Resilience Plan of the Republic of Bulgaria. The plan is intended to kick start the economy after the COVID-19 crisis and provide the basis for sustained economic growth, while contributing to the dual goals for a green and digital transformation. The Plan has divided the government's planned interventions under four pillars: Innovative Bulgaria (20% of the total funds available), Green Bulgaria (37%), Connected Bulgaria (22%), and Just Bulgaria (21%)[103].

In terms of peers to follow in its digital transformation and practices to borrow, Bulgaria could focus on two European regions[104]: (a) the digital front-runners from Northern Europe (Nordic countries, Belgium, the Netherlands, Ireland, and Estonia), and (b) digital challengers or candidates from Central and Eastern Europe (all new Member States, except Estonia).

3.1.2 Stakeholder vision for the future economy

In relation to a vision of the future in ICT & mechatronics the consultations under this POINT review have demonstrated that there does not seem to be a clear collective vision amongst key stakeholders, where Bulgaria could stand in ten years.

Obviously, in the enterprise sector orientation and planning is predominantly conducted by the businesses and entrepreneurs for their own business strategic and commercial purposes. There are few large indigenous enterprises who can set out a transformation path that can act as inspiration to other actors. However, there are a number of enterprises who have initiated concrete steps and investments to address the shortcomings, such as in education and applied research in both ICT and mechatronics. Examples of such have been provided in Chapter 2.

Stakeholders in ICT and mechatronics has been increasingly active through their business associations and other forms of voluntary organisations. Through the tripartite social dialogue and the obligatory public consultations process such organisations have become more actively involved in the drafting of strategic documents on national level in and outside Parliament[105].

In addition, the various cluster organisations set up in many sub-sectors, including ICT and mechatronics engage in activities for the benefit of their members. Although these are predominantly business led initiatives, the government has acted as facilitator providing funding through the OPs to help these type of networking activities to evolve. In a similar vein it can also help steer their orientation and long-term social contributions. In this respect, the Bulgarian government could seek more proactively to support existing private sector initiatives, which it deems successful in priority areas such as digitalisation, ICT and mechatronics. For example, network industries, such as banks and telecom operators, could serve as important enablers and amplifiers of government policies.

The key stakeholders are facing a number of major bottlenecks that hamper growth and diversification into higher value-added parts of the international value chains. The common view amongst them voiced during the consultations for the current POINT review is that in order to progress with industrial transition, a number of structural reforms are necessary in particular:

- Improving the education system and lifelong learning in order to raise the general skill levels as well as the digital skills across the population;

[103] Council of Ministers, National Recovery and Resilience Plan of the Republic of Bulgaria, Available online at: https://www.nextgeneration.bg/upload/36/Bulgaria_Recovery_and_Resilience_Plan_ENG.pdf

[104] McKinsey, The Rise of Digital Challengers, presentation in Sofia.

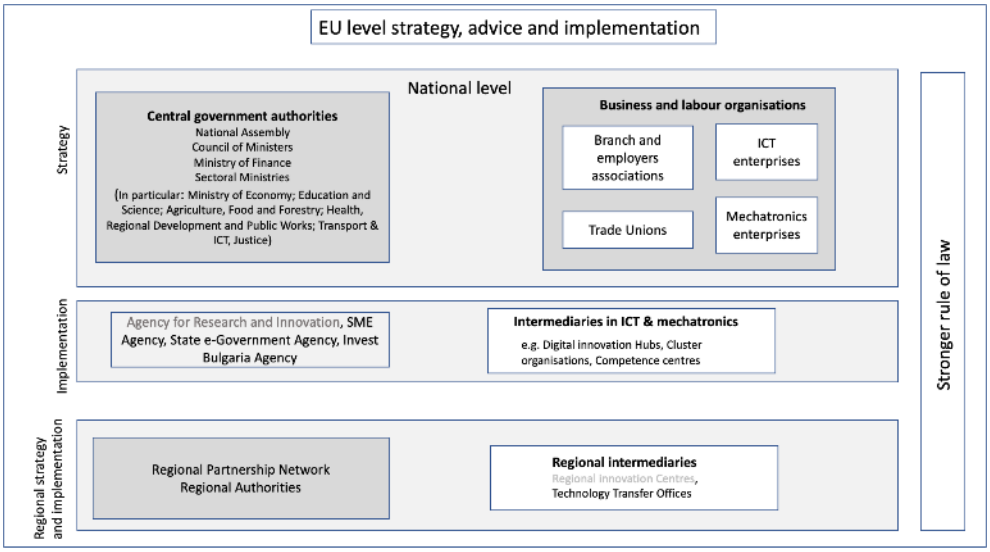
[105] All draft laws are published on the Bulgarian Parliament's web-site, while all strategic documents and decisions of the Council of Ministers, including the PA are published online at the portal for public consultations www.strategy.bg.

- Developing whole-of-government approaches to future strategies and policies instead of fragmented policies;
- Enhancing the implementation of policies and in particular ensure that strategies and initiatives are carried through with transparent investment schedules. Too many initiatives are launched waiting for subsequent funding;
- Broadening the scope of R&I funding to go beyond infrastructure and equipment projects, but rather a more holistic approach to business innovation.

3.1.3 Connections

The following Figure 20 depicts the main actors and important external conditions for the system of orientation and planning in Bulgaria as it relates to industrial transformation through digitalisation on the example of ICT and mechatronics. The roles of the individual actors in the system have been described in Chapter 2.

Figure 20 Orientation and Planning



Note: As of November 2020, the Agency for Research and Innovation is not operational and Regional innovation Centres do not exist.

The central government authorities are crucial players in Orientation and Planning as they plan and implement both the national and European funding for the industrial transition system. They have a strong role in setting out the directions for key policy areas that affect the ICT & mechatronics production and consumption systems such as digitalisation strategies, education, research and innovation and regional development policy. The two-key system – external variables that have been outlined by stakeholders as important determinants for industrial transition success have been EU level interaction (conditionality) and the quality of rule of law and public governance. The following paragraphs elaborate which linkages in the system could be reinforced to support the industrial transition processes.

3.1.4 Missing parts and reconfiguration

The system Orientation and Planning seems to have all the needed key actors or institutions in its structure. At national level, there seems to be even an oversupply of actors and institutions, which might require better coordination and delineation of functions. There is notable deficiency of specialised players in this system at regional level though. However, what the most important missing parts of the system are structured platforms for continuous dialogue and strategy forming between different groups of stakeholders, particularly between government authorities and non-government stakeholders in industrial transformation (e.g., enterprise sector and trade unions). In order to ensure industrial transformation and change, reconfigurations in the linkages between the existing key actors are necessary.

The key reconfigurations that could help enable industrial transformation are:

1. Better **coordination and policy coherence** between policy domains that shape industrial transformation (e.g., education, innovation, digitalisation, industrial and regional policies).

2. Stronger interaction and coordination between the **national and regional** authorities.
3. Continous, reliable and transparent **implementation** of strategies and policy interventions.
4. **Stronger rule of law and governance mechanisms** to regain overall trust in government actions.
5. Enhanced **partnership and engagement** between the public authorities, the enterprise sector and other stakeholders affected by industrial transformation.

Better coordination and policy coherence

The draft Industry 4.0 Strategy for Bulgaria[106] notes in its SWOT analysis that one of the weaknesses of the system is the lack of a coherent policy and a whole of government approach to digitalisation. This gap seems to have been dealt with the development of the strategic document Digital Transformation of Bulgaria for the period 2020 – 2030[107], which integrated more than a dozen existing strategic documents across the whole government. For the first time, the development of such a strategic document on digital transformation also involved representatives of all the line ministries and different government agencies. Yet, this initial step for coordination needs to be further strengthened. The underlying institutional fragmentation with silos between the agencies responsible for different domains under the direction of line ministries, such as investments, SMEs, sustainability, metrology, digitalisation, etc. requires a lot of coherent coordination to implement what is essentially a horizontal policy, such as digitalisation.

Despite the underlying fragmentation, Bulgaria has a strong asset in its system with the Council of Ministers (CoM) overseeing policy strategy across all policy areas. In addition, the Council of Ministers holds the coordination of all EU and EEA funds' programmes, in which Bulgaria participates (e.g., the Norwegian and Swiss support programmes, etc.) It also manages the EU funds' Unified Management Information System, which could allow for a robust monitoring and evaluation function to support policy development. In the desired system the overarching coordination body such as the Council of Ministers has a well-resourced secretariat to prepare policy work, including a Strategic Intelligence Unit that coordinates, delegates and if needed conducts the data gathering and analysis necessary to develop evidence-based policy strategies. This is a major missing link in the current system.

In 2020 the Council of Ministers has proposed to further strengthen its operational involvement in guiding digitalisation in the country through the establishment of a new Agency on Research and Innovation under its management. The idea is for the agency to play a policy coordination role through taking over the implementation of Bulgaria's RIS3. At the same time, the Council of Ministers concept for the agency foresees that it manages a newly created OP, which would seek to develop missing transformation links between different government policy areas and between the central and regional government. The agency would focus on system change in the research and innovation system as well as on digitalisation[108]. Indeed, adding another agency might result in further policy fragmentation if the position of the agency at the Council of Ministers does not allow it to pull together resources from other policy domains, and if it replicates existing functions. It would be important for the agency to develop a clear whole of government approach and also focus in its early stages of development on delivering different policy experiments, which have not yet been tried in the country in the ICT and mechatronics domains.

The National Development Programme 2030 demonstrates this 'whole-of-government' approach by addressing a breadth of national policy objectives and the inter-linkages between them. However, in its implementation this risks to be divided in sub-systems that do not take into account the potential synergies or contradictions. Of course, working horizontally across government implies coordination costs, which cannot always be justified. However, the transition is an exceptional case, with stakes that are high enough (see Chapter 1) to justify the additional coordination effort.

Regarding the domain of mechatronics and ICT this means in particular a close cooperation between the Ministry of Economy, the Ministry of Education and Science, The Ministry of Transport, Information Technology and Communications and the Deputy Prime-Minister's office overseeing Structural Funds investment. The existence of inter-ministerial working groups on topics such as digitalisation is also an important asset. However, these

[106] Ministry of Economy, 2019, Strategy on Bulgaria's Participation in the Fourth Industrial Revolution (Industry 4.0), Draft
[107] Strategic document Digital Transformation of Bulgaria for the period 2020 – 2030, [Available in Bulgarian and English]
[108] The Concept for the creation of the Agency for Research and Innovation can be seen in Bulgarian at: http://www.strategy.bg/PublicConsultations/View.aspx?lang=bg-BG&Id=5333. The Council of Ministers has voted the creation of the Agency along this concept in September and it is planned to be operational by the end of 2020.

need to be made continuously operational to ensure the constant flow of information even outside the initial efforts towards creating a common strategic document.

Interaction and coordination between national and regional authorities

If there is one clearly missing link in the Orientation and Planning system that could be reinforced in the future, it is in the coordination between the national, regional and local authorities. The link to the local (NUTS IV or municipality) level is in particular missing in Bulgaria. The NUTS IV is the first, or closest to the citizens and companies, level of political representation and accountability. This makes it the level most directly involved in identifying emerging competitiveness strengths and weaknesses. It is also the most cash strapped level, as most of the municipalities outside the six largest cities and the seaside and winter resorts, rely for their budget on the central government level. The intermediate NUTS II and III levels are directly appointed by the central government, and can serve as a link or transmission of dialogue between the central and the local level.

Continuous, reliable and transparent implementation

Continuity and reliability in the support of priorities from the RIS3 strategy and in particular for the thematic domain of the POINT review, support for the modernisation and digitalisation of the manufacturing sector (mechatronics) is needed. Several initiatives have been approved such as the establishment of Digital Innovation Hubs and Regional Innovation Centres but the funding for these important intermediary organisations has been postponed in the wake of the global coronavirus pandemic. Stakeholders from the enterprise and business services involved cannot perform their activities without predictable backing by the government. This postponement of implementation is not conducive to a relation of trust between the government and business sectors. In this respect, there have been positive signs that the Council of Ministers intends to continue support for these initiatives in the new programming period, including also support for the biggest single investments of the OPs so far, the CoE, CoC and the Sofia Tech Park.

One of the issues that adds to the implementation bottleneck is the underinvestment in human resources and competencies within the implementing agencies across the policy spectrum and at regional and local levels. This will need to be addressed in the next Operational Programming cycle.

A stronger monitoring and evaluation system, based on European best practice and the development of comprehensive datasets, needs to be set up that goes beyond the formal accountability requirements for reporting on the Structural Funds expenditures. The monitoring and evaluation system needs to be aligned to a clear set of objectives and targets at policy, programme and project level. In particular it needs to take account of actors outside the OPs' beneficiaries to take account of the whole of the economy and avoid bias towards companies that have already been successful in winning government contracts.

Stronger rule of law to regain trust in government actions

Implementing the range of industrial transition policies considered here in Bulgaria would require a considerable improvement in the general trust in government, which calls for a continuous advancement of rule of law and improvements in governance practices. One way to achieve this is through adhering to international (such as the World Bank governance and doing business indicators) and European (semester, internal market scoreboard, rule of law report) benchmarks on governance. Areas of particular importance for the success of the chosen industrial transition theme are public procurement, business environment, and commercial dispute resolution, for example. Stronger rule of law reduces transaction costs and could encourage entrepreneurship and private investment, which is very much needed in the case of Bulgaria's drive for digitalisation.

Based on the feedback in the stakeholder meetings, it appeared that the interaction between on the one hand the government sector and the stakeholder communities in the enterprise and social sectors is not well developed. While maintaining good governance principles, organising continuous stakeholder dialogues supports the effectiveness of strategies aimed at boosting the economy. In a desired system this linkage would be organised more systematically and based on mutual trust. It would build and take further existing mechanisms for cooperation, such as for example the tri-partite social partners dialogue, to include numerous additional opportunities for involving more actors, such as regular thematic fora, award competitions, feedback mechanisms, etc. In particular, in the ICT and mechatronics domain this could involve engaging with different clusters within the two sectors and seeking feedback on shaping relevant government policies such as public procurement for digitalisation.

Enhanced partnerships and engagement of the enterprise sector

The interconnection between the government authorities and the enterprise sector at the level of strategy formulation and future orientation for industrial transformation, does not have any formal or long-term

dialogue platforms, where exchange of views can take place. Stakeholder engagement is ad hoc and not focused at strategic development and coordination at system level.

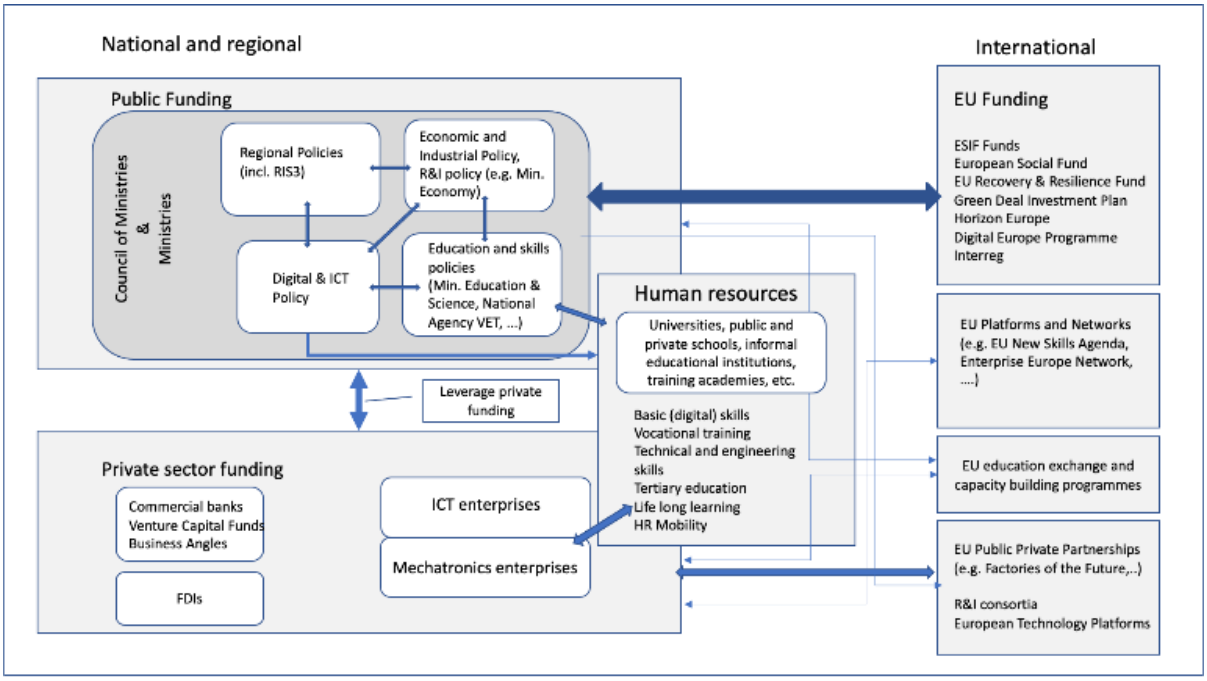
Due to the low level of trust in the public authorities' implementation capacities, key stakeholders, rather than engaging in dialogue with government authorities, engage in private sector initiatives such the ones described earlier in education. The weak interaction between the two segments in the orientation and planning system is illustrated by the dichotomy between the public and private sector education initiatives. This dichotomy hampers the potential synergies that could be achieved if public-private partnerships are embraced.

3.2 Resource mobilisation

3.2.1 Connections

Figure 21 depicts the key actors and mechanisms in the resource mobilisation system, most of them already described in Chapter 2.

Figure 21 Resource Mobilisation



As stated in the previous chapters, Bulgaria compared to other EU countries is undercapitalised and the gap is closing only slowly. European funding is the single most important source of investment and driver for transformation of the Bulgarian economy. Bulgaria is among the EU countries with the highest EU support as a share of GDP and per capita in the EU. The instituting of the Recovery and Resilience Plan will further increase the EU resources available to Bulgaria. According to the preliminary allocation key, Bulgaria is likely to receive in the next years additional €15 billion euro (€12 billion in grants and €3 billion in loans) from the EU, which would constitute slightly more than 19% of the country's annual GDP[109]. Part of these funds are likely to offset the loss of national budget revenue as a result of the COVID-19 pandemic. In addition, the relaxing of the EU fiscal constraints in response to the crisis is likely to provide some more options to the Bulgarian government, which enjoys stable low level of debt and sound public finances. The EU recovery resources are likely to be approved together with the next Multiannual Financial Framework (MFF) by the beginning of 2021. The Bulgarian government has a very narrow window of opportunity to prepare for putting in place the system architecture and the organizational configuration to deliver the envisioned digital industrial transformation.

[109] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1590742540196&uri=SWD%3A2020%3A98%3AFIN

The next MFF prioritises explicitly digitalisation, which will aid the Bulgarian government to fast-track projects in this domain. The Recovery Package would allow for additional resources to be directed towards priority transformation initiatives in the 2021 – 2023 period. This comes on top of relaxed rules for spending the remainder of the funds from the 2014 – 2020 MFF in response to the coronavirus crisis.

Whether the EU resources will allow Bulgaria to achieve its headline targets for digital transformation will depend to a very large extent on the capacity and capability of the Bulgarian government to muster its own national resources and leverage EU funds to attract as much private investment, including European investment as possible. In this respect, digitalisation could be used to both increase the share of investment in the GDP as well as improve productivity and increase the county's catching up with its EU peers.

Private sector investment in Bulgaria is still very much dependent on public sector resources, in particular EU funds. Due to its relatively shallow capital endowment, as noted in Chapter 2, Bulgarian private sector entities are more overburdened with debt than their European counterparts, limiting their capacity to create capital through further borrowing. Hence, it seems particularly important for Bulgaria to continue and intensify the attraction of fresh FDIs.

3.2.2 Missing parts and reconfiguration

Both analysis and stakeholder consultations on the state of play in resource mobilisation point towards the following missing elements and needs for reconfiguration:

1. Leveraging private sector funding into different parts of the Industrial Transformation systems. Attracting more strategic FDIs in ICT and mechatronics, as well as other industrial sectors.

Across the system there is a serious underinvestment in human resources. The way forward could be significantly improved and sped up by the adoption of a nation-wide skills agenda that prepares Bulgaria for industrial transformation, combined with a missing platform involving stakeholders to jointly develop and grow that agenda.

Making better use of synergies between the different EU funding mechanisms and sources to achieve joined up and coherent policies to support industrial transformation.

Leveraging private sector funding

Leveraging private resources will be an important factor in amplifying the effects on growth and jobs of the industrial transformation. In this respect, banks and other financial intermediaries will be an important actor and multiplication mechanism. During interviews for this report public and private bank stakeholders have noted the need for the Bulgarian government to try to develop more public-private partnership projects, which are commercially viable and attractive to the private sector. In this respect, it seems that it will be important for the Bulgarian authorities to try to empower as many intermediaries as possible in engaging, spinning off, incubating, or joint-venturing private sector actors to help Bulgarian mechatronics businesses integrate local ICT knowledge in production, and as a result improving the productivity of manufacturing sector whilst providing a path of value-chain upgrading for the ICT sector. Experience from other countries demonstrates that trying to involve businesses in public intermediary organisations, such as Centres of Excellence, Centres of Competence, Digital Innovation Hubs, etc. is unlikely to produce much co-investments. Instead, these public intermediaries need to focus on developing as many as possible privately bankable projects in the target areas to attract new investments. In the case of Bulgaria, with its limited internal capital market, it is important that such projects attract FDIs. One pathway to achieve this is through much better integration of the country into pan-European networks, such as the Enterprise Europe Network and others.

An important source of new capital for Bulgarian business is its partners in Europe, where most of the markets of the Bulgarian ICT industry are. In this respect, many business leaders have underscored in interviews for this report the need for the Bulgarian government to support the shortening of the supply chains for European multinationals, re-directing more resources to closer to home EU markets. For this to have a long-lasting impact on the Bulgarian economy and society though the system actors need to prepare and ensure a steady stream of adequate human resources and better business environment, including rule of law and stronger market regulation.

Addressing the underinvestment in human resources

Strengthening the **human resource factor** is a key element underpinning industrial transition. The demographic situation in Bulgaria is not easily solved in the short term and therefore any future system will need to take account of the shortage of human resources across the entire economy.

The National Development Programme 2030 acknowledges the dire situation with human resources in Bulgaria and outlines possible directions for addressing it. Yet, its ambition falls short of comprehensively addressing the skill deficit by 2030. In view of the new opportunities presented by the EU impulse towards digitalisation, and funding from the Recovery and Resilience framework, the Bulgarian government needs to build a long-term national consensus on binding targets for improving two critical aspects of the output of the country's education system:

- Firstly, Bulgaria needs to increase dramatically the level of school participation and the functional literacy of high school students, which would form the backbone of a potential blue-collar workforce. These are currently among the lowest in the EU.
- Secondly, the country needs to focus on increasing digital literacy and skills across the board, alongside increasing the quality of higher education in cooperation with the business community, including new investors from Europe.

For the industrial transformation to stand any chance of success, education and skills need to be improved across many levels. The main ambitions for a desired system would be:

- An augmented level of digital skills acquired in the formal education sector including Vocational Education and Training (VET) and Higher Education Institutions;
- A system that supports re-skilling and up-skilling of those in work as well as those not in the labour force, and which preferably operates in close cooperation with the business sector;
- The establishment of an active and effective strategic platform where future skills needs and investments are discussed with representatives of government, education and business, that builds on international good practice examples[110];
- Outlining an ambitious plan for attracting talent from Europe and internationally, which could target Bulgarian diaspora returnees from the EU and the US, underutilised young graduates from Southern Europe, and specialised skilled workers from other neighbouring countries.

It will be important to put mechanisms in place to ensure that the increase in skills investments benefits primarily the Bulgarian economy. Doing so requires linking the national skills drive with business investment and the creation of employment, so that newly skilled human resources can be productively absorbed by the Bulgarian labour market and not fuel further emigration. One possibility would be the introduction of a dynamic allocation mechanism for skills budgets, whereby additional business investment results in greater skills budgets. The mechanism could operate at a low level of territorial aggregation (e.g., a region or city) and give say on skills development to local businesses, thus effectively tailoring skills to market needs.

The **European New Skills Agenda** launched in 2016[111] has triggered a number of activities and initiatives to make the right training skills and support available to people in Europe. Particularly interesting for the thematic domain for this POINT review are the Blueprint for Sectoral Cooperation on Skills[112] where stakeholders work together in sector-specific partnerships to develop and implement strategies to address skills gaps in these sectors. Bulgaria could launch its own national alliances in parallel with these European initiatives and take advantage of the findings and results of these European alliances. Another interesting initiative within of the New Skills Agenda is the Digital Skills and Jobs Coalition to support the cooperation among education, employment and industry stakeholders with the goal of improving the digital skills of the wider population.[113] In one of the stakeholder meetings for this POINT review the active role that commercial banks can play in spreading the use of IT tools across the Bulgarian population by disseminating on-line banking and related IT-tools was discussed as an interesting opportunity. The future Bulgaria wide skills strategy should be closely linked to the national Industry 4.0 and Research and Innovation strategies and is already highlighted in the National Development Programme 2030.

The New Skills Agenda makes a strong plea for reinforcing Vocational Education and Training (VET) as it is valued for fostering job-specific and transversal skills, facilitating the transition into employment and maintaining and updating the skills of the workforce according to sectoral, regional and local needs. Business and social partners should be involved in designing and delivering VET at all levels, as demonstrated in the "dual

[110] See for example the longstanding Irish Expert Group on Future Skills Needs (http://www.skillsireland.ie/), set up in acknowledgement of the crucial role that skills have played in underpinning FDI into Ireland and its current levels of prosperity.
[111] https://ec.europa.eu/social/main.jsp?langId=en&catId=1223
[112] https://ec.europa.eu/social/main.jsp?catId=1415&langId=en
[113] https://ec.europa.eu/digital-single-market/en/digital-skills-jobs-coalition

system" of apprenticeships. VET should include a strong work-based dimension, whenever possible coupled with an international experience. To ensure the balanced development of skills, it is advisable to foster much stronger collaboration in the triangle of education, business and government. As shown by a recent study for the European Commission on Skills for SMEs[114], SMEs face particular challenges in accessing and developing the skillset necessary to adopt new technologies related to Big Data, the Internet of Things and Cybersecurity. The report has elaborated a roadmap with supporting measures for EU, national, regional and local levels. The roadmap rests on three evidence-based principles building on good practices identified across Europe, which are also very relevant for Bulgaria:

1. **Industry-led**, i.e., a skills development strategy based on a good understanding of the needs of SMEs. Doing so requires the regular collection of intelligence on the (changing) needs in the different value chains. The cross-industry collaboration between ICT and mechatronics could serve as an example in this respect;
2. **Tailored and innovative education and training:** offerings need to be tailored to make them useful for SMEs. This requires innovation of current approaches: modular, blended courses, targeted at SMEs in their specific sector and geography, delivered with flexible timing, with practical content to enable direct action of the SME.
3. **Government (co-) funded and data-driven**, while SMEs will have to invest at the operational level, good practices show that the overall strategy for fostering Industry 4.0 type skills will require considerable complementary public investment. Monitoring is required to assess if the training activities are effective and still respond to business needs.

Deficits in the skills to master new digital technologies can be found across different roles in an enterprise: 1) user skills by employees missing basic digital skills, 2) missing professional skills from IT specialists, and 3) digital leadership (eLeaders) skills in the management of enterprises. The roadmap for skills support should take account of these different roles as well as the differences in maturity of the uptake of digital technologies[115].

The Bulgarian education and training strategy can build on a pool of initiatives, studies and platforms set up under the New Skills Agenda. Inspiration for good practices can be found from a 2019 study report for the Executive Agency for Small and Medium-sized Enterprises (EASME).[116] Some relevant key findings and recommendations from this study are that:

- Skilling programmes need a long-term vision and strategy based on the needs of industry and have an inclusive approach to reduce inequalities;
- Higher education and VET providers could become larger re- and upskilling players with multi-stage funding models that could allow them to expand their capacities if proven successful;
- Business leaders and policy makers are to prepare for substantial investments in skills development;
- Policy briefs and guidance should be developed for policy makers aimed at a better integration in the future of new learning principles into education and training, career path tracking;
- Relevant key stakeholders at EU, Member State and regional levels should join forces and further develop VET competence centres based on clusters and digital innovation hubs.

These are important lessons to take on board in future skills strategies and investment plans in Bulgaria. A central lesson is that there are no quick fixes. An adequate response to the formidable challenge of skills development is the development of a *comprehensive skills system* that delivers results on multiple fronts: ascertaining skills needs, coordinating with businesses, gathering intelligence, mobilising resources for skills development, steering educational policy, broadening skill provision to include those already in employment, guiding capacity building in skill providers, empowering highly tailored local skill development, among other things.

The National Development Programme 2030 acknowledges this challenge and identifies competitive education and training and improving the access to and enhancing the quality of education and training as a key priority

[114] Capgemini Invent, Technopolis Group and the European Digital SME Alliance, 2019, Skills for SMEs, Supporting specialised skills development: Big data, Internet of Things and Cybersecurity for SMEs, Final Report, European Commission (EASME), Brussels.
[115] See Capgemini Invent et al 2019, page 8-9.
[116] Korte, W., T. Hüsing and E. Dasha, (2019), Skills for Industry, High-Tech Skills: Scaling up best practices and re-focusing funding programmes and incentives, Empirica report for EASME, Brussels.

to raise living standards in Bulgaria.[117] In 2020 the OECD published a report on *Strengthening the Governance of Skills Systems* that provides lessons from six OECD countries.[118] The report identifies four challenges that need to be met in order to strengthen skills systems:

- Promote co-ordination, co-operation and collaboration across the whole of government.
- Engage with stakeholders throughout the policy cycle.
- Build integrated information systems.
- Align and co-ordinate financing arrangements.

The current production and consumption systems in Bulgaria lack an authoritative and continuous platform to monitor, discuss and strategically plan for the economic and societal needs for education, training and skills development. On this matter well documented good practice examples from other countries can help to define how such a platform could be introduced in Bulgaria (Box 8).

Box 8. Platforms bringing together stakeholders in the skills area across Europe

In **Denmark** national trade committees (faglige udvalg) constitute the backbone of the VET system. Approximately 50 trade committees are responsible for 106 main programmes. The committees normally have between ten and fourteen members and are formed by labour market organisations (with parity of membership between employer and employee organisations). Local training committees, meanwhile, are affiliated to each vocational college and ensure close contact between vocational colleges and the local community, thus improving responsiveness to particular local labour-market needs.[119]

Ireland established a National Skills Council in 2017. Its members are formed of representatives of the Education Department, the Department of Business, Enterprise and Innovation, the Department of Public Expenditure and Reform, the Department of Employment Affairs and Social Protection and Employers. The Council is supported by a number of bodies that support its work, including the gathering of data, providing future perspectives and linking the Council to Regional Fora, as is shown in the following schematic overview[120]:

In the **Netherlands** the *Platform Bèta-Techniek* was set up in 2004 as a foundation to specifically address the shortage of people in the labour market with technical skills. It was set up as a public-private partnership between employers, trade unions and educational institutions. The organisation was financially supported by the Ministry for Education, Culture and Science, the Ministry for Economic Affairs and the Ministry for Social Affairs and Employment. Activities included promotion of technical school subjects to young people and

[117] The programme also acknowledges that (NDP 2030, page 12): "discrepancies between the knowledge and skills of the workforce and the needs of the labour market, in particular the skills associated with new technologies, are a serious obstacle to the development of the competitiveness of the Bulgarian economy. Creating a closer relationship between education, training and business needs is the major focus of this priority."

[118] OECD, (2020), Strengthening the Governance of Skills Systems, Lessons from six OECD countries, OECD, Paris, https://www.oecd.org/publications/strengthening-the-governance-of-skills-systems-3a4bb6ea-en.htm

[119] Andersen, Ole Dibbern & Helms, Niels Henrik (2019). Vocational education and training in Europe: Denmark. Cedefop ReferNet VET in Europe reports (2018).

[120] Burke N.; Condon, N.; Hogan A.; (2019). Vocational education and training in Europe – Ireland. Cedefop ReferNet VET in Europe reports 2018.

particularly girls, bringing together companies and VET colleges in the regions, addressing the shortage of teachers in the technical subjects, awareness building in companies to cooperate with regional colleges for further education of their workforce. In addition, the organisation monitored data, for instance on the number of pupils and teachers in technical subjects in all types of education, the (financial) involvement of companies in schools and VET colleges. In 2017 the organisation could report a rise in the number of both pupils and

teachers in technical subjects, the increased involvement of the business sector with education institutions led to a number of innovative approaches to make VET colleges more attractive for students and businesses. In 2019 the Platform merged with a number of other initiatives into the Platform Talent for Technology (in Dutch only: https://www.pbt-netwerk.nl).

Create synergies between different European funding mechanisms

One possible pathway to speeding up the industrial transformation in the chosen domain in Bulgaria would be better coordination and use of the different EU level instruments. The Bulgarian government could for example create a continuous feedback loop between EU and national programmes. On the one hand, it could support Bulgarian private and public sector organisations'' participation in strategic EU initiatives and programmes (such as Horizon 2020, EEN, Interreg, scoreboards, evaluations, etc.). On the other hand, it could more actively engage in piloting and implementing in Bulgaria outcomes or results from EU projects or initiatives. It could further streamline and strengthen the synergetic effect from making use of EU capacity, such as for example: (i) the management of financial instruments by the European Investment Bank under OPs, or (ii) the employment of advisory services provided by the JRC in support for smart specialisation or the management of the centres of excellence and centres of competence.

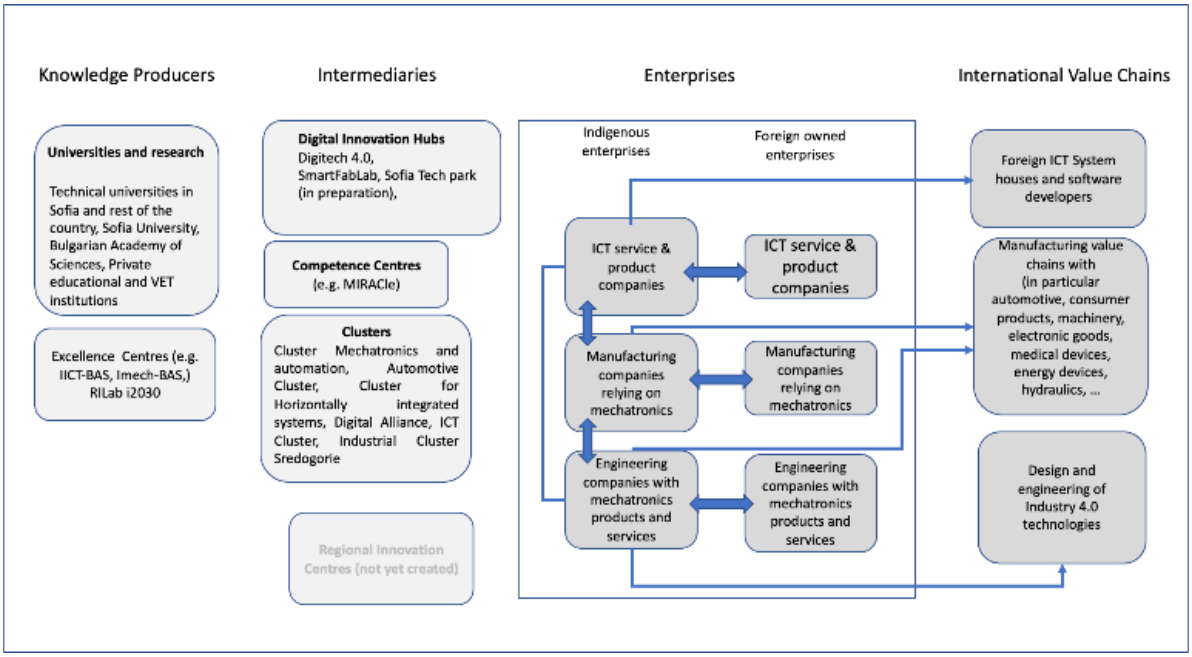
Bulgarian stakeholders need to be on the constant lookout for good European practices in the industrial transition domain to adapt and implement in the country. In this respect, the Bulgarian government could help by encouraging the Bulgarian participation in EU-wide projects and programmes for digitalisation and then ensure OP resources for mainstreaming relevant outputs in Bulgaria.

3.3 Production

3.3.1 Connections

Figure 22 depicts the Production for ICT & mechatronics in Bulgaria. In addition to the enterprise sector and the international value chains in which they conduct business, the knowledge production actors and intermediaries are also important actors in the system. Their characteristics and roles, including the provision of specific company examples, are described in Chapter 2.

Figure 22 Production



3.3.2 Missing parts and reconfigurations

The industrial eco-system for ICT and mechatronics lacks large-sized, R&D intensive companies, both indigenous and foreign owned, that create networks of local suppliers and push established digitalisation patterns to its supply and customer base. Access to these types of companies could incentivise local suppliers to upgrade their technological and digital capacities.

In the desired system the following interlinkages and reconfigurations in the subsystem can enhance the industrial transition process:

1. Stronger business interactions between the different segments of the sectors in the domain, in particular between ICT service companies and manufacturing companies relying on mechatronics and in need of digitalisation.
2. Stronger inter-connections with cross-border partnerships, particularly with the ambition to tap into the high-end of value chains.
3. Enhanced implementation of the intermediaries that can support digitalisation, innovation and networking in enterprises.
4. Investment in the public R&D capacities, particularly for the universities.

Stronger business interactions across the sub-sectors

Enterprises in the mechatronics sectors have a clear need to upgrade both their process technologies as well as their product innovation using a variety of digital technologies. Establishing closer business linkages with Bulgaria's ICT enterprises, and particularly ICT service companies with expertise in electronic engineering can contribute to the reinforcement of digitalised production processes in manufacturing businesses. The low absorptive capacity for innovation and digitalisation of the Bulgarian manufacturing companies and particularly the SMEs will need to be raised.

The fact that Bulgaria has a strong and growing ICT (service) sector co-existing with pockets of strength in mechatronics-based industries, does not automatically mean that there is a strong business case for companies from both sectors to integrate and do business together. The business models of companies in these sectors are not necessarily aligned and are likely to operate in completely different supply chains. This needs a level of **cross-fertilisation** between different types of business that faces a number of barriers such as information and network failures. While the mechatronics sector faces more urgent pressures to digitalise and incorporate competencies available in the ICT sector, particularly the ICT service sector working for customers operating on global markets are unlikely to switch their business activities to local firms operating in lower value supply chains. The absorptive capacity of many firms in the Bulgarian manufacturing sector is likely to be too low. They are therefore not a commercially interesting customer base for the domestic ICT sector. Changing this might call for specific government interventions to spur cross-industry work.

Chapter 2 described the low DESI scores for integration of digital technologies and internet services for Bulgaria. Industrial Transformation will only reshape the economy if the general level of digital skills across the business sector is augmented.

In addition, as stated clearly in the stakeholder meetings, Bulgarian manufacturing businesses do not only need to acquire better technologies, they are in need of upgrading their entire business and particularly improve their in-house product development capacities and customer focus. This asks for an integrated innovation support approach that combines hard technologies with soft innovation skills and possibly completely new business models.

The best chance for a mobilising a transition in the shorter term is to identify different niches of emerging innovators within the Bulgarian manufacturing sector that do have the capacity to develop new business based on further digitalisation and integration of other Industry 4.0 technologies. The most likely actors that can identify and activate these emerging innovators are the intermediary organisations, in particular such already working on EU level, like the Enterprise Europe Network, the teams that have developed a steady stream of Horizon 2020 and previous Framework Programmes' but also the various clusters, the Digital Innovation Hubs, as well as the Regional Innovation Centres in the future. Sofia Tech Park as well as thriving industrial zones could also provide good platforms in this respect should the Bulgarian government design specific rules of engagement for their operation.

Stronger inter-connections with cross-border partnerships

Another route to mobilise companies with a potential to move up international value chains and (re-)focus their attention to potential customers in Europe is to facilitate their **interaction with key European public-private-partnerships** in research and innovation. Examples of such networks are the current Contractual PPPs that operate under Horizon 2020 such as the European Factories of the Future Research Association (https://www.effra.eu), that is proposed to continue as *Made in Europe* under the new Horizon Europe Programme. Another industry led partnership of interest proposed for Horizon Europe could be the *European Partnership for Key Enabling Technologies*. Both are foreseen to start in 2021 depending on final decision on Horizon Europe. Multi-lateral initiatives such as Industry4.E (https://industry4e.eu) are also of interest to Bulgarian government agencies and intermediaries to relate to for support. Providing a limited amount of financial support for international travel and conference attendance for companies with a potential to find partners in these networks is an instrument that has been applied in various European countries.

Very often developing new production capabilities and collaborations depends on the availability of new and abundant skills. Hence, the proposed vision for production collaboration needs to be aligned and integrated with the skills initiatives discussed in sub-section 3.2. In particular, manufacturing companies could support and follow suit from fledgling ICT companies' good practice in developing their own training and education academies. The government could aid these through a competitive grants programme.

Enhanced implementation of the intermediaries

In the desired system the Regional Innovation Centres and the Digital Innovation Hubs are fully operational and an adequate level of government funding secured for a period of at least 4-5 years.

Their mission should not follow the linear innovation model (i.e., aimed at 'selling' the research results of universities) but focus on comprehensive innovation capacity building within enterprises so that they can create high-quality employment and generate value for the Bulgarian economy and society. While it is important that these centres are equipped with state-of-the-art infrastructure and technical equipment, in the next OP funding phase emphasis should shift from purchasing infrastructure and equipment to building a pool of competencies and skilled staff in these Centres to be able to support enterprises to innovate and modernise. In addition, they need to seek to promote specific manufacturing productivity enhancement tools, such as digitalisation, automation, design, etc. They should also seek to promote cross-industry fertilisation, in particular the mobilisation of the Bulgarian ICT sector in the digitalisation of other sectors of the Bulgarian economy.

The government and the Centres have jointly agreed to a set of customised SMART (**S**pecific, **M**easurable, **A**chievable, **R**elevant and **T**imely) goals that are monitored regularly to assess whether their performance is on track.

Digital Innovation Hubs (DIH) are an initiative of the European Commission as part of the Digitalising European Industry Initiative. In the Future Financial Framework (2021-2027) more DIHs will be implemented through the new Digital Europe Programme. A recent study by the European Investment Bank came to the conclusion that DIHs play a critical role in facilitating the digitalisation of European companies. [121]

While Bulgaria has taken a good decision to establish the Regional Innovation Centres and Digital Innovation Hubs, in the future their funding should be more predictable and transparent and when functioning satisfactorily, be taken up as an essential cornerstone in the 'smart industry' ecosystem and digitalisation strategies that are foreseen in the NDP 2030. In particular, they need to be firmly rooted in and/or attract the investment strategies of key European multinationals in the ICT and mechatronics niches to ensure their sustainability.

Investments in knowledge production and flows

Responding to the weak interaction between the business sector and the public research system, the Bulgarian government has set up new initiatives as described in Chapter 2 (Box 3): Centres of Excellence and Centres of Competence in domains closely aligned with the RIS3 strategy. These initiatives have a dual role of conducting research and training researchers and delivering graduates that could add to the talent pool in Bulgaria. However, they do could also be handed an assignment to offer training to the enterprise sector which would be

[121] Casorati, A., A. Verbeek, Financing the digitalisation of small and medium-sized enterprises, The enabling role of Digital Innovation Hubs, European Investment Bank, 2020

a valuable contribution to addressing the skills issues. This would be an important addition to the production system.

As these initiatives have been established only recently, it is too early to assess their performance. In addition, in 2020 the government has unveiled plans to establish a new Agency for Research and Innovation, which would focus on building system links and establish missing governance actors in line with an updated RIS3 strategy.

When these competence centres such as the MIRACle are fully operational, in order to contribute to the industrial transition, they should position themselves as intermediaries between the business sector and research institutes and universities, taking guidance from lessons on these type of centres across many European countries. They can also take an active role in bringing together the competencies in the Bulgarian ICT sector on the one hand and the mechatronics sector on the other. That requires a transdisciplinary approach in their research and development activities.

In a desired system, companies in the manufacturing sectors applying mechatronics and other technologies that are captured in the global Industry 4.0 developments, would face low barrier to access state-of-the art know-how on the application of these digital technologies in their production process. The Centres of Competence are the typical organisations tasked with lowering access barriers to companies of different maturity levels. In order to move up companies to higher levels of the international value chains, they should not only engage in process innovation to improve their productivity, but also develop new products that can be commercialised internationally. The need to support product innovation was clearly voiced by experts and stakeholders during the consultation process.

Although there are quite different models in place, good practice from industry oriented 'Competence Centres' across many countries provides guidance to how this could be achieved:[122]

- They should facilitate the move from 'ad-hoc' industry academia collaborations towards a more strategic partnership for the longer term in specific technological and business domains, such as mechatronics and ICT;
- Applied industrial research type competence centres should have a clear role of industry in the governance of the organisations and contribute to shaping the research agenda;
- While moving towards a funding model where industry financial contribution increases over the years, have a realistic business model where government funding should facilitate its continuity if the centre performs according to the set targets.

The Government of Bulgaria has requested the JRC to provide a functional review of the CoE and CoC, which could provide possible solutions to strengthening their role as intermediaries in the knowledge flows from research to industry and between industries in Bulgaria, the EU and internationally[123].

Box 9. The Irish Technology Centre approach and the Irish Manufacturing Centre

In 2004 Forfás, the Irish national policy advisory board for enterprise, trade, science, technology and innovation, concluded that the levels of linkages between enterprise and academia were low and a cause for concern. This was re-emphasised in the National Development Plan 2007-2013. In the decade that followed this report Ireland established an applied research landscape, adjacent and linked to prevailing university research and government laboratories.[124] A key policy intervention that was taken to remedy this situation was the launch of the Technology Centre Programme by Enterprise Ireland.

Technology Centres allow Irish companies and multinationals to work together on market focused strategic R&D projects in collaboration with research institutions. The programme to initiate and support the centres was launched in 2007 and is jointly run by Enterprise Ireland, responsible to support Irish firms and IDA Ireland, responsible for Foreign Direct Investment.

[122] See for instance TAFTIE, (2016), Future Competence Centre Programmes, https://taftie.eu/sites/default/files/Taftie_TF_CompAct_Final_Report%20_LV.pdf; Arnold, E. et al., (2004), An International review of Competence Centre Programmes, Technopolis Group,; Boekholt, P. et al, (2010), International cooperation of competence research centres, Final Report for COMPERA, Technopolis Group; Lähteenmäki-Smith, K. et al. (2013), License to SHOK? External evaluation of the strategic centres for science, technology and innovation.

[123] As of November 16, 2020, the review is ongoing.

[124] Fikkers, D., M. Ploeg, E. Arnold, P. Boekholt, C. Hull, Z. Jávorka, P. Stern, M. Svetachova, M. Wain and G. van der Veen, (2015), *Strengthening Ireland's Market-Focused Research Centre Landscape*, report for the Department of Jobs, Enterprise and Innovation, Technopolis Group, Amsterdam.

Essential characteristics of these Technology centres are:

They should have a clear industrial research focus in a specific domain or sector;

Industry members have a role in the governance of the centre;

Universities with relevant research activities are linked into the centre and in most cases one university acts as a Centre host;

An ideal funding model that the centres need to achieve is 1/3 block funding from the government (for 5 years), 1/3 competitive funding (national and EU programmes) 1/3 industrial contributions in kind and cash.

The government provides funding for a period of five years on the basis of a Business Plan that is reviewed by international experts and by mid-term evaluations. The government can decide not to continue funding for another five years, for instance when industry commitment is weak. There are currently 10 Centres in operation.

For the present POINT review the domain that is most relevant is the **Irish Manufacturing Research** (IMR) centre established in 2010 (https://imr.ie). IMR's ambition is to significantly accelerate the implementation of key elements of Ireland's industrial strategy and enable Irish based manufacturers to be early adopters and winners in the fourth industrial revolution. IMR will enable industry to capitalise on these opportunities and tackle the threats head-on, through a broad-based service offering to ensure industry has access to the latest technologies and knowledge in a timely fashion. The centre works with foreign companies based in Ireland as well as with indigenous SMEs and high-tech start-ups. Ireland has had world leading foreign investors for a number of decades such as Microsoft and HP. Gradually they have built a small supplier network of Irish firms and help to upgrade the local manufacturing and service eco-system. Through the Centres these foreign companies also invest in R&D conducted by Irish universities. IMR also invests in training programmes for SMEs on Industry 4.0 topics of interest.

The Centre has physical pilot lines where companies can test process and product innovations in four pillars: Digitalisation, Automation & Advanced Control, Design for Manufacturing and Sustainable Manufacturing. In addition to collaboration with research staff from multiple Irish universities, the Centre has its central staff, with ICT and engineering skills that can work closely with companies to design and test the application of advanced manufacturing technologies.

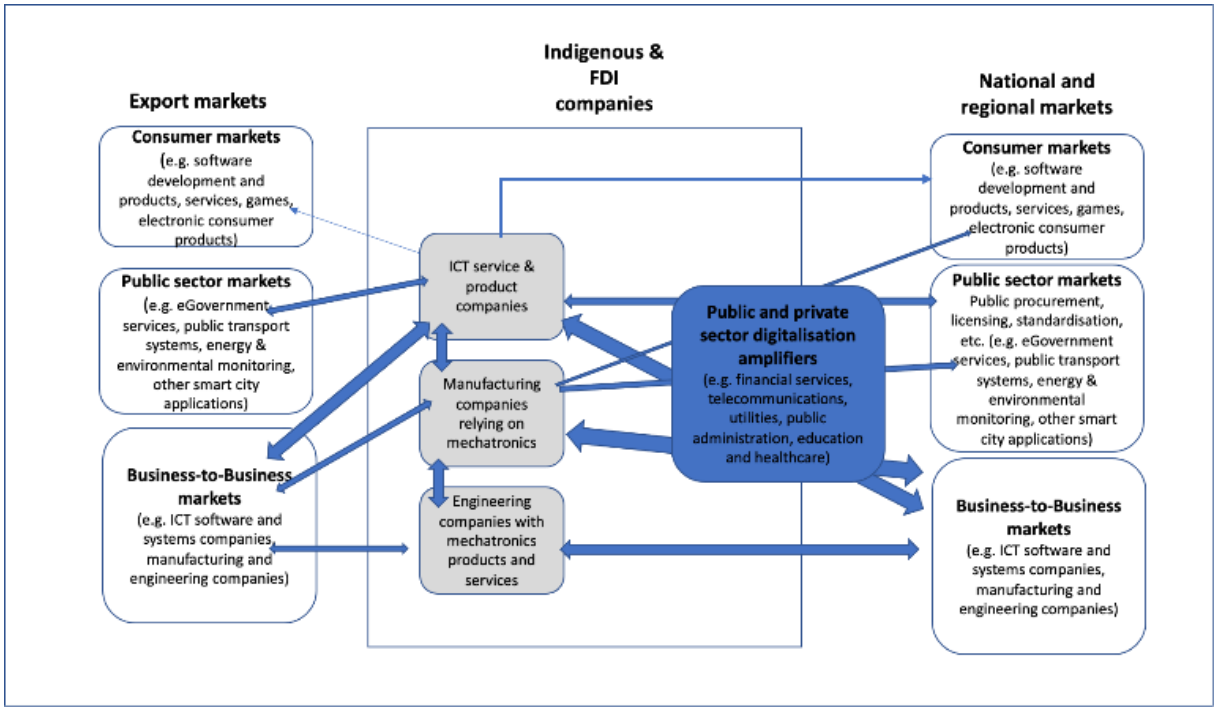
Other Technology Centres related to the POINT review domain are CeADAR, Ireland's National Centre for Applied Data Analytics & machine Intelligence (https://www.ceadar.ie) and the Pharmaceutical Manufacturing Technology Centre (https://www.pmtc.ie)

3.4 Consumption/Use

3.4.1 Connections

Figure 23 shows the main actors and mechanisms in the Consumption system including both the national and regional markets and the export markets. The domestic and foreign market opportunities differ for the ICT sector on the one hand, already quite export oriented in the ICT services segment, and the mechatronics-based sector on the other hand which so far have far less opportunities in the consumer markets and public sector markets.

Figure 23 Consumption



3.4.2 Missing parts and reconfigurations

The key weaknesses in the Consumption system in Bulgaria in relation to the chosen thematic focus are the following:

1. Small and not very sophisticated consumer and business-to-business markets.
2. The public sector is not acting as driver for innovative services and products in the ICT and mechatronics sectors.
3. Export markets not used to their full potential due to the lack of integrated public-private market intelligence services and instruments.

The domestic consumer market and business-to-business (B2B) markets in Bulgaria do not act as a driver for high-end or innovative products integrating mechatronics and ICT towards higher digitalisation. In the desired system there is an increased internal B2B activity particularly between the ICT service sector and the mechatronics sector, which is currently very limited. This is a longer-term strategy as the B2B will grow gradually with the mechatronics sector moving up to higher value segments of the global value chains, increasing also the margins of their commercial activities. The B2B integration between the two sectors will thus produce an exemplary pathway for industrial transformation, which could serve as an example for the wider industry. The integration will lead to new and better products, providing each of the sectors with niche capabilities, which they could then take forward benefiting from public policies encouraging European and international commercialisation.

As noted in Chapter 2 six sectors, three private- (Activities in the Field of Information Technology and Information Services, Financial Service Activities and Telecommunications) and three public-dominated (Public Administration, Education and Healthcare) are the leading consumers of IT services. In the envisaged system these six sectors could play the role of amplifiers of ICT penetration in the Bulgarian society and the digitalisation of the Bulgarian industry. The envisaged system would aim to have the highest impact on economic growth by helping digitise the larger sectors of the economy first, like manufacturing, trade, transport, professional services and utilities, providing higher value-added mechatronics and ICT products[125]. In the envisaged system Bulgaria would catch up with its CEE peers in terms of digitalisation of mass-scale services

[125] Novak J., et. al. (2020). The Rise of Digital Challengers. McKinsey Company, p. 16. The report defines economic sectors as digital novices, digital followers and digital leaders base on their degree of digitization and ranks them according to their contribution to GDP. Available online at: https://digitalchallengers.mckinsey.com/files/McKinsey%20CEE%20report_The%20Rise%20of%20Digital%20Challengers.pdf

like finance and insurance and utilities, while maintaining its lead in all other sectors[126]. Provided the high share of exports in the output of the Bulgarian mechatronics and ICT the envisaged system would provide good market foresight and internationalisation services (also based on the better use of existing EU networks, such as EEN), as well as encourage further investments from Bulgaria's primary markets and partners in the EU, Turkey and the US.

Three trends are likely to continue to drive the rise in consumption/use of ICT. In the first place the drive towards digitalisation, which is at low levels in the Bulgarian industry will result in higher demand from within the country. In the second place, if global production networks get shortened from Asia to Europe, the additional demand from new investments from European multinationals can be expected. Finally, the drive of the Bulgarian government towards digitalisation of its services is likely to continue expanding the demand for ICT products and services (mostly). In addition, certain sectors, like banks and telecommunications can provide strong demand for digital services in the development of fintech and data.

For the envisaged industrial transition to take firm hold, it needs to be rooted in strong demand incentives, which could involve:

- Government as sophisticated user driving digitalisation and the ICT sector through its public procurement programmes in the public administration, defence, education and healthcare. This calls for further integration and conceptualisation of the long-term e-government related procurement budgets and instruments. They could be supported with offset agreements. One way to provide an edge to the local ICT industry and higher cooperation opportunities is for the government to insist on open-source solutions. In the mechatronics sectors the government can act as sophisticated consumer by purchasing advanced systems in for instance energy, waste management and environmental monitoring that require physical electronic monitoring systems.

- Continuous monitoring and sensing out of the demands of EU value chains in mechatronics and ICT, building an integrated all-of-government information system of internationalisation opportunities and further welcoming the penetration of ICT intensive EU and US investors in Bulgaria. Existing Bulgarian and EU networks for business foresight could be better integrated and used to strengthen this dimension in particular.

- Banks and telecoms will help digitalisation on consumer level and among SMEs by disseminating digital tools among their clients. This would require the establishment of public-private partnership collaboration between public institutions and branch associations of the two sectors and the development and rolling out of a plan with specific steps to increase the digital skills and products for the final consumers. The work with banks and telecoms operators needs to be coordinated with the e-government work to ensure all-round approach to building digital skills and demand in the country. In addition, the government could resort to more light touch regulatory innovation and stimulate the digitalisation of services as a matter of urgency.

- Stimulate local private consumption of ICT services through tax breaks or the introduction of minimum non-taxable income, and through the delivery of broadband connectivity through recovery funds, in particular for vulnerable and lower income communities.

- Develop local language soft skills and demand for ICT in education, piloting innovative curricular changes through the available recovery funds, which could then be mainstreamed through national or OP funds after their mid-term performance review in 2024;

- The government could trigger critical partnerships in the private sector to stimulate cross-sectoral learning and push digitalisation through engaging with business clusters and intermediaries and network industries such as banking, telecommunications, etc.

To arrive at the level of stated ambition by the Bulgarian government, i.e., the average EU level of digitalisation, investment in ICT is likely to increase at least twice from the current level by 2030, assuming no increase in in the other member-states. But if we assume more realistically that other Member States will also develop strong digital transformation agendas, then the overall investment growth in ICT by Bulgarian industry will have to outperform average EU investment growth even more.

[126] McKinsey, The Rise of Digital Challengers, presentation in Sofia.

4 How to accelerate the transition

This chapter of the POINT review is about enabling the transition envisioned in Chapter 3, provided the constrains outlined in Chapter 2. It further provides ideas for specific policy and pilot actions, which can help kick start the industrial transformation in Bulgaria.

4.1 Leverage Points

The timing of the POINT review is excellent as the government is preparing for the next generation of Operational Programmes and the updating of the smart specialisation strategy for that new phase. In addition, Bulgaria will receive extra resources from the recovery package of the EU, which it would need to absorb by 2023 in parallel to OP funds. In October 2020 the government has unveiled its draft Plan for Recovery and Resilience, which could also benefit from the ideas presented in this review.

Bulgaria faces many simultaneous challenges and needs to work on all points of leverage in the system to achieve effective transformation. Bulgaria, as is common internationally, has so far focused mostly on the points of leverage that have not proven to be very effective to trigger transformation, i.e., subsidies, taxes and standards. This POINT review suggests there are also several more important leverage points to consider:

- **Changing the goal of the system**. Bulgaria needs to focus on skills and talents for the digital future both in terms of quantity (which is unlikely to change dramatically) and in terms of quality (which can change substantially across all forms of education, learning, and training). As the output of such changes in the system goals are likely to be fully realised only over the course of 15-20 years, Bulgaria needs to build political and social consensus about the goals of transformation and agree on continuous support for these priorities no matter what the political leadership of the country.
- Bulgaria needs to rapidly and steadily **increase the growth rate of the stock of capital** to match the increasing skills and competences of graduates and employees for digital transformation. For Bulgaria to reach the capital stock per employee of more advanced countries, it would need a tenfold increase[127]. This would require the attracting of increasing volume of foreign and domestic private investment, to gradually reduce the overreliance on EU funds, and seek to establish investment loops between currently disparate pockets of domestic strength with potential complementarities (e.g., between ICT and mechatronics).
- **Revamping the rules of the system and the structure of information flows**. Like many other lagging regions Bulgaria needs to considerably strengthen the rule of law and nurture confidence that can facilitate the flow of investments to the country. It needs to further reduce bureaucracy and modernise the information flows within government and to the outside world. Rapid and transformative digitalisation of government itself can contribute to all the above objectives. The Bulgarian government needs to position itself as a digital champion and demonstrate its ability to innovate continuously its governance in relation to public investments (including RIS3), in particular by ensuring better coordination among different ministries, agencies and OPs. Critically, the government needs to use the opportunity of digitalisation to rethink and modernise administrative structures to allow policies to be more responsive to emerging needs.
- **Leveraging the self-organisation of the business sector** through partnerships with the public sector, in areas such as training and education. This requires the strengthening of the interlinkages between the Orientation and Planning system and the Production system.

4.2 Governance of government

An important issue for all strategies aiming at system-level change, is how to coordinate the actions of different line ministries and their agencies under a coherent industrial development logic. It is not enough to make it one of their tasks to coordinate with one another: the governance mechanisms that both allow and encourage disparate parts of government with distinct objectives to cooperate must be put in place.

Provided the substantial resources, which will be placed at the disposal of the Bulgarian government to aid industrial transformation, its governance will have to change in important ways to be able to leverage as much private support as possible.

[127] McKinsey, The Rise of Digital Challengers, presentation in Sofia.

The first aspect of change will be the creation of more coherent and dynamic system of cooperation with the local (municipal) level in the country. There is a need for a lot of skills and capacity investment in developing the understanding and capabilities at the local level to drive digitalisation and industrial transformation and to feedback, emerging signals and trends to the central government. In turn, this will require the building of local public-private coalitions, which will also have to be included in interactions and dialogue (e.g., through a public consultation mechanism or a coordination body, such as the multi-level sectoral commissions existing in Spain) with the central government to reinforce synergies between national and regional specialisations in the RIS3 strategy. For example, the Centres of Excellence, the Centres of Competence, the Digital Innovation Hubs, as well as the planned Regional Innovation Centres will have to create their own local coalitions of support, which will also have to be linked to the national level. The link with national and international eco-systems will be beneficial for the upgrading of local actors who can access new markets and partners. It will also help to build more scale and scope in policy support interventions by pooling local, national and if possible international resources.

The second aspect for better governance is the use and analysis of data to continuously drive digital and industrial transition. Bulgaria is among the leading countries in Europe on open data standards and it has created a potent United Management Information System for European funds, which can serve as the backbone for developing detailed monitoring and evaluation, based on big data collected from registries and other sources. This will by itself create more opportunities and demand for ICT services and the creation of additional products for improving public services. The Bulgarian government has pledged to move online 100% of its public procurement contracting by 2020 and to continuously interlink public registers to increase the effectiveness of public service delivery. These two goals would create favourable prerequisites for using big data analysis techniques to further improve digitalisation of public services, link it with public sector reform (improving or eliminating practices that serve no real purpose in a fully digitalised public sector) and leverage change in the private sector through them. Realising this aspect of governance would accomplish simultaneously the following:

- Increase demand and help develop capabilities in domestic ICT through procurement of systems for data and analysis;
- Accelerate the industrial transition by producing quantifiable evidence on the effectiveness and efficiency of policies;
- Improve governance transparency, accountability and responsiveness to policy and external changes;
- Increase efficiency and reduce the cost of public procurement.

The third aspect of better governance can be sought in the direction of increased efficiency and coherence of government policies in the realms of digitalisation and industrial transformation. The government needs to develop its capacity to deliver horizontal policies, as its current structure is more focused on sectoral/vertical principles, leading to multiplicity of state actors, duplication of functions and the lack of single, lean points of contact for businesses and other stakeholders.

One way to do this is by creating a centralised agency that will focus on the missing links within the system. The Bulgarian authorities have pledged to establish such an agency at the Council of Ministers, which will oversee centrally the implementation of RIS3. This effort could be further strengthened by bringing the many agencies dealing with digitalisation, investment, standards and business support (e.g., Invest Bulgaria agency, SME agency, National Innovation Fund, National Science Fund, Industrial Zones company, etc.) under one hood, similar to the Innovation Norway agency. At the same time, such convergence of agencies could allow the increasing of territorial expertise and representation of Bulgarian regions by developing more regional nodes of such a future structure and its empowerment with budget and personnel.

Another way to improve horizontal coordination across thematic ministries and their agencies is to develop a national mission to digitally transform Bulgaria, if the political will to do so is present (see Box 10). A national mission would be a long-term undertaking and require broad social support to ensure it lasts longer than any one administration. The mission would give a clear signal to all parts of government about the priority afforded to transition-minded actions. As the transition is time-dependent, until the goals set out in the mission are met, the government could introduce temporary policies to prioritise actions that favour alignment. For example, a new compulsory criterion for public investments could be introduced. Under this hypothetical criterion all public investments (with only few clearly specified and appropriately justified exceptions) would have to demonstrate relevance to the mission's goals (with specific reference to one or more mission objectives) and include investment components that enable synergies with realised or future public or private investments linked to the mission (e.g. industrial placements / skills development, public procurement of innovation). If this is done

rigorously (and this should be monitored effectively without excessive bureaucratic burden, probably digitally and with on-the-spot checks), it could ensure that the bulk of public investments combine under a coherent industrial development logic.

Box 10. Differences between visions, missions and targets

Visions articulate a desired end-state for a particular socio-technical regime (energy, mobility, food) supported by an actor network, to guide and motivate processes of technological, institutional and behavioural change (Berkhout, 2006). Visions are a means for introducing directionality into policymaking. An example is a vision of 'a resource-efficient and low-carbon energy system' or 'a sustainable and flexible mobility system'.

Missions identify an opportunity and provide a solution and approach to address societal challenges (Mazzucato, 2018). Often used in the innovation and defence policy areas, they create directionality and a focus for coordinating activities by different actors, sometimes across sectors. A mission is more specific than a vision, often expressing urgency and the need for immediate action. Examples of missions include having plastic-free oceans, or 100 carbon-free cities by 2030 (Mazzucato, 2018).

Targets make concrete a vision or a mission, often in quantifiable and measurable terms. In contrast, visions and missions can include non-quantifiable or only partially measurable elements and are often less concrete. Examples of targets are reduction of energy demand by industry by 50 % by 2030, replacing 30 % of combustion engine vehicles with EVs by 2025, or halting the use of non-recyclable single-use plastics by 2020

Source: European Environment Agency (2019), Sustainability Transitions: Policy and Practice, Luxembourg: Publications Office of the European Union, p. 107)

Yet another more immediately practicable way of delivering a whole of government approach could be to experiment with joint calls for financing across OPs, so that different parts of the government can formulate and actually implement common goals. In terms of digitalisation effort this would best involve the CoM through OP Good Governance and the new OP Research, Innovation and Digitalisation, the Ministry of Economy through OPIC and the National Innovation Fund, the Ministry of Education and Science through the National Science Fund and OPSESG, the Ministry of Regional Development, the Ministry of Transport, Information Technology and Communications, the Ministry of Agriculture, Food and Forestry, and the Ministry of Environment and Waters. They could think of designing their own internal (i.e., inside government) entrepreneurial discovery process, which could aim to develop specific joint interventions in Bulgaria's regions to support interconnection of industries with ICT, starting with mechatronics.

Last but not least, the Bulgarian government needs to cultivate monitoring and evaluation practices and capabilities, designing specific national instruments for the purpose. Currently, most, if not all of the monitoring and evaluation in the country is done in relation to OP implementation and typically involves stakeholders that were directly involved in the implementation of EU funded projects. This is a good start and needs to be continued, expanding the role of the Unified Monitoring System to cross-link it to national registers and the National Statistical Institute, to make sure OPs are properly reflected there. Yet, there is a need to better understand emerging trends and weak signals within the Bulgarian economy and in its major trading partners. In this respect, Bulgaria needs to develop regular monitoring instruments of non-OP businesses to track drivers and obstacles to the digitalisation transition in industry, education and government. It should also supplement the RIS3 EDP consultations with more sophisticated tools, such as GIS-enabled statistical systems, surveys, foresight exercises, etc. A good example in this respect could be the Gabrovo pilot innovation monitoring system[128] developed within the Know-Hub partnership. In addition, in view of the very strong dependence of the country on exports, Bulgaria needs to develop more cooperation and sophisticated monitoring tools to track developments among its largest trading partners. It could also strengthen this aspect by more active engagement with international fora maintained by the World Bank, JRC, EIB, EBRD, as well as through harnessing the opportunities for engaging with the OECD as part of its membership application process.

4.3 Building support coalitions

Digitalisation is likely to create a lot of higher paid opportunities but at the same time it would require re-skilling and could mean also relocating to new growth areas. By one estimate, the related drive towards automation, which is important for mechatronics, could require reskilling among up to 1.5 million FTE or slightly above the

[128] You can see the description of the system here: http://www.know-hub.eu/knowledge-base/good-practices/economic-gis-layer-for-innovations-of-gabrovo-municipality.html. The actual latest version of the system is available here: https://gishub.gabrovo.bg:3344/webappbuilder/apps/34/.

half of currently employed persons in Bulgaria[129]. Hence, raising awareness of the need to change and about the potential opportunities and creating the drive for skills retooling will require the building of broad support coalitions. These have emerged naturally at points of public support for the creation of intermediaries, such as cluster initiatives, Digital Innovation Hubs, CoE and CoC. The one player that is typically missing from such coalitions is business representatives. A good starting point to attract businesses to such support coalitions is to manage and sustain more actively relations with former or potential recipients of EU grant funds, which are more likely to respond positively to requests for engagement. Yet, this could create closed groups bias, which calls for reaching out to wider constituencies, including businesses from the EU that have not yet invested in Bulgaria but are likely to do so in the future. The Bulgarian government needs to build a steady presence in key international fora, such as WEF annual events, or EU related initiatives like EASME, and EEN annual gatherings. At the same time, it needs to develop such national business gatherings, at which it can present and debate its policies, outside of the formal tripartite meetings with social partners. They could use as platforms ongoing initiatives of non-governmental organisations, such as EEN's National Innovation Forum, Webit Summits, National Digital Alliance, etc.

Support coalitions can best be developed through engaging stakeholders in the RIS3 redefinition process at all levels. A good example is the inclusion of members of the industry and the research community in the Council of Ministers Council for Smart Growth. Yet, these formats need to be reinvigorated, providing stakeholders other than the government with the possibility to vote and shape policy and missions. They need to also actively seek to engage new actors by rotating membership, e.g., every second year and allow the wider community the right to table and present specific initiatives. To encourage such wider participation though would require an increase in the information and dissemination action on the part of the government in particular in the two years leading up to the re-formulation of RIS3 or its mid-term review. In this respect, there is a need to pull together information and communication resources from different agencies and develop better push technologies for informing stakeholders, e.g. through the open data portal, through the strategy.bg portal or through the eufunds.bg portal. Participation from the business community could be elicited through the introduction of innovative engagement tools, such as networking vouchers, for example, which encourage stakeholders to develop new connections and "compensate" them for the time they spend engaging in matters of common interest (e.g. providing intelligence about sectoral needs, offering advice from experience) or exploring participation to common projects.

Transformative system innovation can also happen when decision making embraces traditionally neglected constituencies and finds ways to address their needs. In the case of the proposed industrial transition in Bulgaria in this review these can include for example representatives of the global vanguard of science, technology and industry. They would normally have to be convinced to engage in such collaboration but can be potentially co-opted to at least offer advice, as Bulgaria needs to attract further foreign capital and thinking. In addition, the Bulgarian government could seek to engage non-profit organisations or foundations that are purpose-driven (e.g., linked to a social challenge), disadvantaged social groups, local governments, traditional (non-technological, even non-scalable) SMEs, which collectively play an important role in demand formation and collective economic (e.g., aggregate labour productivity) or societal (e.g., unemployment, exclusion, environmental sustainability) outcomes. This whole array of potential support coalitions requires an upgrading of capacities within public administrations for engaging with external stakeholders and coordinating within government.

4.4 Managing resistance to change

The international debate on the negative effect of Industry 4.0 and further digitalisation is mostly focused on the threat of job losses and unemployment and the need for re-skilling of employees[130]. As Bulgaria has a low unemployment rate (on average 5% in last three years) and a shortage in the labour force, the threat of a higher level of unemployment appears less ominous in the short to medium term. The need for re- and upskilling the Bulgarian workforce however will not be met if digitalisation is only addressed in the formal education system. In order to avoid this outcome, Bulgaria needs a coherent Lifelong Learning strategy for the entire society that is based on the principle of inclusiveness.

As Chapter 2 highlighted a promising development has been the investment by the private sector in training and development activities. However, a true coherent Lifelong Learning approach will require more pervasive and continuous (co-) investment of enterprises in the training, and re- and upskilling of their workforce. Firms are well known to underinvest in employee training when they expect that the benefits of this investment may

[129] McKinsey, The Rise of Digital Challengers, presentation in Sofia.
[130] See for instance World Economic Forum: https://reports.weforum.org/future-of-jobs-2016/

spill over to other firms. This is particularly true in industries with small profit margins. At the very least, a consultation is needed between the government and enterprises to identify what support measures could be taken to alleviate the financial burden of training and skill development on businesses for the collective good. Internationally, the under-provision of socially beneficial on-the-job training is routinely used as an argument to justify public co-investments to workforce training[131]. The recent EU initiative on Centres for Vocational Excellence (COVEs)[132] can potentially help develop a nationally-relevant blueprint in Bulgaria for working closely with the business sector on world-class vocational skills development. It is encouraging that Bulgarian skills providers have been successful in the first COVEs call[133], and additional participation in future calls would be compatible with the paths for skills development examined in this review.

The Bulgarian government could reduce some of the resistance to re-skilling from companies and at the same time address their needs to retain personnel during the COVID-19 crisis and immediately afterwards by designing appropriate support schemes. These could foresee the payment of re-training fees and social security and healthcare contributions for workers who undergo digitalisation courses. Alternatively, such support measures could compensate universities for organising digitalisation courses, while at the same time reimbursing companies for lost revenues from staff re-skilling.

Bulgaria is most likely to see adaptive resistance, in particular related to the strain of re-skilling the education system and employees. Given the very low educational and functional literacy status of large parts of Bulgarian society, such as the elderly, Roma and Turkish minority, some groups will be especially vulnerable and require dedicated attention and support. More generally, it will be important to study the roots of potential resistance in the skills provision system and address them as soon as possible, as the cost of their negative impacts is likely to compound over time.

4.5 Defining experiments, reforms, and policy instruments

The specific actions in the short and medium term that could accelerate the reviewed industrial transition pathways in Bulgaria are listed in the following Table 16. The proposed policy instruments and experiments concentrate on the major issues relating to the ICT/mechatronics domain that have been identified in the previous chapters:

- the fragmented governance and funding mechanisms preventing a systemic support of the domain;
- the skills shortages and mismatches;
- the lack of an ecosystem with organisations championing innovation and digitalisation of the mechatronics sector;
- the weak connection with international networks and value chains and particularly European partnerships and competitive funding;
- the low FDI attractiveness, which hampers the inflow of fresh capital for swifter digital transformation of mechatronics.

The boldest policy experiment proposed is specifically focused at the thematic domain of the POINT review: reinforcing the current intermediaries to set up a Digital Manufacturing Research and Innovation Centre.

Table 16 Recommendations for Actions

What to achieve?	**What gaps will it fill in the system?**	**Which actors to take action?**	**Timefra me**
Develop a well-resourced Secretariat and Intelligence Unit for the Council of Ministers to prepare and coordinate overarching policy strategies	This will contribute to national and regional policy strategies including the RIS3 to be followed up, so that resources will be mobilised effectively.	Deputy prime Minister's office, Minister of Finance and Council of Ministers	2021

[131] See for instance Miller, R. (1996), *Measuring What People Know: Human Capital Accounting for the Knowledge Economy*, OECD, Paris.
[132] https://eacea.ec.europa.eu/erasmus-plus/actions/centres-of-vocational-excellence_en
[133] https://eacea.ec.europa.eu/erasmus-plus/funding/ka3-centers-of-vocational-excellence_en

Reinforce the Implementation Agencies involved in the continuation of RIS3, and the relevant national strategies related to digitalisation, Industry 4.0 and the RIS3 priority domains	This will contribute to national and regional policy strategies including the RIS3 to be followed up, so that resource mobilisation will take place in Production and Consumption sub-systems	Deputy prime Minister's office, Agency for Research and Innovation, Minister of Finance, Council of Ministers, Minister of Economy, Minister of Education and Science	2021
Ensure continuation of (financial) support to already established intermediary organisations on the basis of clear objectives and targets that are jointly defined with the stakeholders	This will contribute to national and regional policy strategies including the RIS3 to be followed up, so that capacity building will take place	Various Ministries, Centres of Excellence and Centres of Competence, Sofia Tech Park, Digital Innovation Hubs, Cluster organisations	2021
Key intermediaries identify emerging innovators to launch demonstrator R&D projects to showcase innovative ICT-mechatronics combinations	This will increase the absorptive capacity for digital/mechatronics innovations and ultimately the productive capacity (and competitiveness) of both ICT and mechatronics businesses.	Ministry of Economy, Intermediaries	2022
Establish an active and effective strategic skills platform, where future skills' needs and investments are discussed with representatives of government, education and business	This will improve the resource mobilisation subsystem as well as the orientation and planning subsystems in the short to medium term as it will contribute to a better match between skills supply and demand. In the long-term this will improve both the production and consumption subsystems	Ministry of Education and Science, Ministry of Economy, Ministry of Labour and Social Policy, Business leaders from a mix of enterprise segments, trade unions, representatives of educational institutes including HEI and VET, as well as private sector training initiatives. Initiated by government authorities, set up as semi-independent PPP	2021
Strengthening the VET segment of formal education and providing them a role in re-skilling and up-skilling of the current work force in Bulgaria, including via further participation to European Centres of Vocational Excellence (COVEs)	This will improve the Resource Mobilisation subsystem in the first instance and will have a positive impact on the Production subsystem by raising the skills levels	Ministry of Education and Science, VET institutions, future Skills Platform, Ministry of Finance, Ministry of Labour and Social Policy	2025
Setting up a Digital Manufacturing Research and Innovation Centre	This will help raise the absorptive capacity in the production subsystem, to increase skills levels and bridge the gap between public research and industry	Council of Ministers, Ministry of Education and Science, Ministry of Economy	2022

Nurturing and stimulating internationalisation of key actors in the public and private sectors	This will contribute to the competitiveness of the subsystem production as international ties are known to augment the quality of domestic activities in research and innovation. It can also become a conduit for more and more knowledge-intensive FDI.	Ministry of Education and Science, Ministry of Economy, EEN	2021
Developing an action plan for attracting strategic FDIs in mechatronics and ICT that encourage upward movement on the value-added chain.	Closing the private sector capital gap and ensuring new lead actors for digitalisation	Ministry of Economy, Invest Bulgaria Agency, Bulgarian SME Promotion Agency, Ministry of Transport, Information Technology and Communications, State eGovernment Agency	2021
Piloting joint OP calls encouraging industrial transformation efforts based on ICT and mechatronics	Ensuring comprehensive horizontal support for industrial transformation pilots	Managing authorities of the OPs and the Central Coordination Unit at the Council of Ministers	2021
Creating virtuous circles of synergies between national (including OPs) and European programmes (Horizon Europe, Interreg, etc.)	Leveraging EU membership to benefit from OPs but also from EU-level support	Agency for Research and Innovation, Ministry of Economy and Ministry of Education and Science, Ministry of regional development and public works	2022
Review of conditions and measures to establish a national digitalisation mission	Stimulating demand for digitalisation through different public policies, such as public procurement, investments, etc.	Council of Ministers, Agency for Public Procurement, Ministry of Finance, Ministry of Economy	2021

For the set-up of a bold policy experiment that has a **coherent and systemic approach** from multiple policy domains, the recommendation is to establish a **digital manufacturing research and innovation centre** that combines the development and dissemination of digital production technologies, education and training in ICT and production technology skills, applied research, pilot and demonstration facilities and business services. This would become the core ecosystem **hub** that initiates programmes, projects and services for the mechatronics domain. In order to ensure that all regions have easy access to its services, it could be considered to set up smaller satellites within the different regional innovation centres that can serve as a first entry point for companies. As this initiative encompasses research, innovation, business support, education and training it should be funded by bundling the Operational Programmes Innovation and Competitiveness, Science and Education for Smart Growth, Human Resource Development and Growth Regions. In addition, the hub could partner with the existing ICT Academies that are set up by the business sector. This would leverage the resources of both the public and private sector and provide important inputs and feedbacks on the business needs.

We recommend that this centre is not set up from scratch, creating yet another structure, but that it constitutes additional tasks and matching resources to the Competence Centres, Digital Innovation Hubs and other intermediaries that have already been set up in this domain, with the MIRACLe Centre as a potential core. Its current set up should be revisited to ensure that its activities are in line with the needs of Bulgarian industry. Partnerships with other Competence Centres, universities and intermediaries that complement the knowledge base and potential services could be envisaged.

Such a centre should be based on a number of principles:

- It should find the right balance between the short-term business needs and the medium-term research and technology challenges that might be beyond the horizon of the current businesses.

- The centre should be based on a solid business plan for a period of at least five years. The Business Plan and Strategic Research and Innovation Agenda should be developed in consultation with different segments of the business sector (e.g., ICT but also manufacturing, large international firms but also indigenous firms and start-ups, those in the capital city region but also those in other regions)
- By bundling funding streams and ensuring funding for a sufficiently long term (5+5 years) the centre can become operationally stable and develop collaboration networks with industry. Agreement of objectives and targets and KPIs together with a transparent evaluation and monitoring system (e.g., after Y4 and after re-submission of the BP in Y6). The share of competitively won funding and private sector funding should slowly increase, however public funding looks likely to be needed at a level of 50-75% of the operations.
- The governance of the centre should acknowledge the needs and interests of the main actors involved. It should be clear that academia has other incentives and interests than the business sector and the government authorities involved need to ensure the public interests.

Yet there are also other ideas for identified useful policy experiments, which the Bulgarian government might want to consider in stimulating the industrial transition. For example, it could provide co-financing for workforce training, and for "planting" programmers and other digitalisation experts in mechatronics in particular but also in other industrial sectors. Such programmes for embeddedness could start small and be potentially scaled up. A more ambitious possibility would be for the **subsidised placements** to become part of a well-endowed (and well remunerated so it could attract global talent) challenge-driven innovation project, linked to specific problems faced by mechatronics (and potentially other manufacturing sectors).

One avenue that is likely to have a positive effect on the upgrading and export orientation of Bulgarian mechatronics enterprises is the stimulation of **internationalisation** of key actors in the eco-system. The actors involved include individual companies, clusters, competence centres and universities. In addition to a strategy of strengthening the export orientation of firms and clusters, trans-regional cooperation in Europe is increasingly oriented on innovation partnerships, according to analysis of the European Cluster Observatory. [134] This study found that many firms have re-directed their focus on business activities of internationalisation such as cross-border partnerships with foreign companies, foreign investments and cross-border networking. There are plenty of opportunities offered by European supported networks and alliances that the Bulgarian actors in the eco-system can aim to develop closer relationships with.

The Bulgarian government could launch a number of policies to help key actors to internationalise and make better use of the networking and cooperation opportunities offered in Europe. These should be both generic (across all sectors and domains) and specific for the ICT/mechatronics sectors. This should be addressed to both the business sector as well as to the public research sector that is as shown in Chapter 2 also not performing well in terms of international collaborations and co-publications.

1. Provide in a systematic manner **strategic information** to companies and their associations on European support programmes, networks, conferences and other networking opportunities focused on international cooperation regarding technology, innovation, skills development and so on. While the COVID-19 pandemic is still hampering travel and physical events, this should be set up through a user-friendly portal that is addressed to different target groups. The portal should combine information that is collected and transferred from different Bulgarian agencies as well as directly from sources in Brussels. Bulgaria should also consider investing in human resources of liaison officers present in Brussels similar to for instance the Slovenian Business and Research Association (SBRA) and similar national liaison offices that are informally associated in the IGLO-network (https://iglortd.org).[135] This could be quickly set up an indigenous R&D procurement process attracting the most well-known Bulgarian (and possibly international) AI companies (such as Ontotext, Sensika, BizPortal, etc.) to offer cutting edge solutions and training to potential customers on how to use the portal.
2. Provide **intermediary organisations** such as clusters, digital innovation hubs and competence centres, EEN, co-working spaces, dedicated funding to develop initiatives (e.g., visits, events, exchanges, memberships fees for European networks, etc.) to link up with international peers. The allocation of funding should be based on a multi-annual internationalisation strategy, developed by these intermediaries, with clear objectives and targets. A prerequisite for this type of funding is that the

[134] Iszak, K. and G. Meier zu Köcker, 2015, European Cluster Trends, Executive Summary, European Cluster Observatory Report, European Commission, DG Internal Market, Industry Entrepreneurship.
[135] Bulgaria is one of few EU member countries not represented in this network

intermediaries are in a situation of stable operation and have secured base line funding for the medium to long term (5-10 years) in order to develop a longer-term strategy that includes internationalisation. In the domain of ICT/mechatronics there are plenty of international platforms that can help enterprises and research organisations to become more present in their appropriate domains. Examples are Industry4e (https://industry4e.eu/about/) and European Factories of the Future Research organisation (https://www.effra.eu/factories-future), both awarding industry-oriented research and innovation projects.

3. Steer more actively funding provided by the Ministry of Education and Science for preparation of Horizon 2020 projects to **focus on priority RIS3 themes**, and increase the follow up on European research and innovation projects. Bulgaria has provided travel support for preparation of Horizon 2020 projects but this needs to be beefed up both from the input and the output side. From the input, Bulgaria could widen the support to provide small levels of funding to individual organisations (universities, firms, competence and excellence centres) to prepare Horizon Europe proposals with European partners. The experiences of a number of European countries that have provided such incentives in previous years can be used to design a specific policy portfolio suited to the Bulgarian situation.[136] The incentives used in other EU countries range from providing information, proposal writing training, grants for travel and grants for proposal writing. Yet, Bulgaria could benefit even more from supporting the mainstreaming of successful outputs of Horizon 2020 and Horizon Europe by making sure to showcase the results of projects to Bulgarian enterprises and the private sector to pick up.

4. Given its investment shortfall, Bulgaria needs to make sure it leverages any opportunity available to **attract new innovative capital from the international markets in the form of FDI**. This is particularly true for OPs and the Recovery and Resilience Plan, which are meant to structurally change the Bulgarian economy and society and lead them onto a new path of innovation-driven growth. One potential avenue for attracting more and better quality FDI is to align Invest Bulgaria agency's efforts with Managing Authorities, the newly created Research and Innovation Agency, the Bulgarian SME Promotion Agency, the State eGovernment Agency and design OP interventions that aim to specifically leverage FDI for industrial transformation in mechatronics. The avenues for this are numerous:

    a) Involving the Public Procurement Agency to prepare public procurement driven innovations in digitalisation and mechatronics, including green procurement;

    b) Involving business clusters (e.g., Cluster Mechatronics and Automation[137]) and associations (e.g., Bulgarian Employers' Association Innovative Technologies[138]) to develop pilot projects in attracting missing supply and demand actors from the international value chains to seek to upgrade value added for the whole cluster/industry;

    c) Linking the newly created actors such as the Sofia Tech Park, Centres of Excellence and Centres of Competence to international value chains, attracting new market entrants in the process;

    d) Gradually establishing different FDI attraction communities, e.g., with municipalities to leverage regional development funds, with transport and environment OPs' Managing Authorities to leverage construction and environmental/climate contracts;

    e) Involving the Industrial Zones Company and other public enterprises to attract investments from global leaders in mechatronics and digitalisation.

5. Strengthen international research collaboration by devoting more funding and governance resources within the Ministry of Education and Science and the Agency for Research and Innovation to competitive funding for establishing links with European and international research teams. This will achieve the twin goals of improving the quality and the international attractiveness of academic and public research. In addition, such policies that foster internationalisation will also facilitate learning and participation to global knowledge networks and as a result raise quality.

[136] See for instance: Nauwelaers, C., 2018, Thematic Report 3, MLE on national practices in widening participation and strengthening synergies, European Commission, https://rio.jrc.ec.europa.eu/sites/default/files/report/MLE%20Widening_Topic%20Report%203.pdf; Åström T. et al, 2018, Improving Norway's Performance in the EU Framework Programme, Technopolis Group, Stockholm, page 139-164; Arnold E. et al, 2010, Evaluation of Austrian Support Structures for FP7 & Eureka and Impact Analysis of EU Research Initiatives on the Austrian Research & Innovation System, Technopolis Group, Vienna, page 227-251.
[137] http://www.cluster-mechatronics.eu
[138] https://brait.bg/index.html

ANNEX – Agendas of stakeholder consultation meetings

DRAFT AGENDA
6 December 2019, Sofia, Bulgaria

Review of Industrial Transition of Bulgaria: *Fact-finding and stakeholder consultation meetings*

European Commission, DG Joint Research Centre

Venue: Council of Ministers, 6 Serdika Street,
2nd floor

IMPORTANT: TO ACCESS THE COUNCIL OF MINISTERS PREMISES YOU MUST SHOW A VALID ID OR PASSPORT

6 December 2019

09:00 – 10:00	BUSINESS REPRESENTATIVES – GROUP I • Svilen Rangelov – Dronamics • Lulcho Georgiev – Dronamics • Petar Kazakov - Center of Plant Systems Biology and Biotechnology • Daniel Lorer - BrightCap Ventures • Mariya Nakova – Cleantech Bulgaria • Mihail Panayotov
10:00 – 11:00	GOVERNMENT REPRESENTATIVES – GROUP I • Zlatina Karova – Ministry of Education and Science • Iumer Kodjaiumer – Ministry of Education and Science • VLADIMIR MANOLOV – MINISTRY OF EDUCATION AND SCIENCE • Yanko Stoyanov - Ministry of Regional Development • Kaloyan Mitev– State Agency "Good Governance" • Anton Dushev – State Agency "eGovernment" • Anna Stoimenova - State Agency "eGovernment" • Martin Danovsky – Fund of Funds
11:00	BREAK
11:15 – 12:15	USERS, INTERMEDIARIES AND CIVIL SOCIETY – GROUP I • Daniela Tchonkova - Enterprise Europe Network – Bulgaria • G. Stoev - Joint Chamber of Commerce and Industry Bulgaria-Korea and Vice-President of the Bulgarian-Japanese Economic Council at BCCI for Business in the Country • Jasmina Balabanova – Bulgarian Alliance for Precise and Personalised Medicine

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12:15 – 13:15	TRAINING, SKILLS, KNOWLEDGE CREATORS – GROUP I • Dr Nayden Shivarov - Institute for Information Technologies at BAS • Hristina Zaharieva - NIK Electronics Ltd • Boyko Rangelov - MGU
13:15	LUNCH BREAK
14:00 – 15:00	BUSINESS REPRESENTATIVES – GROUP II • LUBOMIR VASSILEV – IRISE • KRISTINA ESHKANAZI - CHAIRMAN OF BIOTECHNOLOGY AND LIFE SCIENCES CLUSTER • KIRIL RAYTCHEV - ECONOLER S.A. • DIMITAR HRISTOV – GEOWEALTH • IVAN GORANOV – OFFICE SMART • KONSTANTIN BOBCHEV – OFFICE SMART • STOYAN BOEV • VLADIMIR STAVROV – AMG TECHNOLOGY • PETAR STATEV – SOFIA TECH PARK • VLADIMIR FILIPOV - NEARSOFT EUROPE • VASIL TCVETKOV – VOCATIONAL SCHOOL OF ELECTROTECHNICS PLOVDIV • OGNIAN OGNIANOV - O & K CO.
15:00 – 16:00	GOVERNMENT REPRESENTATIVES – GROUP II • DR BOYKO TAKOV – EXECUTIVE DIRECTOR OF BULGARIAN SMALL AND MEDIUM ENTERPRISES PROMOTION AGENCY (BSMPA) • DESISLAVA MIHALKOVA – OPIC, MINISTRY OF ECONOMY • VLADIMIR SPASOV – ECONOMIC POLICY DIRECTORATE, MINISTRY OF ECONOMY • SLAVA YORDANOVA - ECONOMIC POLICY DIRECTORATE, MINISTRY OF ECONOMY • MARGARITA DJOGANOVA – DIRECTOR OF ADMINISTRATION AND GOVERNANCE DIRECTORATE OPERATIONAL PROGRAMME "SCIENCE AND EDUCATION FOR SMART GROWTH" • TSVETAN SPASOV - ADMINISTRATION AND GOVERNANCE DIRECTORATE OPERATIONAL PROGRAMME "SCIENCE AND EDUCATION FOR SMART GROWTH" • STAMEN YANEV – INVESTMENT AGENCY • LUDMILA TOZEVA – CCU
16:00	BREAK

16:15 – 17:15	USERS, INTERMEDIARIES AND CIVIL SOCIETY – GROUP II • VENTSESLAV KOZAREV - FOUNDATION APPLIED RESEARCH AND COMMUNICATIONS • KAMELIA STOYANOVA - PROFESSIONAL GYMNASIUM FOR ELECTRICAL ENGENEERING AND ELECTRONICS • SVETLANA BOYANOVA - AGRO INNOVATIONS • VESELIN GROZDANOV - Р ВЕСЕЛИН ГРОЗДАНОВ – GREEN TRANSPORT CLUSTER
17:15 – 18:15	TRAINING, SKILLS, KNOWLEDGE CREATORS - GROUP II • Jivko Ivanov – Institute for Medical Research • Yana Topalova - Faculty of Biology, Sofia University "St.Kliment Ohridski" • Ivan Simeonov - Ecological Engineering and CAB • Teodora Georgieva - International Business School • Zornitsa Yordanova - University of National and World Economy
18:15	END

European Commission

DRAFT AGENDA
4 June 2020

Review of Industrial Transition of Bulgaria:
Fact-finding and stakeholder consultation meetings
European Commission, DG Joint Research Centre

Venue: Online Meeting

IMPORTANT: (Zoom link will be provided to confirmed attendants. Please, make sure you have available audio and video connection. Please, make sure to join your session 10 minutes in advance of the indicated time to check for any technical glitches)

4 June 2020*

09:30 – 11:00	IN-DEPTH DISCUSSIONS WITH STAKEHOLDERS – GROUP I 1. ALEXANDER MADZHIROV – APPLICATION INTEGRATION SALES LEADER | INTEGRATION & DEVELOPMENT | IBM EUROPE – 2. ПРОФ. ГЕОРГИ ТОДОРОВ, ТУ СОФИЯ "НАЦИОНАЛЕН ЦЕНТЪР ПО МЕХАТРОНИКА И ЧИСТИ ТЕХНОЛОГИИ" КАМПУС "СТУДЕНТСКИ ГРАД" 3. GEORGE ANGELOV, ASSOCIATE PROFESSOR, PHD, DIRECTOR OF INFORMATION AND PUBLIC RELATIONS TECHNICAL UNIVERSITY OF SOFIA 4. НАЙДЕН ШИВАРОВ – ИНСТИТУТА ПО ИНФОРМАЦИОННИ И КОМУНИКАЦИОННИ ТЕХНОЛОГИИ БАН 5. СОФИЯ КАСИДОВА – ББР 6. ПЕТЪР СТАТЕВ, ПРЕДСЕДАТЕЛ НА УС НА ФОНДАЦИЯ "КЛЪСТЕР ИНФОРМАЦИОННИ И КОМУНИКАЦИОННИ ТЕХНОЛОГИИ" – 7. ДЕСИСЛАВА АТАНАСОВА, PHD, VICE RECTOR INTERNATIONALIZATION AND COMMUNICATION POLICY UNIVERSITY OF RUSE 8. КРЕМЕНА НЕДКОВА-КАРАИВАНОВА, НАЧАЛНИК НА ОТДЕЛ "СЕКТОРНИ АНАЛИЗИ" ДИРЕКЦИЯ "ИКОНОМИЧЕСКА ПОЛИТИКА", МИНИСТЕРСТВО НА ИКОНОМИКАТА

Joint Research Centre
Research & Innovation

11:00 – 11:30	COFFEE BREAK & JRC TEAM COORDINATION 1.
11:30 - 13:00	IN-DEPTH DISCUSSIONS WITH STAKEHOLDERS – GROUP II 1. МАРИЯ ТОДОРОВА – МОН - MARIA TODOROVA 2. ПЛАМЕН ДИМИТРОВ – КНСБ - PLDIMITROV@CITUB.NET 3. ЛЮБОСЛАВ КОСТОВ – КНСБ 4. Д-Р КИРИЛ ВЕЛИЧКОВ, ДИРЕКТОР ДИРЕКЦИЯ „ЕВРОПЕЙСКИ ПРОЕКТИ И ФИНАНСОВИ ИНСТИТУЦИИ", МЕНИДЖЪР "ЦЕНТЪР ЗА КОМПЕТЕНЦИИ НА КВС GROUP ЗА ЕВРОПЕЙСКИ ФИНАНСОВИ ИНСТРУМЕНТИ" - 5. МАЯ НИНОВА И МАРУСЯ ИЛИЕВА – ОПНОИР 6. Г-ЖА КРАСИМИРА ШИНДАРОВА, КООРДИНАТОР НА КЛЪСТЕР ЗА ЦИФРОВА ТРАНСФОРМАЦИЯ И ИНОВАЦИИ"

List of abbreviations

ARC Fund - Applied Research and Communications Fund

B2B - business-to-business

B2C - business-to-consumer

BAS - Bulgarian Academy of Sciences

BGN - Bulgarian lev

BSMEPA - Bulgarian SME Promotion Agency

DG EFC - Directorate-General "European Funds for Competitiveness, Ministry of Economy

EA ECNIS - Executive Agency 'Electronic Communication Networks and Information Systems'

EC - European Commission

EPO - European Patent Office

EU - European Union

EUR - euro

FA EA Fisheries and Aquaculture Executive Agency

GDP - gross domestic product

GEM - Global Entrepreneurship Monitor

GGD – 'Good Governance' Directorate, Council of Ministers

ICT - information and communication technology

JRC – Joint Research Centre, Directorate-General of the European Commission

KIS- knowledge-intensive services

MA - Managing Authority

MAFF - Ministry of Agriculture, Food and Forestry

ME - Ministry of Economy

MES - Ministry of Education and Science

MEW - Ministry of Environment and Water

MF - Ministry of Finance

MFP - 'Maritime and Fisheries' Programme

MH - Ministry of Health

MI - Ministry of Interior

MLSP - Ministry of Labour and Social Policy

MRDPW - Ministry of Regional Development and Public Works

MTITC - Ministry of Transport, Information Technology and Communications

NCSR - National Council for Scientific Research

NFD - 'National Fund' Directorate

NGO - non-governmental organisation

NIC - National Innovation Council

NIF National Innovation Fund

NRA - National Revenue Agency

NSI - National Statistical Institute

OP - Operational Programme

OP GG - OP 'Good Governance

OP IC - OP 'Innovation and Competitiveness'

OP SESG - OP 'Science and Education for Smart Growth'

OP TTI - OP 'Transport and Transport Infrastructure'.

POINT – Projecting Opportunities for INdustrial Transition

PORB - Patent Office of the Republic of Bulgaria

R&D - research and development

R&I - research and innovation

RDD - Rural Development Directorate

RDP - Rural Development' Programme

RIS3 – Regional Innovation and Smart Specialisation Strategy

SEGA - State eGovernment Agency

SME - small and medium enterprise

SMEI - OP 'SME Initiative 2014-2020'

SWOT – Strengths, Weaknesses, Opportunities and Threats

UK - United Kingdom

USA - United States of America

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KJ-NA-30643-EN-N

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Publications Office of the European Union

doi:10.2760/241737

ISBN 978-92-76-32322-8