European Commission

JRC SCIENCE FOR POLICY REPORT

Global Value Chains Mapping: Methodology and Cases for Policy Makers

Thematic Work on Value Chain Mapping in the Context of Smart Specialisation

Emanuela Todeva
Ruslan Rakhmatullin

2016

Joint Research Centre

EUR 28085 EN

JRC Science Hub
https://ec.europa.eu/jrc

JRC102803

EUR 28085 EN

PDF ISBN 978-92-79-61507-8 ISSN 1831-9424 doi:10.2791/273290

How to cite: E. Todeva, R. Rakhmatullin 2016; Global Value Chains Mapping: Methodology and Cases for Policy Makers, JRC Science for Policy Report, European Union, EUR 28085 EN; doi:10.2791/273290

Abstract:

This paper is a paper in a series of work on Global Value Chains (GVCs), developed under the auspices of the Joint Research Centre (JRC) of the European Commission. It builds upon the theoretical discussion presented in the first two papers and offers a new methodological approach for mapping GVCs, using a bespoke dataset of the most innovative biopharma MNEs. The paper takes the example of the global biopharma value chain and describes the step-by-step procedure for mapping interconnected capabilities at a global scale, the concentration of biopharma capabilities in Europe, and two cases of regional and national specialisation in this sector. The proposed methodological approach contains two distinctive methodologies – for top-down global value chain mapping of an established industry sector (such as biopharma), and for a bottom-up mapping of capabilities within the GVC that operate at specific locations. Both methodologies can be applied to emerging sectors and segments driven by key enabling technologies, such as photonics, advanced materials, 3D printing, or renewable energy, or any other cross-sectoral value chains. The paper includes two cases of application of this methodology at regional and national level. These are the cases of Bulgaria and the Greater South East of England in the UK. The novel methodology and methods for data collection and visualisation demonstrate the linkages across segments of the biopharmaceutical GVC and the position of firms at the cross-section of biotechnology discovery and pharmaceutical drug development and manufacturing activities, managing a complex network of outsourcing, insourcing and supply relationships, through a vast empire of subsidiaries around the world. Capturing and representing the value-chain within biopharma MNEs enables policy makers to understand the complexity of industry organisation across multiple locations around the world and the global knowledge and resource linkages that drive further growth in the sector.

Table of contents

Executive summary

Policy context

This paper is the third paper in a series of work on Global Value Chains (GVCs), developed under the auspices of the Joint Research Centre (JRC) of the European Commission. The proposed methodological approach for mapping of global value chains, illustrated by two empirical cases of regional and national capabilities audit provide the foundations of evidence-based policy intervention which is co-aligned with a number of policy frameworks in Europe: EU industrial policy 'Towards Industrial Renaissance', Regional growth through Smart Specialisation Strategy, COSME programme for SME support, building Circular Economy for sustainable and inclusive growth, cluster policies such as cluster internationalisation and mobilisation of European Strategic Cluster Partnerships for smart specialisation investments, RECONFIRM Initiative for Regional Co-Operation Networks, or the implementation of regional smart specialisation strategies and inter-regional cooperation under the new thematic platforms launched at the Smart Regions conference.

Key conclusions

The paper takes the example of the global biopharma value chain and describes the step-by-step procedure for mapping interconnected capabilities at a global scale, the concentration of biopharma capabilities in Europe, and two cases of regional and national specialisation in this sector. The proposed methodological approach contains two distinctive methodologies – for *top*-down *global value chain mapping* of an established industry sector (such as biopharma), and for *a bottom-up mapping of capabilities within the GVC* that operate at specific locations. Both methodologies can be applied to emerging sectors and segments driven by key enabling technologies, such as photonics, advanced materials, 3D printing, or renewable energy, or any other cross-sectoral value chains. The paper includes two cases of application of this methodology at regional and national level. These are the cases of Bulgaria and the Greater South East of England in the UK.

The cases are selected to represent a country with no cluster concentrations in biopharma (Bulgaria), and a region that hosts a mature biopharma cluster (the Greater South East of England in the UK). The UK region combines 5 distinctive regional entities surrounding London - East, South, South East of England, Inner London and Outer London. The mapping of biopharma capabilities in these two cases follows the bottom-up data collection method in order to include all small and medium size firms for each location, representing a comprehensive dataset.

The proposed methodologies are designed to assist regions, cluster managers and network coordinators in their efforts to advance through the first two stages of the Vanguard methodology for inter-regional collaboration: *Learn – Connect – Demonstrate - Commercialise.* It is suggested that mapping cross-sectoral and cross-regional value chains for individual demonstration projects and thematic prototypes will enhance the knowledge of regional stakeholders of their own capabilities and will enable them to connect to other regions in the most effective way, facilitating accelerated input-output market relationships through match-making.

1. Introduction: the need for value chain capability mapping

Value chains are *product* and *technology* driven, where each new radical innovation in product design or technology development initiates a new cycle of connectivity called a value chain. Modern *value chains* are so complex that they are better described as *value networks*, or interconnected firms and value added activities that integrate resource flows across manufacturing and service providers, pushing final outputs to markets.

All current European economic development policy initiatives state that inter-firm, inter-cluster, or inter-regional networks should be based on value chains – upgrading positions or facilitating the emergence of new ones. Inter-cluster and inter-regional business ecosystems for innovation and entrepreneurship are designed to facilitate the development of new industrial value chains[1]. Strategic cluster partnerships[2], or the current European cluster consortia all aspire to build innovative value chains which foster joint inter-cluster, inter-regional and international strategies and activities.

> **Value Chain Networks** are interconnected firms and value added activities that integrate resource flows across manufacturing and service providers, pushing final outputs to markets.

Although the emphasis on value chain integration is profound in all current initiative of the European Commission, the most recent thematic paper promoted by DG Growth on mapping advanced manufacturing networks is still short of utilising firm databases in order to scale up the value chain integration processes in Europe[3]. Naming the key European players is extremely important as large companies design the value chains and drive their integration. Large firms play a pivotal role also in driving innovation, but share this role with small technology and service firms, which sometimes operate under the radar. Listing of the key players, hence bares the strong risk of omission, as it circulates information of firms with reputation, ignoring innovation capabilities at the periphery, or early stage creative ideas. Patenting also is a weak predictor of investments in new products, processes and systems. The short lists of large and medium size companies and public research organisations hardly represent value chain integrators, but rather can be seen as lead components of fragmented value chains. The observation that 20% of the regions in EU28 account for 80% of all innovation activities indicates a high concentration of innovation capabilities and value chain activities in the Vanguard and the first tier regions.

This concentration, however, cannot be substituted for value chain integration, and identifying the detailed mapping of the physical location of scattered capabilities across all European regions is paramount in order to enhance the collective performance of the new priority sectors, such as energy, agro-food, advanced manufacturing and industrial modernisation, ICT, digital and circular economy sectors.

The recently announced thematic platforms on agro-food, Industrial modernisation and Energy (Smart regions conference) exhibit a new approach to economic growth, whereby inter-regional and inter-sectoral collaboration is sought to address essential societal and economic challenges. The essence of this approach is that inter-regional and inter-

---

[1] Cluster facilitated projects for new industrial value chains.
[2] ESCP, 2016.
[3] Regional Innovation Monitor Plus, 2015.

cluster collaborations should be driven by the smart specialisation priorities, set by each region; such inter-regional partnerships should refocus existing capabilities to address major societal challenges, and they should aim to establish new and transform existing value chains through innovation in technologies, products, processes, or services[4]. The harvesting of information through entrepreneurial discovery process during the platform info-days on industrial modernisation and agro-food, and the official platform launch event at the smart regions conference highlight that we need to learn more about value chains, so to be able to orchestrate them through investment in specific and selected projects and activities.

Economic development policies require more GVC insights and comprehensive understanding of the concentration of capabilities in countries, regions and clusters, as well as the backward and forward linkages that are taking place across sectors and between core and periphery actors, and the distribution of these capabilities across SMEs, medium and large firms. Using comprehensive databases of firms for representing industry value chains is an essential step towards scaling up from single demonstration projects, to integrated capabilities and global competitive advantage in emerging industries. Mapping strategic concentrations of capabilities and areas of firm specialisation and diversification across sectors is the way forward for effective orchestration of GVCs.

The current methodology paper, advances our knowledge on value chain mapping and capability mapping for established industrial sectors such as biopharma, and offers a new analytical tool for mapping of emerging and integrated cross-sectoral value chains at regional and national level. This approach is designed to offer practical solutions for the successful implementation and operability of the new thematic platforms. It addresses four main challenges:

- **How to map value** chains **and concentrations of capabilities** in new emerging sectors and to demonstrate the transformations that are taking place in established sectors under intense innovation in products, processes and services;
- How to identify **region's own capabilities** in each specific industry segment that is part of an integrated global value chain;
- How to identify all business actors, who are **active R&D performers** in a particular industry segment (including SMEs with potential but no visibility, or established reputation);
- How to exhibit the **region's position** in global value chains.

The use of industry codes and data on large multinational enterprises (MNEs) is not new. The value chain mapping methodology, outlined in this paper, however, offers a new approach for mapping synergies across industry sectors and interconnected segments, facilitating scaling up of value chain integration. Our approach is based on the assumption that MNEs as multiproduct and multi-technology establishments internalise multiple value chains and exhibit an integrated value system. Related diversification of MNEs, combined with concentrations of localised capabilities in SMEs and medium size firms exhibits chains of value added activities. Combining data across the top MNEs in a sector can deliver a comprehensive value chain map that can be used for positioning SMEs and new market players.

This paper discriminates between two distinctive methodological stages that require different datasets. These are: a) mapping the global value chain (GVC) through interrelated capabilities across MNEs and their subsidiaries; and b) mapping regional capabilities in a sector, and positioning of these capabilities within the GVC through a comprehensive dataset of firms in a particular location.

[4] Smart regions conference.

For the purpose of illustration of this approach, we have selected the global biopharma, which is an established sector with clearly identifiable related industry codes and an integrated global value chain. An adaptation of this methodology using text mining enables building a dataset of firms and value chain mapping in emerging industry sectors. For the second stage of mapping of regional capabilities and positioning these capabilities on the global value chain we have selected two cases – a national case with smart specialisation strategy under the label of *healthy life and biopharma* (Bulgaria), and a regional case of strong *biomedical and biopharma capabilities* (UK – Greater South East, comprising East of England, Southeast of England and Inner / Outer London). Each of these cases required the development of a bespoke dataset of firms within the regional and national boundaries.

1.1. The global biopharma

Biopharma sector is an example of multi-product and multi-technology production environment with multiple intermediary markets for technologies, intermediate products and services, where co-specialisation is an essential component in the knowledge and technology management process. Biopharma global value chain, hence, is expected to follow the internationalisation of firm activities and the growth of the MNEs in this sector. Biopharma MNEs are particularly efficient in generating synergies across multiple technologies – both in the drug discovery and development and in the market development segments.

Biopharma analysts have created numerous representations of the value-added links – from drug discovery – through drug development and market development. The biopharmaceutical industry is traditionally represented by 6 groups of activities (or micro-bundles of resources and capabilities): *design, make, test & develop, license and reimburse, distribute, sell*. This flow of value added along the chain of interconnected activities in biopharma, however, is far too simplified, and industry analysts already have pointed that the biopharma value chain is driven by two distinctive business models - *disease driven discovery* activities, and *development driven* set of operations[5].

A large biopharma MNE, such as *Abbot laboratories*, have capabilities across the entire spectrum of operations and integrate both parts of the biopharma GVC. Abbot laboratories has 135 registered large and very large subsidiary firms, active in 40 countries around the world, including 16 subsidiaries registered in the UK and 1 in Bulgaria. This company alone manages operations across 24 industry codes and report total revenue for 2013 over €33 bn[6].

Regarding the representation of biopharma GVCs through input-output tables, World Bank, OECD and other international institutions have selected the International Standard Industrial Classification (ISIC) system, specially developed for global comparisons. The ISIC categorisation bundles biopharma industry with the chemical sector at a two-digit level (ISIC code 21 - *Manufacture of pharmaceuticals, medicinal chemical and botanical products*), which excludes all other related activities, such as manufacturing of herb infusions, pharmaceutical glassware, medical, surgical and dental instruments and supplies, as well as research and development (R&D) for pharmaceuticals and biotech pharmaceuticals, as well as growing of drug and pharmaceutical crops[7].

The industry codes used in the European Union (NACE), or the North American Industrial Classification System (NAICS) in the same way provide a fragmented representation of the biopharma sector. As a result, current mapping initiatives that focus on the biopharma sector offer metaphorical evidence of interconnected activities in the

---

[5] Figure 13; Kearney (2013).
[6] Bespoke global biopharma MNE dataset 2015, own calculations.
[7] Table 8.

biopharma. For example, European Cluster Panorama has labelled the biopharma R&D as *education and knowledge creation activities*, while the US cluster mapping defines the biopharma outputs as biological products, biopharma products, health and beauty products, as well as ophthalmic goods, diagnostic substances, dental instruments and suppliers, surgical instruments and medical equipment, and the R&D is qualified as activities of teaching and specialised hospitals, research organisations and educational institutions[8]. *All current biopharma mapping initiatives exclude both generic and biopharma specific R&D codes identifying strictly commercial activity, as well as other related value added activities that support the biopharma GVC.*

At the same time, an early application of the value chain mapping methodology reveals that the core biopharma industry codes include a strong wholesale of drugs component, as well as other related manufacturing segments, such as diagnostic substances, toilet preparations, and broad woven fabric and cotton (both as input and output market for biotech products)[9]. Although this connectivity is empirically observed for companies located in the South East of England (UK), it can be argued that such connectivity represents technological pathways of interconnected markets, and hence, can be expected in other regional contexts.

A later study with the same methodology reveals also that the commercial R&D sector comprises of two distinctive segments - Bio-pharma R&D and Drug development support, where the second segment exhibits consistently a better performance[10]. The two R&D strategic groups are bundled in the region with other strategic groups of related activities, such as: IT and technical support services, diagnostics and telecare – among other medical and health services. Both of the studies in 2006 and 2008 provide data driven evidence from bespoke datasets at regional and industry level.

The conceptual representation of the biopharma value chain in the South East of England (UK) clearly indicates distinctive specialisation of firms into R&D, manufacturing, wholesale / trade, and other support services, whereby the service component contains approximately 25% of the firms and the wholesale, trade and retail component contains additional 37% of firms. The manufacturing itself is concentrated only in 25% of the firms, including 115 large biopharma MNEs that have capabilities across the entire value chain[11]. Similar proportions of distribution of industry capabilities across the value chain are observed in the EU Cluster observatory sector report on biopharmaceuticals[12].

The building of the bespoke global biopharma MNE dataset was facilitated by the preliminary allocation of MNEs to the biopharma sector using EU R&D scoreboard[13]. The bespoke dataset contains the top biopharma MNEs with all of their subsidiaries. The company data has been collected from Orbis: international corporate database in 2015 and includes detailed description of activities and firm level data on operations, revenue and employment, country of origin and location of operations. The bespoke datasets of the two cases of biopharma capabilities in Bulgaria and in the Greater South East (UK) have been built from the same source, using specific selection criteria – to match the capabilities already identified in the global biopharma value chain. Full details are described in the methodological section of each case. The dataset of the two cases include all relevant SMEs, and hence capture the regional biopharma capabilities with more depth.

[8] European Cluster Observatory, 2014a; Figure 15; US cluster mapping initiative; Figure 16.
[9] Todeva and Keskinova, 2006; Figure 17.
[10] Todeva, 2008.
[11] Figure 18, own calculations based on Bespoke GSE biomedical and biopharma dataset (2008), Todeva, 2008.
[12] Figure 15.
[13] EU R&D Scoreboard, 2014.

2. Mapping global value chains with data on multinational firms

Large MNEs internalise large parts of the value chain across their network of subsidiaries, and each of their products or service groups is delivered through a uniquely designed chain of value added activities. The MNEs are the main vehicle both for the fragmentation and the integration of global production, and hence mapping the diversification portfolio of MNEs is a way of representing GVCs[14]. Each MNE designs its own value chain in all three dimensions of upstream, mid-stream, and downstream activities, as well as auxiliary services that support their operations. The diversification and scope of MNEs, determine how their value chain network is constituted, where individual products, services or technologies generate their own value chain and value chains intersect within the boundaries of the MNE into a value network. The upstream supply chains are assumed to be constituted outside of the firms, and in the case of MNEs, they often run through the network of subsidiaries.

The outline of biopharma mapping techniques and methodological approaches to analysis of GVCs clearly points at the diversity of theoretical foundations and empirical research to capture, measure and represent the global connectivity of biopharma[15]. It is acknowledged that using trade statistics and indicators of input-output of intermediary products and services at country level gives an aggregate number which can be used for global comparisons, but the picture often is difficult to interpret. All current efforts focus heavily on the manufacturing side and are lacking insights into the support and services, or the R&D and innovation that is taking place behind the scene of intermediate trading.

There are currently three attempts at mapping diversified capabilities within regional (cluster) boundaries and as a value chain network. These are the concerted efforts of the European cluster panorama that establishes a tree or cluster relatedness based on prior categorisation of industries, the US cluster mapping initiative that combines regional / industry economic data from multiple sources, and the novel data driven approach by Todeva and Keskinova[16], which is developed and elaborated further in this paper.

Although the European cluster panorama map demonstrates a creative and systematic effort to combine data from multiple sources and to measure concentration and growth at regional and industry level, their data source is incomplete. The lack of adequate representation of the UK biopharma on the European cluster map exposes one of the inherited weaknesses in the dataset, as self-reporting clusters are not necessarily the most legitimate source. In addition, categories, such as 'Education and knowledge creation' misrepresent the actual biopharma activities, such as biopharma R&D, medical testing and drug trials.

The US cluster mapping initiative represents another and more comprehensive effort to establish comparability of clusters and regional performance. The methodology, however, is top-down, using the natural geographic boundaries of the 172 Economic Areas in the USA, categorising individual industries into cluster-related categories, and applying national statistics to these categories. All clusters, according to this methodology, are first divided into 16 local and 51 traded, excluding effective cross-industry fertilisation, and then, each cluster is described using sub-cluster names, on the

[14] Todeva and Rakhmatullin, 2016.
[15] Todeva and Rakhmatullin, 2016.
[16] Todeva and Keskinova, 2006.

basis of categorised NAICS industry codes. The biopharma sector is referred to three distinctive categories of traded activities: Biopharmaceutical Products, Biological Products, and Diagnostic Substances[17]. Although this systematic benchmarking of standardised industry agglomerations enables comparability of cluster measures and industry measures across the geographic regions in the USA, it does not represent the real diversification of firms generating inter-industry value-added links, and hence, has limited applicability to mapping global value chains.

Todeva and Keskinova[18] on the other hand, offer a bottom-up approach for mapping GVC, that builds upon intra-firm and inter-industry diversification, and combines ideas from multiple approaches. The foundation of this methodology is to generate a unique and comprehensive dataset of firms and to categorise the entire population in strategic groups according to domineering patterns of diversification, enabling subsequent analysis of concentrations, connectivity, and comparative performance[19]. This study is a demonstration of the advantages of this mapping approach and its application at regional and national level.

The subsequent sections of the paper outline the main methodological principles and steps for the value chain mapping and mapping of regional and sectoral capabilities of the global integrated biopharma. The value chain mapping methodology is applied with three bespoke datasets: one containing the global biopharma, second, containing biopharma capabilities in Bulgaria, and third, containing the regional biomedical and biopharma capabilities in one of the fastest growing regions in the UK – the Greater South East. The analysis of all three bespoke biopharma datasets follows the same steps, aiming to reveal the main strategic value chain groups (VCGs) - as evidence of patterns of diversification and bundles of capabilities that add value to the final output markets, and subsequent analysis of the location and connectivity across the value chain.

2.1. Lead principles

A: **MNEs are the lead firms in E/GVC** – MNEs design and initiate activities in the value chain by making strategic choices about the scope of their capabilities (to undertake activities in-house or outsourced); the geographic location of operations; the industry segment; the ownership structure of governance and control; selecting suppliers and placing orders to them (including governing supply relationships); giving market power to suppliers (through volumes of trading and sharing market information); implementing selected product / process technologies; and developing specialised strategic capabilities within their own value chain, including R&D, manufacturing or services. GVCs are constituted within MNEs and hence, mapping MNE subsidiaries can be used for mapping the GVCs that they control. The industry codes declared by the selected MNEs and all their subsidiaries represent a unique bundle of capabilities within the value chain. The geographic location of operations indicates the global spread of the GVC and the main hubs with concentration of capabilities that are integrated into the GVC.

---

[17] US cluster mapping initiative.
[18] Todeva and Keskinova, 2006.
[19] The literature on strategic groups highlights that industries are constituted of firms that exhibit group behaviour, or while aiming to gain strategic advantage in the market place, they follow similar strategies (Caves and Porter, 1977, Porter, 1980, Caves, 1982, Kogut, 1984). Kogut also highlights that strategic groups are under-researched, and hence we know very little about how multinational firms transfer strategic advantages across various geographic locations of operations.

B: **Industry fragmentation in E/GVC** - emerges out of product and process specialisation and a combination of cost reduction strategic outsourcing by MNEs and entrepreneurial activity in a particular geographic location. Fragmentation leads to cluster development and regional co-specialisation. Hence, there is a strong link between dynamic industry / regional clusters and participation in GVCs. Mapping co-location of activities and capabilities in geographic locations can represent regional comparative advantage and competitiveness in attracting further E/GVC participation.

C: **Geographical dispersion of E/GVC** - results from the internationalisation strategies of the lead MNEs, building subsidiaries and operations, or outsourcing to host countries, selecting suppliers abroad and selling products and services in global destinations through: 'importing to produce' (I2P), 'importing to export' (I2E) and cross-border 'value added trade'[20]. Mapping trade flows between countries can confirm increase/decrease of GVC participation of a particular country or a region. This, however, cannot confirm an upgrade of the position of this region in the GVC.

D: **E/GVC re-integration** – is affected by a combination of market and technology drivers, such as specific customer demand, or technology upgrade and disruptive technologies, and the strategic choices made by MNCs in response to these drivers. Regions and governments can play very little role in this respect, apart from promoting, facilitating and financing networking with potential customers.

E: **Total global connectivity** - there are no clear boundaries between industries and value chains – both upstream and downstream components of value chains connect to multiple other industries, or input/output markets. Each value chain resembles a segment of a highly interconnected global network of money and resource flows, and large MNEs have ownership ties to multiple other industries that constitute input / output markets. In this complex scenario, mapping GVC requires data at the level of MNEs, including identifying strategic groups of firms that co-specialise in a particular segment of the value chain. The geographic location and dispersion of economic activities is best identified through mapping of the location of firms. The most critical requirements are to identify a method that reveal and demonstrate the re-integration of value added and the global connectivity, and as such the application of network analysis techniques are essential *complementors*.

2.2. Methodological steps

Step 1: Identifying core industry boundaries

The first step requires identifying the industry boundaries, as value chains are industry specific, product specific and technology specific. As value chain boundaries are not self-evident, a decision is needed on what value chain is to be mapped. This decision determines the scope of the subsequent work, as each value chain is connected to other sectors of the economy. A definition of the core product / market / technology is used to determine the boundaries within which a requirement for a comprehensive dataset of all firm capabilities is fulfilled. At this stage of value chain mapping, geographic boundaries are not required as value chains cross regional boundaries. However, when mapping regional capabilities within a value chain, then administrative boundaries of the target location are necessary.

For mature industries, sectoral boundaries can be determined around core industry codes. For emerging industries value chain boundaries can be determined by core technologies, or core products, services and processes. In our example, the boundary definition of the global biopharma sector was pragmatically adopted from the European

[20] Baldwin and Lopez-Gonzalez, 2015.

R&D Scoreboard and the 2014 listing *of the world top 2 500 companies*[21] with the highest investment in R&D.

> ***Step 1:*** The industry boundaries can be determined pragmatically in many different ways – either adopting existing categorisations, or by key words that represent lead technologies, products or service markets. This top-down selection is complemented by a bottom-up approach for the build of the comprehensive bespoke dataset to include all subsidiaries of the selected MNEs and all NACE codes declared as part of the MNEs' portfolio.

The pragmatic selection of the boundaries for the global biopharma enables us to determine the analytical strategy for: the building of the bespoke sectoral dataset and the extraction of firm data; and the analytical procedures for the global value chain mapping. The sections below outline the subsequent steps of the mapping procedure.

***Step 2*: Building a comprehensive dataset of firms**

Although it is assumed that each MNE has internalised the biopharma value chain, a single case cannot establish a generic industry pattern. In order to derive at a generic representation of the sectoral biopharma GVC, a dataset of all lead MNEs with their complete portfolio of operations is required. The data source may vary and different data sources have different coverage of MNE activities. The extracted data should contain a detailed description of activities and operations of all firms in the MNE portfolio – in order to categorise them in strategic value chain groups.

Dataset boundaries that are determined by key words of technologies and product markets are built in the same way as those using industry codes. However, firm data of activities in this case contains text description, and the subsequent categorisation of firms in strategic value chain groups requires text analysis.

Further in this section we illustrate this step with a description of the build of the bespoke global biopharma MNE dataset. Essentially this is extraction of data from ORBIS International Corporate Database, on firms that comply with a set of selection criteria regarding industry and geographic boundaries. Firms are identified by their unique BvD ID number – either as parents, or as subsidiaries. Essential principle in the building of the dataset is to obtain comprehensive full population data and a thorough cleaning of the data from errors, duplications, or incomplete records.

The *pre-selection criteria* for our dataset were the following:

- The top global R&D investors in biopharma, identified by the EU R&D Scoreboard 2014 – identified as MNE parents;
- All of their subsidiaries worldwide (maximum of 10 levels of subordination);
- All additional data on branches of the MNEs;
- When duplicate records of the same company exist, the highest level of authority is selected – starting from parent, subsidiary level 1, … subsidiary level 10;
- All ownership data is preserved in the output dataset;
- Only companies with activities data remain in the derivative dataset (European record preferred for the mapping in cases of dual ownership subsidiaries).

Firm level data for the core 293 biopharma MNEs was obtained for all of their subsidiaries (up to level 10), and branches.

---

[21]Source: http://iri.jrc.ec.europa.eu/scoreboard14.html

The final **output dataset** after cleaning comprised of 33 653 cases of firms with ownership ties[22]. The output dataset preserves duplicate cases when subsidiaries have more than one parent. These ties are preserved for the network analysis, while all duplicates are deleted for the cluster analysis[23]. This dataset is used for the analysis of the biopharma GVC and the geographical maps showing concentration of generic biopharma capabilities around the world. In the output dataset every parent appears as many times as its subsidiaries.

After cleaning all duplicates with dual ownership ties and firms without activity data, we establish the final **derivative dataset** containing 20 508 firms with a record of activities, revenue and employment for the last available year, as well as further ownership, management and performance data[24]. All these firms develop drugs, manufacture, supply, finance, or deliver services in the global biopharma industry. A **sub-sample** of this data, containing the full population of large and very large firms – a total of 4 656 in total (BvD categorisation), is further selected for the categorisation and mapping of strategic value chain groups in the GVC. The main assumption behind this selection is that diversification is more likely among large and very large firms. In addition, the re-focusing of the categorisation in value chain groups on the largest firms reduces the cases with missing data[25].

Step 2: The building of a comprehensive bespoke dataset of firms involves multiple steps of cleaning and organising of the data and includes multiple formats and structures of the data, broadly described as output dataset and derivative dataset. Each format of the data is used for different observations and analytical procedures, enabling rich and insightful analysis (Steps 3, 4, and 5). The sub-sample of large and largest firms is a convenience sample for the data categorisation – to reduce the heterogeneity and the cases with missing data.

[22] *Table 10*; The first level cleaning involves removal of duplicate cases with identical parent and subsidiary BvD ID number, or cases in which a subsidiary appears on more than one level of subordination under the same parent. It is possible to be simultaneously a parent and a subsidiary when firms have engaged in a swap of shares, or other cross-ownership ties. In these cases, the record of the parent is kept in the dataset for further analysis.

[23] Cluster analysis as a statistical technique is used in the *multi-stage cluster methodology* (Todeva and Keskinova, 2006; Todeva, Knoke and Keskinova, 2016) as part of the pattern recognition procedure for mapping strategic value chain groups.

[24] Table 10.

[25] A descriptive analysis of the sub-sample from the derivative dataset reveals that the population of firms declare activities in 416 related and unrelated industries. There are 150 firms in the derivative sub-sample, that have no NACE code, 2 507 firms have 1 code only, and 1999 firms have more than 1 code (14 of which are multi-diversified firms with 20 industry codes). These observations confirm a highly heterogeneous dataset of firms (*Table 10*). Two core codes domineer the entire dataset sub-sample with 30% occurrence (NACE 2120 – 'manufacture of pharmaceutical preparations' and NACE 4646 – 'wholesale of pharmaceutical goods'. Only 8% of the sub-sample of the largest biopharma R&D performers declared the specific NACE 7211 – 'research and experimental development on biotechnology', while 10% declared the more generic code NACE 7219 – 'other research and experimental development on natural sciences and engineering'.

The top-down development of the bespoke biopharma dataset ensures that the population of firms represent the entire sector. The full use of all declared industry codes by the firms ensures that the strategic value chain groups represent the actual diversification of firms. All decisions during the development of the bespoke dataset aim to ensure simultaneously *sectoral focus*, and *all-inclusive diversification profile of firms*[26].

Step 3: Categorisation of firms in core value chain groups

The observations of the global biopharma dataset confirm that the original ORBIS BvD categorisation of firms in *peer groups* does not correspond with the declared primary and secondary NACE codes, and hence, cannot be used for mapping of strategic value chain groups. In addition, large firms maintain cross-sectoral diversified portfolios, which are exhibited by multiple industry codes connecting complementary value added activities across industries, which cannot be captured by a single industry code. The categorisation of firms according to the pattern of their diversification offers an insightful representation of the complex organisation of interconnected value added activities. This approach is suitable for any R&D intensive sector, as value chains are technology driven, and large firms are expected to engage in diverse activities aiming to gain competitive advantage through vertical and horizontal integration.

The mapping of the core value chain groups was undertaken with the derivative dataset, which was divided into sub-segments for the application of different categorisation procedures. The segmentation involved the following:

Segment A: a sub-sample of the top 4 656 large and very large firms (Table 10).

Segment B: firms from Segment A that contain two or more industry codes - identified for the application of the first stage cluster analysis and the subsequent network analysis (1 999 firms in total).

Segment C: all firms in the derivative dataset that contain only one NACE code and firms that have only text description of activities.

Segment D: unique multi-diversified cases in the derivative dataset, individually allocated to strategic value chain groups.

The categorisation of firms and the constitution of strategic value chain groups within the biopharma GVC was executed in four stages. The first stage of categorisation involved formal clustering of the diversified firms in Segment A. Due to the huge diversity of codes, only 17 of the most commonly occurring NACE codes were selected – to represent the core and the largest concentrations of biopharma capabilities. These codes were selected on the basis of occurrence and relatedness and represent core biopharma activities, including manufacturing, R&D, and specialised services. The pre-selection of codes mainly ensures that the strategic value chain groups are framed by core value added activities[27].

The *pre-selected NACE codes* represent the following[28]:

---

[26] All industry codes, are transformed into dichotomous variables for the analytical categorisation of firms.

[27] Table 8, 9. The pre-selected NACE codes are expected to have a strong impact on the categorisation process and to generate meaningful 'centres of capabilities' for the strategic value chain groups. A number of generic industry codes with high occurrence that potentially can represent biopharma, as well as capabilities in other sectors, were suppressed from the analytical categorisation, so they cannot form an independent strategic value chain group. Firms with missing NACE code, containing text description of activities are categorised using text mining technique, replicated from previous studies.

[28] Overall 3759 firms from the sub-segment have declared at least one of our pre-selected NACE codes, while 747 firms contained codes that do not represent core

- all codes with intensity more than 5% occurrence in the population;
- two core manufacturing codes for 'medical and dental instruments and supplies' and for 'other chemical products, n.e.c' (with intensity of 2% occurrence in the population) as strongly related activities;
- five additional manufacturing codes that represent other related diversification in input and output markets (with intensity of 1% occurrence);
- the specialised code for 'technical testing and analysis' (NACE 7120) which is known from previous research (Todeva, 2008) to constitute the value chain group of R&D support services (with intensity of 1% occurrence in the population);
- one specialised retail code as output market - NACE 4774 'retail sale of medical and orthopaedic goods' (with intensity of 1% occurrence in the population).

The categorisation procedure was implemented with Word's method, Binary Euclidian distance measure, cases sorted according to their primary code[29]. Groups of firms with strong cluster centres complete their categorisation at the first stage and receive provisional labels as a value chain group, based on the attributes of the group (NACE codes). Each value chain group represents a strategic agglomeration of firms with similar portfolio of operations, or similar specialisation within the GVC.

The second stage deals with multi-diversified firms and 'dirty' clusters (691 firms from Segment B) which are categorised as a sub-segment and subjected to the same categorisation procedure as chosen for the first stage. While 600 firms in our example were categorised as diversified value chain groups, 91 firms (Segment D) were individually categorised.

The third stage involves categorisation of firms with one code or no industry code at all (substituted with text description) (Segment C). While in most cases firms are allocated to existing value chain groups (VCG), in some cases of large agglomerations of diversified firms, a new VCG is created. Most of these new value chain segments represent non-core or peripheral and unrelated diversification.

Overall, VCGs that are constituted at the first stage of categorisation represent clear patterns of related diversification, while VCGs that emerge at stage 2 and 3 contain more diversified cases, connected to input or output markets, such as miscellaneous products and services, or exhibit unrelated diversification in the portfolio of capabilities under the control of global biopharma MNEs. Table 1 contains the list of final VCGs and their diversification portfolio.

Table 1. Industry composition of the global biopharma strategic value chain groups

Cluster	NACE codes[30]	Parents all	EU parents	Parents & subsidiaries all	EU parents & subsidiaries
11 - Biopharma R&D	7219, 7211	19	9	903	553
12 - Biopharma R&D & manufacturing	7219, 7211, 2120	90	2	180	13

---

biopharma capabilities. The latter were categorised separately from the main categorisation procedure.

[29] See Todeva and Keskinova, 2006; Todeva, Knoke, and Keskinova 2016. Following a thorough examination of the results, we differentiated between completely 'clean' clusters with a *strong cluster centre* (with mostly 100% occurrence of industry codes in cases), *clusters with a weak cluster centre* (with fractional overlap in firm activities), and *'dirty' clusters* (with no cluster centre).

[30] Industry groups that do not have a specific NACE codes represent very diverse agglomerations of products and services.

Cluster	NACE codes[30]	Parents all	EU parents	Parents & subsidiaries all	EU parents & subsidiaries
13 - Biopharma R&D & services diversified	7219, 7211, 4646, 6420	8	3	262	126
14 - Clinical research & human health activities	8690, 2660, 3250, 2120	2	0	475	194
21 - Bio-pharma manufacturing	2120, 2110	71	20	6 271	761
22 - Biopharma manufacturing and wholesale	2120, 3250, 4646	41	9	282	145
23 - Perfumes and cosmetics manufacturing	2042, 2041	1	1	64	23
24 - Biopharma manufacturing multi-diversified	2120, 3250, 7219	23	4	753	95
25 - Chemical & biopharma manufacturing diversified	2014, 1101, 2041, 2059	6	4	459	168
26 - Medical instruments, dental & electrotherapeutic manufacturing	2660, 2670, 3250	4	0	306	91
27 - Manufactured goods, electronics and instruments	2611	0	0	161	47
28 - Special purpose machinery and equipment		1	0	105	39
31 - Specialised biopharma wholesale	4646	3	2	1 424	1 098
32 - Biopharma retail	4773, 4775, 4618	0	0	1 829	215
33 - Biopharma & cosmetics, wholesale	4645, 4646, 4690	3	0	1 251	43
34 - Pharma wholesale trade & services diversified	4646	0	0	71	60
35 - Chemical & biopharma wholesale	4675, 4646	0	0	119	52
36 - Medical & hospital equipment wholesale & supplies	4690	0	0	355	53
41 - Holding, financial & administrative head office services	6420, 7010, 8299	14	8	1 517	974
42 - Other business and management services	7490, 7220, 7311	3	3	854	555
43 - Finance & insurance services	6499, 6512, 6619, 6492, 6612	0	0	574	152
44 - Miscellaneous services		3	2	1 267	519
51 - Agriculture, food processing & drinks of bio products		1	1	589	115
52 - Manufactured miscellaneous goods	1729	0	0	111	11
53 - Electricity, gas and water supply & services		0	0	290	238
54 - Other miscellaneous wholesale		0	0	615	165
Total		**293**	**68**	**20 508**	**6 505**

Source: Bespoke global biopharma MNE derivative dataset (2015).

The categorisation of firms in strategic value chain groups based on their diversification portfolio of activities is a major breakthrough in the challenge how to capture unique positions in complex value chains.

> ***Step 3:*** The categorisation of firms in core value chain groups involves a multi-stage categorisation technique that consist of formal statistical methods and conceptual allocation. The number of stages and the formal statistical methods are determined mainly by the size, structure and heterogeneity of the data in the dataset.

The method of categorisation enables to reveal patterns of specialisation across the entire population of firms in the bespoke industry dataset. The strategic value chain groups (or strategic industry groups) demonstrate dominant patterns of related and unrelated diversification in the particular sector, and represent complementarities of value-added activities, determined manufacturing technologies. Following this categorisation, the next step of mapping of value chain capabilities represents visualisation of existing relationships.

Step 4: **Mapping of the industry value chain**

The mapping of value chain capabilities essentially is visualisation of existing strong links that connect value added activities within firms and across industry segments. This visualisation enables firms to determine the focus for their investment in core capabilities, while outsourcing to input and output markets. Naturally, the business process of firm growth involves backward and forward integration within the value chain, and hence, the visualisation of value chains and value networks should exhibit these linkages. The categorisation of firms in value chain groups using a comprehensive dataset enables the application of network analysis techniques to reveal such underlying relationships. Step 4 of the GVC mapping, hence, involves evaluation of the content of all VCGs and analysis of the connectivity across VCGs.

In our example of the bespoke global biopharma dataset, the list of VCGs in Table 1 confirms the complexity of input and output relationships across industry segments. This complexity is not currently recognised by the existing conceptual models of biopharma GVC[31]. The network analysis of the relationships between industry codes and value chain groups reveals a fragmented global picture with some emergent connectivity and real evidence of backward and forward integration. Figure 1 exhibits two very distinctive value chains, where diversification across industries is strong. These are the R&D chain, containing all R&D value chain groups (VCGs 11, 12, 13), and the chain of medical and hospital supply of interconnected engineering products and equipment, which includes multi-diversified biopharma companies (VCGs 24, 26, 27, 28).

Figure 1 exhibits further evidence confirming that the multi-stage cluster methodology has produced a clear categorisation of firms, where core industry codes belong to a unique value chain group. All graphic representations of the value chain[32] reveal an important observation that firm specialisation in the global industry in reality involves both vertical integration and horizontal diversification.

[31] Todeva and Rakhmatullin, 2016.
[32] Figure 1, 2, 3.

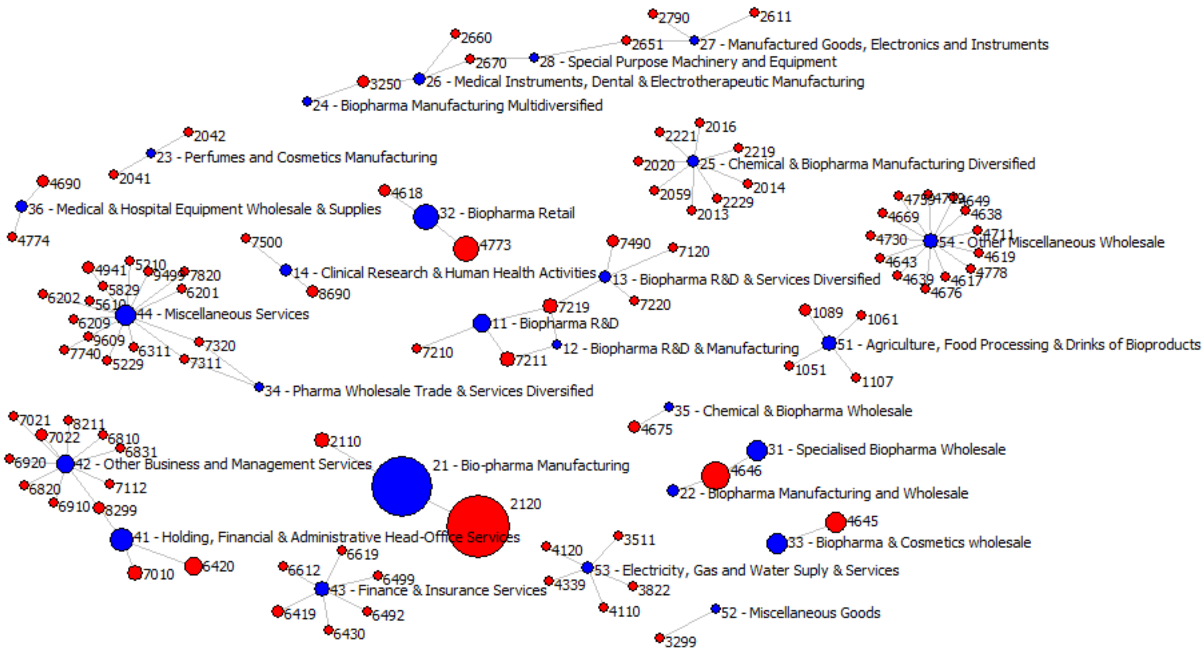


Figure 1: Ties between value chain groups and NACE codes

Source: Bespoke global biopharma MNE derivative dataset (2015).
Note: Exhibited ties with frequency > 0,1% or 25+ firms, 30% of ties; size of the dot indicates number of firms; links indicate interconnected industries through firm co-specialisation.

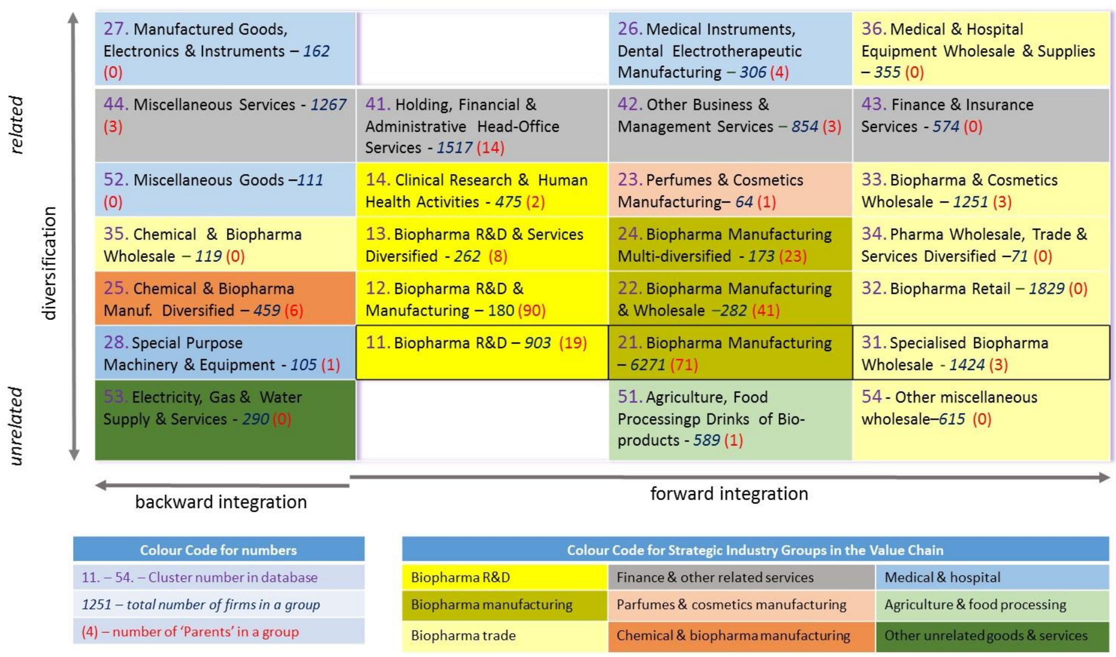


Figure 2. Biopharma global value chain (A)

Source: Bespoke global biopharma MNE derivative dataset (2015).

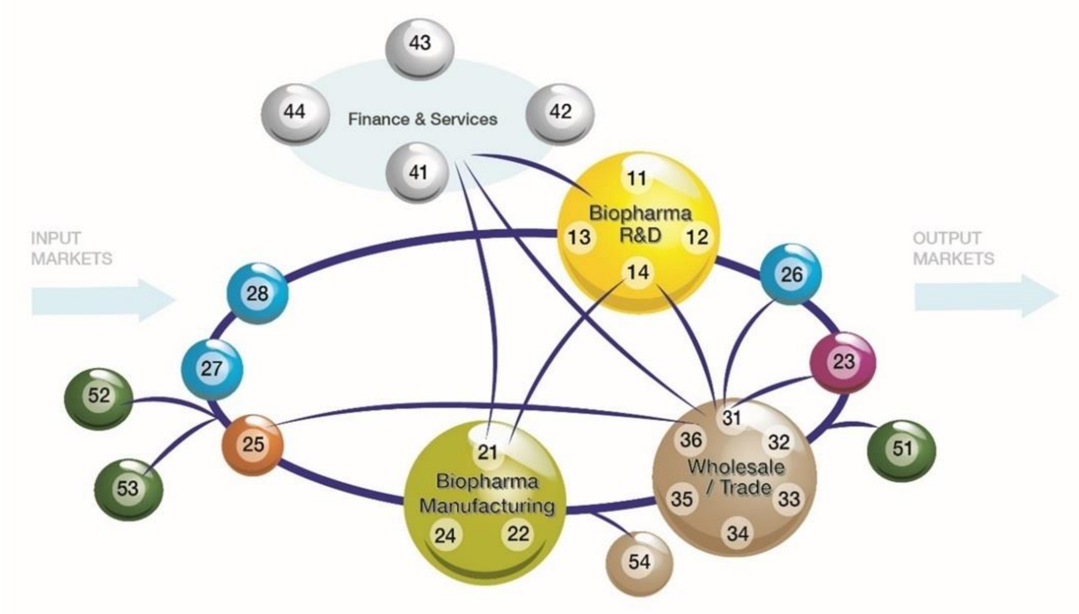


Figure 3. Biopharma global value chain (B)

Source: Todeva / Bell (2015).

Overall the mapping of biopharma value chain reveals 9 groups of activities that correspond with a distinctive diversification portfolio of firms (Figure 2, 3). These are the following[33]:

- Biopharma R&D (VCGs 11, 12, 13, 14)
- Biopharma manufacturing (VCGs 21, 22, 24)
- Biopharma trade (VCGs 31, 32, 33, 34, 35, 36)
- Specialised finance, business, management and other related services (VCGs 41, 42, 43)
- Perfumes and cosmetics manufacturing (VCG 23)
- Chemical and biopharma manufacturing diversified (VCG 25)
- Medical and hospital instruments, equipment and supplies and special purpose machinery manufacturing (VCGs 26, 27, 28)
- Agriculture and food processing (VCG 51)
- Unrelated goods and services (VCGs 52, 53, 44).

Figure 3 illustrates clearly how well integrated into the biopharma value chain are the 'medical and hospital instruments, equipment and supplies', as well as the 'agriculture and food processing', both of which contain parents MNEs[34]. A new observation is also the significant number of subsidiaries in services and non-related sectors, which are labelled as miscellaneous products and services and various utility and infrastructure companies such as gas and electricity[35]. What is also evident from the graphic displays of biopharma GVC in Figures 2 and 3 is the strong presence and integration with engineering activities, grouped in four VCGs - all directly linked both to the biopharma GVC and to health care[36]. The large number of specialised and generic wholesale strategic groups, as well as finance and services indicates two distinctive models of growth – one driven by the market pull, and the other through finance and investment in new products and technologies.

[33] Table 12.
[34] Table 11, 12.
[35] Tables 11, 12, 13, 14.
[36] Figure 2 and 3; Table 12.

The value chain maps (*Figures 2 and 3*) are complementary and provide two different perspectives on the global biopharma. While both figures represent real value chain connectivity based on synergies across related biopharma activities, each of them evokes a different narrative. *Figure 2* provides insights into the backward and forward integration of activities across related industries, and the scale of diversification of firms in different VCGs. *Figure 3* replicates the same diversification links and shows the circular loops across all segments of the biopharma value chain - more clearly described as a value network. All links in *Figure 3* represent shared capabilities across VCGs. These links represent value added flows and provide a map for inter-firm collaboration and seeking suppliers in match-making initiatives.

The input and output markets in *Figure 3* show the direction of value added and the interdependence and interconnectedness of intermediate markets. This graphic display of the biopharma industry exhibits also the co-specialisation of firms within the portfolio of large multinationals and the emergence of complex networks and multi-sectoral value added flows.

The proposed methodology for mapping biopharma GVC is a generic approach that can be applied to different industry sectors or geographic locations. It includes four distinctive methodological steps, as exhibited *in Table 2*.

Table 2. Mapping global value chains – a synthesis

	Methodological step	Method	Outcome
Step 1	Identifying core industry boundaries (at regional or country level)	Selection of NACE codes, regional boundaries *and* key words of products and technologies for text mining	Clear representation of industries and firm capabilities in regions and clusters
Step 2	Building a comprehensive dataset of firms	Extraction of firm data from ORBIS; cleaning the dataset; organising and structuring the records; identifying segments for categorisation of value chain groups	A bespoke dataset of firms enabling the application of a broad range of analytical tools for micro (firms), mezzo (value chain groups), and macro (regions and clusters) level of analysis; Key resource for selection of firms for match-making, R&D partnerships, or investment programmes
Step 3	Categorisation of firms in core value chain groups (VCGs)	Multi-stage clusterisation and categorisation of firms by their diversification portfolio	Identified bundles of capabilities and patterns of specialisation at a regional level
Step 4	Mapping of the industry value chain	Visualisation of interlinked strategic capabilities and the geographic location of these capabilities	Value chain maps with details of concentration of firm capabilities and value chain integration links

The proposed methodology for mapping of value chains has six main advantages:

1. It is based on mapping of real links between value added activities
2. It can be used for mapping of both established sectors and emerging value chains in emerging industries, where the bespoke dataset developed for the mapping exercise determines the scope of the subsequent value chain
3. It enables further in-depth analysis of strategic value chain groups, comparative performance analysis across stages of the value chain, the impact of ownership ties and the patterns of integration of supply chain relationships across different segments of the value chain
4. It enables mapping of regional capabilities and a region's position in global value chains
5. It enables regions to determine the scope of their specialisation in specific industry segments
6. It provides a resource for selection of firms who are active R&D performers in specific industry segments for match-making events and for selecting partners that have complementary capabilities

The following section demonstrates the in-depth analysis of the concentration of firm capabilities and the patterns of integration that reveal emergent business models in the global biopharma.

2.3. Analysis of the structure of biopharma GVC

The bespoke global biopharma MNE dataset enables to perform a number of analyses with firm level data. The categorisation of firms in strategic value chain groups enhances this capability providing additional insights into synergies across activities, linkages, and strategic behaviour of biopharma firms. The retained information on the ownership ties in the original dataset enables also to discriminate between European MNEs and the rest of the world, and to compare performance of European and non-European segments of the global biopharma value chain. The revealed cross-ownership cases and the location of foreign subsidiaries in Europe are indicative of the competitive dynamics in the sector.

The analysis of the concentration of capabilities in locations and segments of the value chain is undertaken with a series of network analysis techniques with one mode and two-mode networks, generated by the membership of firms in VCGs as a secondary attribute. The example of the biopharma GVC explores both network analysis of deeper patterns of ownership ties and detailed geographic mapping of co-specialisation and regional capabilities. In addition, the prior categorisation of firms in value chain groups enables comparative performance analysis revealing the distribution of profits and performance across the value chain and within each value chain group. The subsequent section starts with a preliminary observation of the top biopharma MNEs and demonstrates the insights from the application of the value chain mapping methodology.

Analysis of the structure of the GVC involves multiple analytical techniques that reveal different business models for structuring input-output relationships, as well as the connectivity and distribution of capabilities in selected locations.

The 293 largest pharmaceuticals & biotechnology companies, represent 12% of the total population of the world's largest investors in R&D. These firms are the 'parents', or 'global ultimate owners' (GUO) of assets in the pharmaceuticals and biotechnology sector that design and orchestrate the GVC. Parent companies with European country of origin are 68 (or 23%)[37], while EU is hosting 68% of all subsidiaries of global biopharma[38].

Network analysis of the ownership ties and the relationships between firm specialisation/diversification and value chain groups reveal the structure and connectivity in the global value chain. Figures 4 and 19 reproduce links between parents and subsidiaries. There are two types of 'parents' – those whose subsidiaries are integrated in all segments of the GVC (in the centre of Figure 19), and those that are more narrowly specialised, which are integrated only with part of the biopharma GVC, but are pulled by other value chains, such as: perfumes and cosmetics (VCG 23); medical instruments (VCG 26), or special purpose machinery (VCG 28).

Table 3. Biopharma MNEs from the top 2500 R&D investors by country of origin[39]

Europe		Other	
Country	Count	Country	Count
Belgium	2	Australia	1
Denmark	6	Bermuda	1
Finland	1	Canada	2
France	9	Cayman Islands	3
Germany	8	China	14
Greece	1	Hong Kong	2
Hungary	1	India	8
Ireland	5	Israel	1
Italy	5	Japan	28
Portugal	1	South Korea	12
Slovenia	1	Taiwan	1
Spain	3	US	144

[37] Table 3.
[38] Table 14, 15.
[39] The EU R&D Scoreboard identified 294 top Biopharmaceutical firms with the largest investment in R&D, including 77 MNE parents located in Europe (data from 2013). At the time of our research (2015) the total number of parents was reduced to 293 and EU parents to 68, following an acquisition of DURATA THERAPEUTICS by ACTAVIS on 17 November 2014, 4 company name changes, and the classification of Swiss parent companies under the group of 'Other global'.

Europe		Other	
Sweden	7		
Switzerland	*10*		
The Netherlands	3		
UK	14		
Total	**77 (68)**		**217**

Source: EU R&D Scoreboard 2014.
Note: 'Other' refers to 'the rest of the world'.

The graph on Figure 4 represents the same relationships as *Figure 19*, but reveals more precise structural configuration of relationships between parents and subsidiaries of the core value chain groups, which is an evidence of the existence of 4 distinctive business diversification models in the global biopharma. These are: a) R&D-led agglomeration (led by P11); b) Manufacturing-led agglomeration (led by P21); c) Wholesale-led agglomeration (led by P22); and d) Full integration and services-led agglomeration (led by P24, P41, P12).

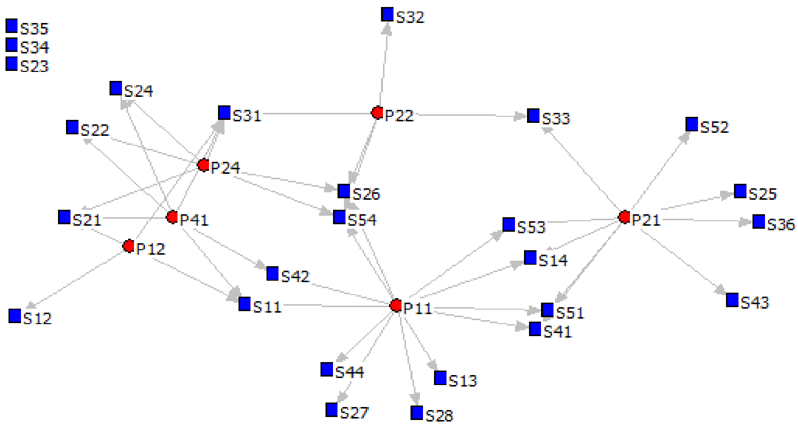


Figure 4. Ownership ties in the biopharma global value chain (A)

Source: Bespoke global biopharma MNE output dataset (2015).
Note: Links between parents and subsidiaries; links represent > 42 ties between nodes;
P – represent parents VCG, S – represent subsidiaries VCG,
numbers correspond with the numbers of VCG in Table 14.

Figure 4 displays also that there is a strong and close circular relationship between parents and subsidiaries in the entire biopharma GVC including R&D, manufacturing, holding and finance. This circular relationship is interpreted as high level of connectivity across the upstream and downstream parts of the value chain, or the existence of a complex inter-sectoral value network. *Figures 1, 2, 3, and 4* all exhibit graphical representations of biopharma value network and collectively reveal that the four distinctive R&D VCGs (11, 12, 13, and 14) correspond with different business models for innovation.

Figure 5 reproduces links between VCGs on the basis of shared capabilities (NACE codes) between firms. It shows structural relationships between VCGs, based on connected activities, internalised by firms. The value chain is pulled by the biopharma manufacturing quite independently, while the four R&D industry groups are entangled in relationships with the service sector (VCGs 41 and 42).

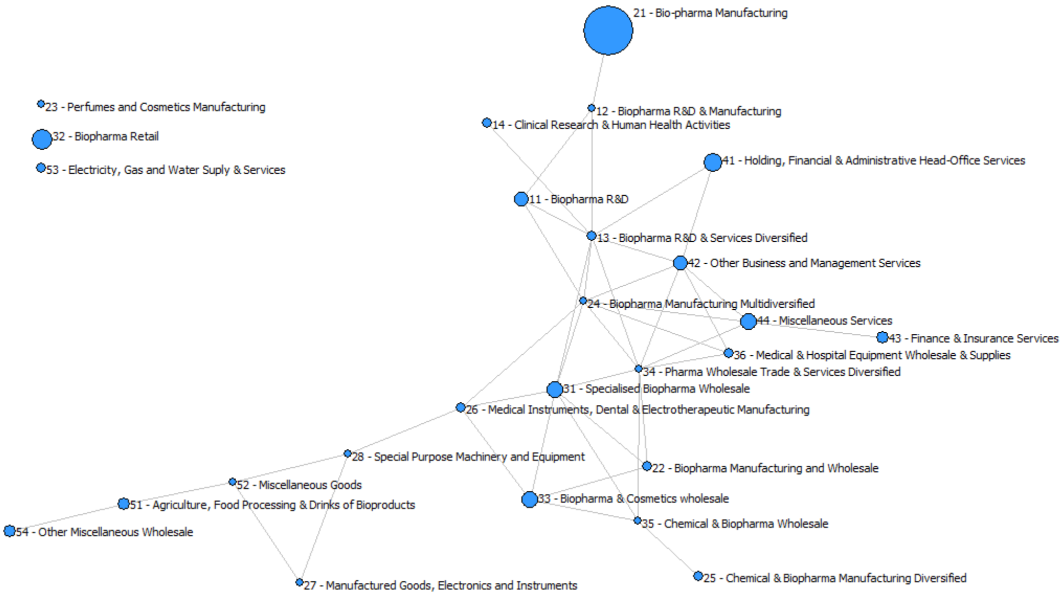


Figure 5. Co-occurrence between strategic value chain groups in the global biopharma

Source: Bespoke global biopharma MNE derivative dataset (2015).
Note: Links represent > 33% of ties between nodes;
The size of the node is proportional to cluster size (i.e. number of firms).

Biopharma manufacturing (VCG 21) is the most dominant in the value chain with the second largest number of parents (71 MNEs) and the largest number of subsidiaries (6271 firms)[40]. It represents VCG with the largest number of outgoing ties, linking to subsidiaries in all other value chain groups[41]. The central position of the GVC is occupied by biopharma manufacturing multi-diversified (VCG 24), surrounded by trade and services (VCGs 31, 34, 36, 42, 44) and the diversified VCG 13 (biopharma R&D and services diversified)[42]. Overall, holding, financial and administrative head-office services (VCG 41) is the only VCG that exhibits a pattern of predominant incoming ties, where parents from other industry groups have established a subsidiary relationship to a holding company enabling independent financing.

The structural map on Figure 5 reveals complex forms of integration around the biopharma multi-diversified (VCG 24) and the medical instruments and dental care (VCG 26), the latter of which draws capabilities from special purpose machinery (VCG 28) and their supply network. Although the chemical and biopharma manufacturing (VCG 25) technologically stands in the heart of biopharma, in the current GVC it exhibits quite an independent structural position, suggesting that it has a limited impact on the competitiveness of biopharma firms. The tail of the GVC is constituted of other related and unrelated sectors, some of which represent distant input-output markets for biopharma[43].

The position of VCG-13 '*R&D and services diversified*' is quite different. Firms combine different R&D operations with different services, among which 52% of the firms declare activities in NACE 7490 (Other professional, scientific and technical activities n.e.c) and 22% report activities in NACE 7219 (Other research and experimental development on natural sciences and engineering). Only 14% of firms report activities in NACE 7211

[40] Table 12.
[41] Figures 1 and 5.
[42] Figure 5.
[43] Figure 5.

(Research and experimental development on biotechnology), and 14% - in NACE 7120 (Technical testing and analysis), or another range of combinations around the R&D and services spectrum. This industry group clearly represents emergent segment which operates on the edge of our standard understanding of industries, offering a new business model within the biopharma GVC.

Aggregate statistics with the bespoke biopharma dataset show cases with extreme performance results and very high variation of indicators across the population. The median indicates that on average European biopharma MNEs report better results for R&D expenditure and sales in 2013, but lower 1-year growth of these indicators and relatively low R&D intensity. European MNEs, report better results on employees for 2013 and 1-year employee growth, which is a good indicator of building capabilities. It is important, however, to identify the exact location of this growth within the value chain, which can be assessed with further analysis of the firm data in our bespoke dataset[44].

Table 4. Comparative business performance - European vs. other global MNEs

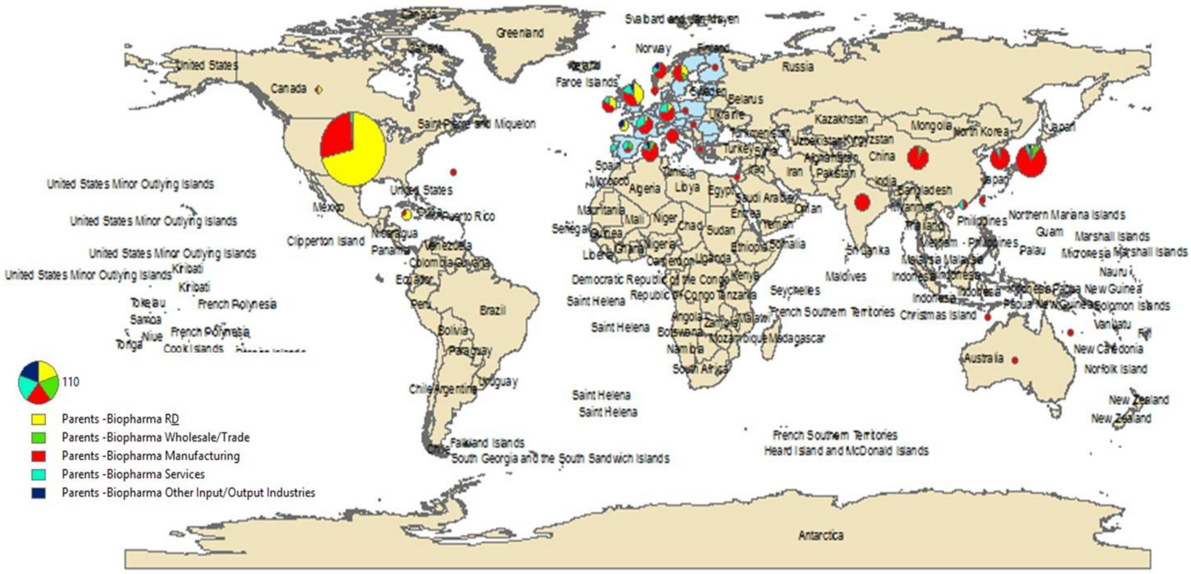
	EU countries		Other countries		Total	
	Median	N	Median	N	Median	N
R&D 2013 (€ million)	53.1	77	36.4	217	42.3	294
R&D 1-year growth (%)	7.1	77	15.4	210	13.0	287
R&D intensity (%)	14.2	76	21.1	195	18.1	271
Sales 2013 (€ million)	512.5	76	260.3	195	315.8	271
Sales 1-year growth (%)	2.9	73	8.3	192	5.2	265
Profits 2013 (€ million)	49.0	77	-7.6	216	12.7	293
Profits 1-year growth (%)	8.7	76	16.0	214	13.8	290
Profitability (%)	12.3	76	2.3	195	7.0	271
Employees 2013	2 018.0	70	433.0	194	765.5	264
Employees 1-year growth (%)	2.9	71	5,6	180	4.0	251

Source: EU R&D Scoreboard 2014

Preliminary observations with the bespoke biopharma dataset also revealed that the scale and scope of diversification does have an impact on performance[45]. The best performers in the four distinctive R&D value chain groups reveal that as average revenue is four times higher for the diversified firms compared with the specialised R&D firms.

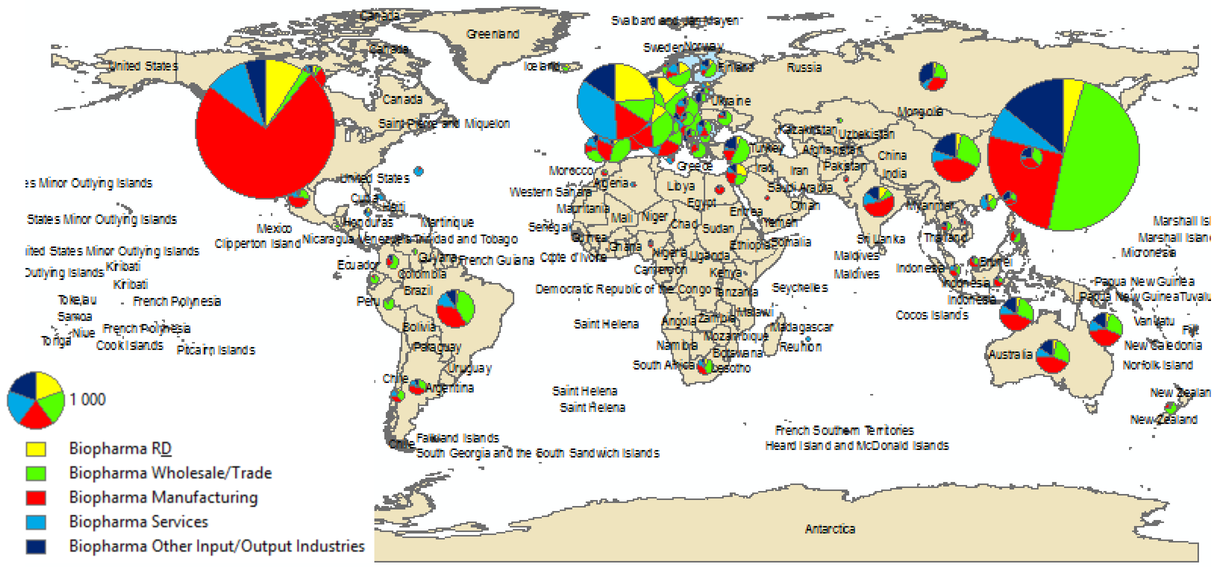
The geographic distribution of biopharma capabilities is exhibited in the following maps. Although the global R&D parents are predominantly from the USA (Map 1), the combined number of R&D parents and subsidiaries in Europe is quite significant[46]. The population of USA firms is strongly domineered by the manufacturing activities. The Japanese market shows much higher concentration of manufacturing and R&D in smaller number of firms, and the proliferation of the wholesale and retail market.

[44] Table 4.
[45] Table 16.
[46] Map 2.



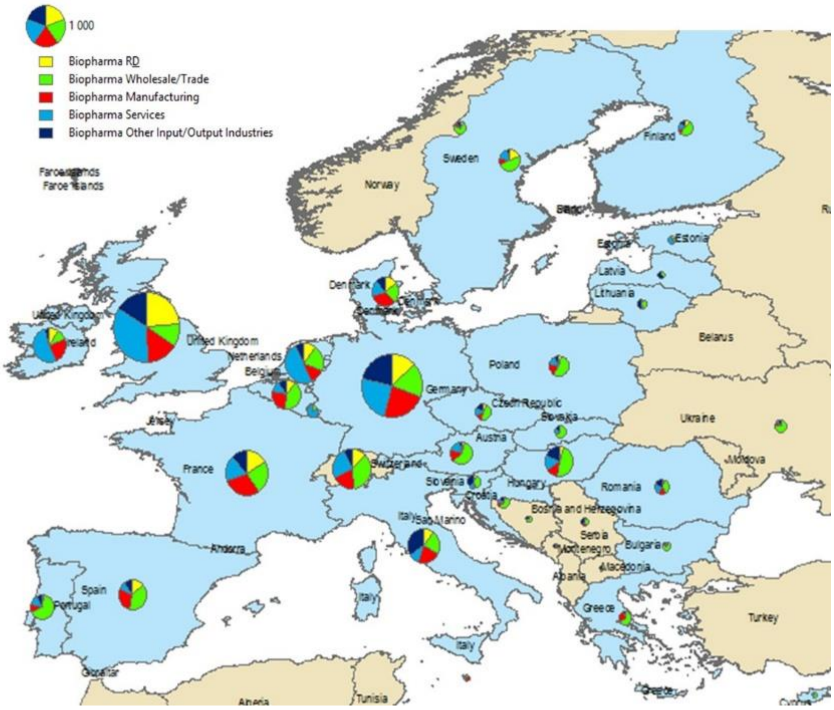
Map 1. Global parents

Source: Bespoke global biopharma MNE derivative dataset (2015).
Note: Total of 293 firms.



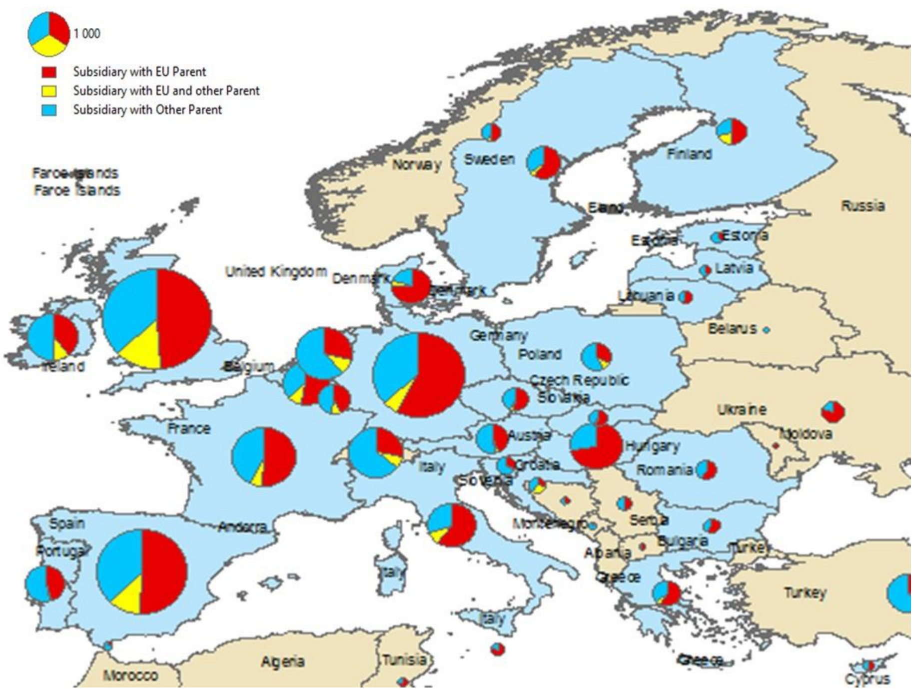
Map 2. Global parents and subsidiaries

Source: Bespoke global biopharma MNE derivative dataset (2015).
Note: Total of 20 508 firms.



Map 3*. *European biopharma parents and subsidiaries

Source: Bespoke global biopharma MNE derivative dataset (2015).
Note: Total of 6 505 firms.



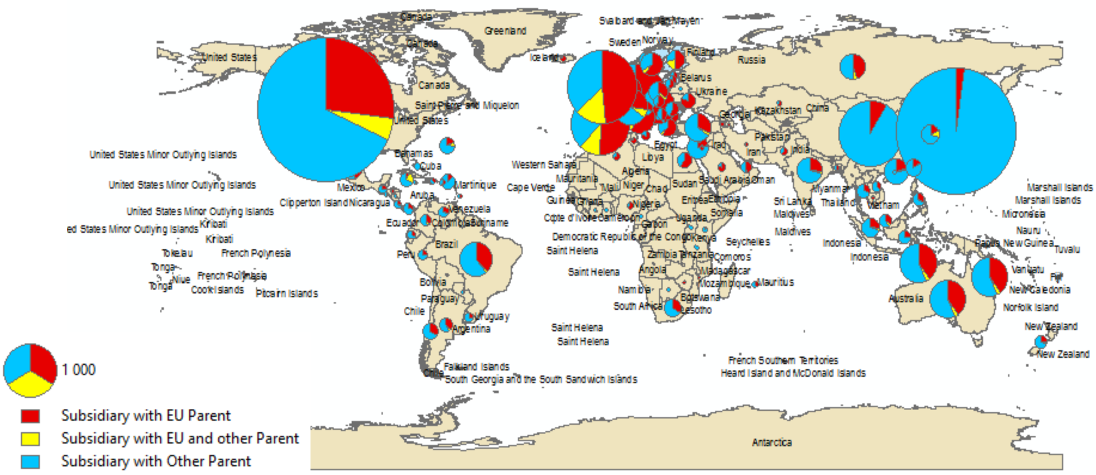
Map 4*. *Biopharma subsidiaries in Europe by source of ownership *(EU vs Others)*

Source: Bespoke global biopharma MNE derivative dataset (2015).

European biopharma exhibits a balance of activities across all segments of the GVC, while the UK shows some particular strength in services. Zooming into the European market reveals that the size of the industry in the UK is comparable with this one in Germany and marginally larger, in spite of the fact that UK does not have officially registered biopharma clusters on the European cluster observatory. The distribution of biopharma capabilities in Europe (*Map 3*) shows mature and diversified industry agglomerations in most member-states, which makes it easy for firms to seek suppliers and to form inter-firm relationships locally.

A distinctive feature of the population of firms is a growing number of cross-ownership between European and other parents (*Map 4*). The total number of biopharma firms operating in Europe is identified as 6 437, which includes subsidiaries of European parents, subsidiaries of other global parents, and subsidiaries that are co-owned by both[47]. This feature is more profound in Europe and in the USA, and much less observed in the rest of the world[48].

The activities data of the global biopharma companies in the bespoke global biopharma MNE dataset reveal a complex picture of focused and diversification strategies, whereby the traditional simple value chain of R&D, manufacturing and wholesale/trade is extended with a combined vertical and horizontal integration of activities[49]. The consequent value chain map contains strategic value chain groups of firms with a specific pattern of diversification towards related services and input / output markets. Examples are the strong presence of the agriculture and food processing firms (VCG 51), or perfumes and cosmetics (VCG 23) and medical and hospital supplies (VCG 36) companies integrated in the portfolio of global biopharma MNEs. The ownership ties recorded in the dataset reveal also a significant overlap, where 4% of subsidiaries have dual or multiple EU / global ownership. It is expected that these business entities are active and profitable units, open to global markets. The large number of subsidiaries and parents that operate in the service sector (such as holding and business administration companies) is also a distinctive feature of the biopharma GVC that requires further research. The service sector comprises approximately 21% of the population of firms in the biopharma GVC, while the R&D segment (including diversified R&D with services and wholesale) is only 9%.



Map 5. Biopharma subsidiaries worldwide by source of ownership *(EU vs Others)*

Source: Bespoke global biopharma MNE derivative dataset (2015).

47 Map 4.
48 Map 5.
49 Figure 2, 3.

In summary, the mapping of GVCs require firm level data and discrimination by country of origin of ‘parents’ and ‘subsidiaries’, to demonstrate the flow of value added within MNEs and across European boundaries. The significant cross between foreign subsidiaries in Europe, and European controlled subsidiaries around the world indicates how entangles is the real flows of value added. This raises a challenge at all levels of organisation of capabilities – industry, cluster, regional, or country level.

The precise **location** of parents and subsidiaries is important particularly in terms of cluster integration and impact on employment and growth. Investments and acquisitions of university biotech spin-offs accelerate the location advantages of some clusters and regions, generating a positive dynamic for growth. The specialisation of these locations hence, becomes less important, compared with the rate of innovation outputs that attracts investment flow. The smart specialisation, in this context, becomes a function of the university system, the university-industry interactions, and the acceleration of knowledge transfer practices, such as spin-offs, start-ups, contract research[50].

The **concentration** of capabilities in strategic value chain groups (VCGs) reveals alternative business models for diversification and for re-integration of value added activities. Relationships between firms from the same VCG, however, remain competitive, and inter-regional collaboration programmes can increase competition, as well as cooperation.

Membership of firms in regional clusters indicates openness and readiness for collaboration, but not necessarily regional strategic advantage. **Patterns of specialisation** in regions and clusters, however, exhibit cluster depth, and as such – it is an attractor for investment. The presence of more diversified firms in clusters is a measure of cluster maturity and a potential for value chain integration, upgrade and growth.

Overall the mapping of GVC results in a dataset that contain details of the **location on capabilities** in a particular industry (in our example – the biopharma), the **concentration of capabilities** in regions and in strategic value chain groups, and the dominant **patterns of specialisation** that drive industry dynamics. All these are valuable prerequisites for an effective selection of partners in matchmaking events.

The subsequent sections of this paper demonstrate the use of value chain mapping at regional level. The implementation of the value chain mapping methodology at regional level can be described as a capability audit, where regions can identify their leading business actors in a particular industry segment. **Mapping of regional capabilities** in a particular segment requires a bespoke dataset of firms, built within known industry boundaries (i.e. biopharma), and representing the entire population of firms operating within these boundaries. The two cases selected for this work are the biopharma industries in Bulgaria and in the UK Greater South East region, which combines the former regional authorities of East of England, South East of England, and Greater London.

[50] Todeva, 2013.

3. Case study: Bulgarian Biopharma value chain

Among the strategic priorities in the approved Smart Specialisation Strategy for Bulgaria (2014) are biotechnology, pharmaceuticals and healthy living. Although these sectors do not exhibit significant foreign direct investment (FDI) (with exception of food processing and bio-foods), they show increase in exports and growth. The strategic document, however, point at biotechnology capabilities only in the capital city Sofia, and does not provide evidence of the pharma capabilities in the country, or the exact location of the emerging bio-food cluster.

The main objectives of this case are to reveal what are the Bulgarian biopharma capabilities and where is their location in the country. For this purpose, we built a comprehensive bespoke dataset for the Bulgarian biopharma industry from Orbis data source. The methodology for mapping the industry capabilities followed the same principles as outlined for the bespoke global biopharma MNE dataset, but designed as bottom-up selection within clear industry and administrative boundaries.

3.1. Capability mapping methodology overview

Step 1: **Identifying core industry boundaries at country level**

The boundaries of the sector were drawn using the results from the mapping of the global biopharma value chain in the previous section and the observations and analysis of the bespoke global biopharma MNE datasets, extracted from ORBIS. We selected the core 15 NACE codes that capture all biopharma R&D, manufacturing, and specialised biopharma wholesale including some generic R&D activities[51]. These codes were identified in the bespoke global biopharma MNE dataset as core related industries constituting the biopharma GVC and attracting the largest concentration of subsidiaries[52]. We excluded from the categorisation two generic codes, which clearly refer to corporate administration, and do not represent specific biopharma activity[53].

Step 2: **Building a comprehensive dataset of firms**

We applied the same methodology of identifying firms through their unique BvD ID number and expanding the data extraction from ORBIS with all their subsidiaries. After the removal of: duplicate cases by BvD ID, firms with no activity data, or foreign subsidiaries (as capabilities that are not within the administrative boundaries of the

[51] The 11 core NACE codes selected for the construction of the bespoke Bulgarian biopharma dataset were: 2014-Manufacture of other organic basic chemicals; 2041-Manufacture of soap and detergents, cleaning and polishing preparations; 2042- Manufacture of perfumes and toilet preparations; 2053 - Manufacture of essential oils; 2110-Manufacture of basic pharmaceutical products; 2120-Manufacture of pharmaceutical preparations; 2660-Manufacture of irradiation, electro-medical and electrotherapeutic equipment; 2670-Manufacture of optical instruments and photographic equipment; 3250-Manufacture of medical and dental instruments and supplies; 4646-Wholesale of pharmaceutical goods; 7211-Research and experimental development on biotechnology, subsequently amended by four more generic codes (*7120-Technical testing and analysis; 7219-Other research and experimental development on natural sciences and engineering; 7220- Research and experimental development on social sciences and humanities; 8690-Other human health activities).*

[52] Table 9.

[53] NACE 6420 - Activities of holding companies; NACE 7010 - Activities of head offices.

Bulgarian state), we derived at a total population for the **output dataset of 7 156 firms**, including 6 235 parents and 921 subsidiaries[54].

Our observations of the concentration of firms in the generic R&D and services codes concluded that nine generic codes cannot be used to define centres of biopharma capabilities, as they capture firms across multiple value chains. This methodological step is described in Table 18, where the population of firms in the output dataset was divided into three subgroups – for further observations. The first group of firms resemble those declaring the 11 pre-selected biopharma specific R&D codes[55] All firms containing these codes were selected as our derivative dataset[56]. After removing firms that do not contain at least one of our 11 selected codes, the population in the **derivative dataset** was set at **1 295 firms**, among which 1 058 parents and 237 subsidiaries.

Only 13% of these firms represent large and very large entities, where we may expect some diversification or horizontal and vertical integration within the value chain[57]. The relatively large number of small and medium size firms indicate good potential for innovation in the sector.

Table 5. Bulgarian biopharma capabilities by firm size

Type of company	Count	%
Very large (VL)	75	7%
Large (LA)	66	6%
Medium (ME)	212	20%
Small (SM)	690	66%
Total	1 043	100%
Missing	152	

Source: Bespoke Bulgarian biopharma dataset (2015).

Step 3: Categorisation of firms in core value chain groups

The VCGs of the Bulgarian pharmaceutical industry were structured to correspond with the VCGs identified in the global biopharma MNE dataset. The assumption here is that the technological drivers in the industry are the same, and hence, interconnected markets and interconnected technologies are expected to generate similar value chain linkages, and to induce similar patterns of diversification.

All Bulgarian firms from the biopharma derivative dataset were categorised in groups defined by the VCG core codes identified with the global biopharma MNE dataset. The main objective of the categorisation was to achieve maximum co-alignment between the core NACE codes of the Bulgarian VCGs and the core global biopharma VCGs[58].

The population of Bulgarian biopharma contained 642 firms with a single NACE code and 653 firms that have 2 or more NACE codes[59]. Firms with two or more codes were categorised using Ward method of clusterisation with Euclidian distance and pre-set cluster centres, transferred from the global MNE dataset methodology. Due to the small number of firms, the clusterisation took place in one step. All small and dirty cluster

---

[54] Table 17.
[55] Table 18, codes highlighted in yellow.
[56] Table 18, generic codes for holding, finance and business services (highlighted in brown), and the generic R&D codes (highlighted in blue) were excluded from the categorisation procedure.
[57] Table 5.
[58] Figure 2, 3.
[59] Table 19.

groups were reviewed at firm level and cases were directly allocated to a VCG according to their portfolio of activities. All VCGs from the Bulgariax dataset received the label of the coordinating VCG in the global dataset[60].

Table 6. Strategic value chain groups in the Bulgarian biopharma sector

Strategic value chain groups	Count	%
11 - Biopharma R&D	177	14%
12 - Biopharma R&D & manufacturing	9	1%
13 - Biopharma R&D & services diversified	42	3%
14 - Clinical research & human health activities	141	11%
21 - Bio-pharma manufacturing	70	5%
22 - Biopharma manufacturing and wholesale	10	1%
23 - Perfumes and cosmetics manufacturing	266	21%
24 - Biopharma manufacturing multi-diversified	13	1%
25 - Chemical & biopharma manufacturing diversified	120	9%
26 - Medical Instruments, dental & electrotherapeutic manufacturing	176	14%
27 - Manufactured goods, electronics and instruments	10	1%
31 - Biopharma retail	18	1%
33 - Cosmetics & biopharma wholesale	10	1%
35 - Specialised biopharma wholesale	48	4%
41 - Holding, financial & administrative head office services	8	1%
42 - Other business and management services	15	1%
43 - Finance & insurance services	7	1%
44 - Miscellaneous services	81	6%
51 - Agriculture, food processing & drinks of bio-products	16	1%
52 - Manufactured miscellaneous goods	13	1%
53 - Electricity, gas and water supply & services	26	2%
54 - Other miscellaneous wholesale	19	1%
Total	1 295	100%

Source: Bespoke Bulgarian biopharma dataset (2015).

Step 4: **Mapping of the industry value chain**

The graphical display of the relationships between strategic value chain groups on Figure 6 reveals mature and diversified operations across most of the VCGs. The industry value chain, however, exhibits different drivers that shape the sector[61].

The Bulgarian biopharma value chain demonstrates capabilities across R&D, manufacturing, and trade, as well as services and other related industries. Particular strengths are exhibited in the cosmetics and medical instruments, where there is a high proportion of operating firms. The large number of firms in the clinical research also indicate capabilities towards the high end of value added.

These capabilities, however, may not be necessarily connected in the most effective way as the current mapping does not indicate inter-firm resource and knowledge ties. The additional network analysis with the Bulgarian dataset in fact reveals fragmentation of the sector[62].

[60] Table 6 and Figure 2, 3.
[61] Figures 6 and 7.
[62] Figure 7.

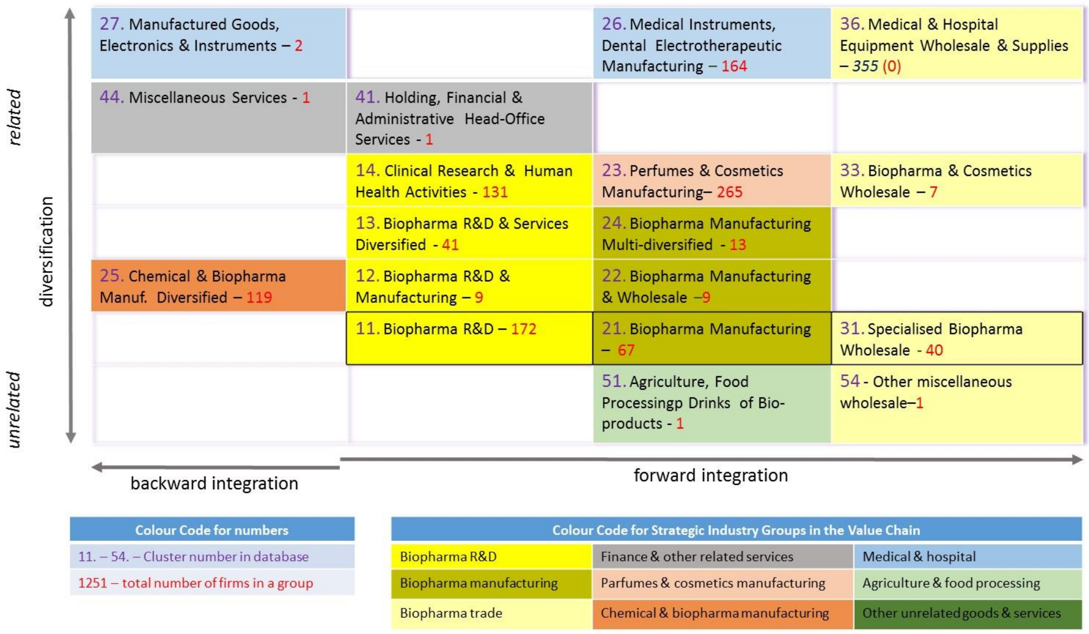


Figure 6. Strategic value chain groups in the biopharma cluster in Bulgaria

Source: Bespoke Bulgarian biopharma dataset (2015).
Note: Background colour indicates major type of activity;
Numbers indicate number of firms in each value chain group.

3.2. Analysis of the value chain structure of Bulgarian biopharma

Following the allocation of all Bulgarian biopharma firms in the derivative dataset in specific VCGs, we applied a number of analytical procedures to reveal the structure of capabilities within the value chain and the diversification links across firms. We used network analysis techniques with two-mode networks to reveal structural relationships within the dataset.

Ties between industry groups and NACE codes indicate patterns of specialisation and diversification in the dataset and reveal a relatively fragmented sector[63]. The biopharma value chain in Bulgaria contains four distinctive components where some integration of capabilities is taking place. There are strong relationships of value added integration between biopharma R&D and services (VCGs 11, 13), agriculture and food processing and organic chemical (VCGs 25, 51), and medical instruments with clinical research (VCGs 14, 26). It is expected, therefore, that firms in these interconnected components of the value chain are looking for specific synergies and complementarities along technological and market links between these segments. Further analysis of these four components is necessary, but we may formulate a hypothesis that these segments are driven by substantially different technological and market processes, and hence, construct their own value chains on a micro scale.

An interesting observation is the relationship between perfumes and cosmetics manufacturing (VCG 23) and biopharma manufacturing (VCG 21), which pulls the entire wholesale and trade portfolio of operations (VCGs 31, 32, 33). The network

[63] Figure 7.

demonstrates also that perfumes and cosmetics (VCG 23) and medical instruments (VCG 26) are quite strong in terms of number of firms that have capabilities in these distinctive segments of the value chain. In addition, the large number of SMEs in biopharma R&D, clinical research, perfumes and cosmetics and medical instruments indicates a high level of entrepreneurial activity[64].

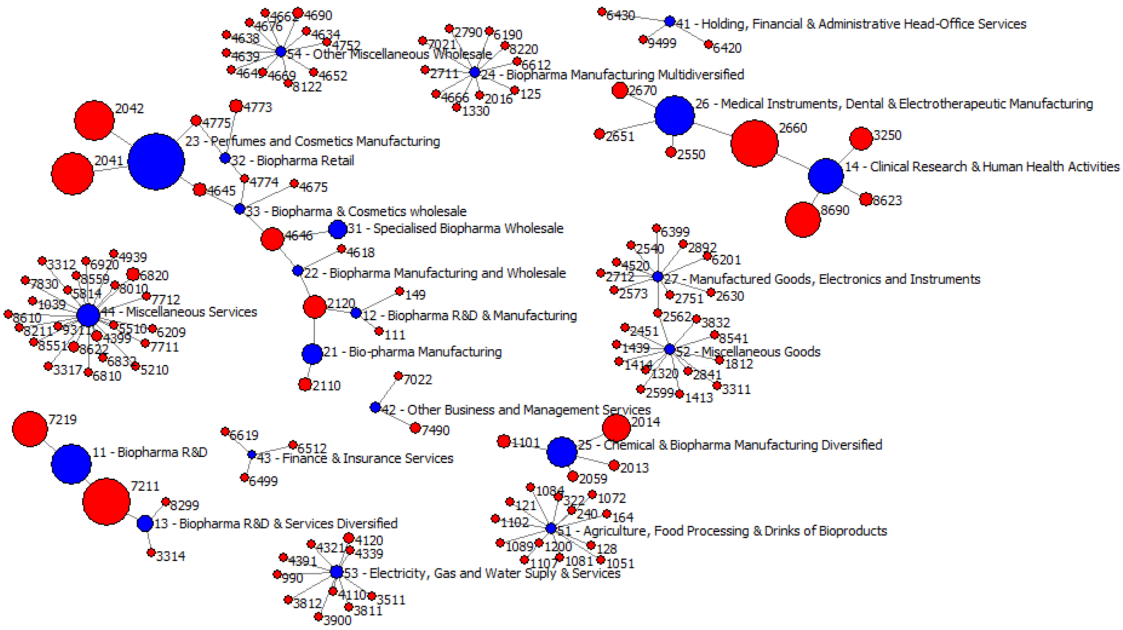


Figure 7. Integrated segments of the Bulgarian biopharma value chain

Source: Bespoke Bulgarian biopharma dataset (2015).
Note: Ties between clusters and NACE codes; the strongest 35% of ties in the network (Chi Sqr >24).

Holding companies in Bulgaria are connected to wholesale, rather than to R&D, as observed in the global biopharma value chain[65]. The same network reveals that the manufacturing capabilities are quite central to the Bulgarian biopharma value chain (VCGs 21, 22, 12). It is through these manufacturing activities that chemical (VCG 25) and agro food (VCG 51) operations are integrated.

The medical instruments group is observed on the same graph as quite disconnected from the biopharma value chain, and this gives scope for intervention that could enhance the synergies between these segments. Perfumes and cosmetics are also quite isolated from the main biopharma value chain, which also gives scope for future integration.

Another interesting observation on Figure 8 is the structural position of the diversified R&D (VCG 13), which is at the end of integrated operations. This position indicates that these diversified capabilities are pulled by other sectors and value chains, and potentially represent areas where cross-fertilisation of technologies may occur. This VCG has 2 large firms, 11 medium size and 28 SMEs, which shows quite a small pool of capabilities, but with a good potential.

[64] Table 20.
[65] Figure 8.

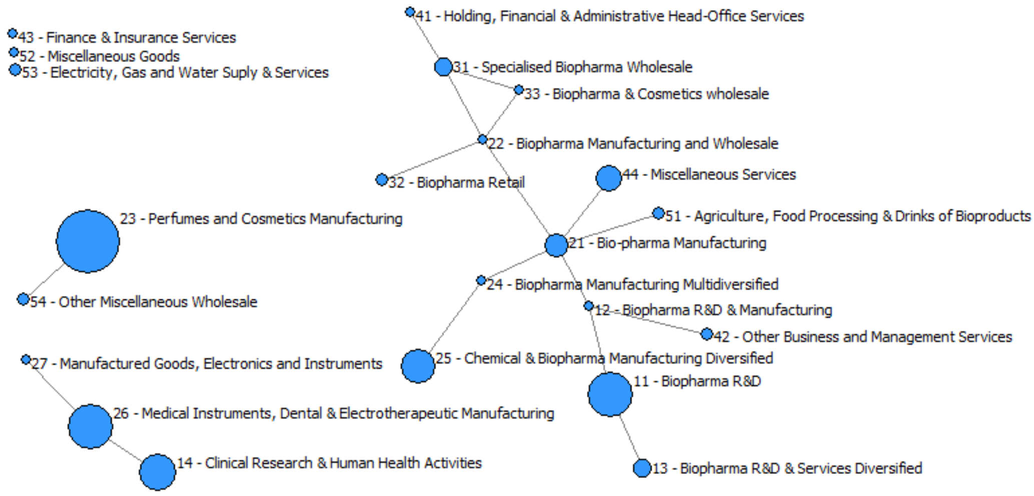
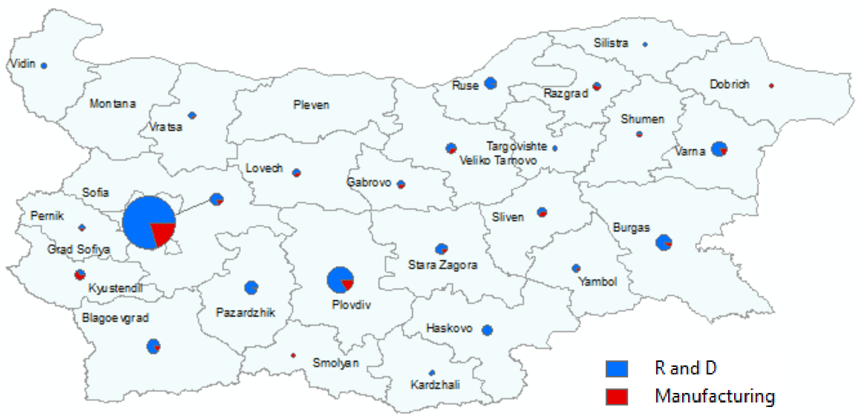


Figure 8. Structural integration of the Bulgarian value chain

Source: Bespoke Bulgarian biopharma dataset (2015).
Note: Co-occurrence between strategic value chain groups within the value chain; the strongest 30% of ties between nodes; size of the node is proportional to cluster size – i.e. number of firms.

Overall, the geographic spread of firms and capabilities is quite good for the country. Biopharma R&D firms are located in almost all regions at NUTS 3 level, with exception of a few[66]. Unfortunately, Montana region which is a host of the lead medical instruments capabilities, shows very little diversification and no R&D capabilities at present. The largest concentration of the 93 biopharma manufacturing firms, or at least their headquarters, is observed primarily in Sofia and Plovdiv. At the same time, the 369 biopharma R&D firms exhibit both – some significant concentration in Sofia and Plovdiv, but also some geographic spread in the country.

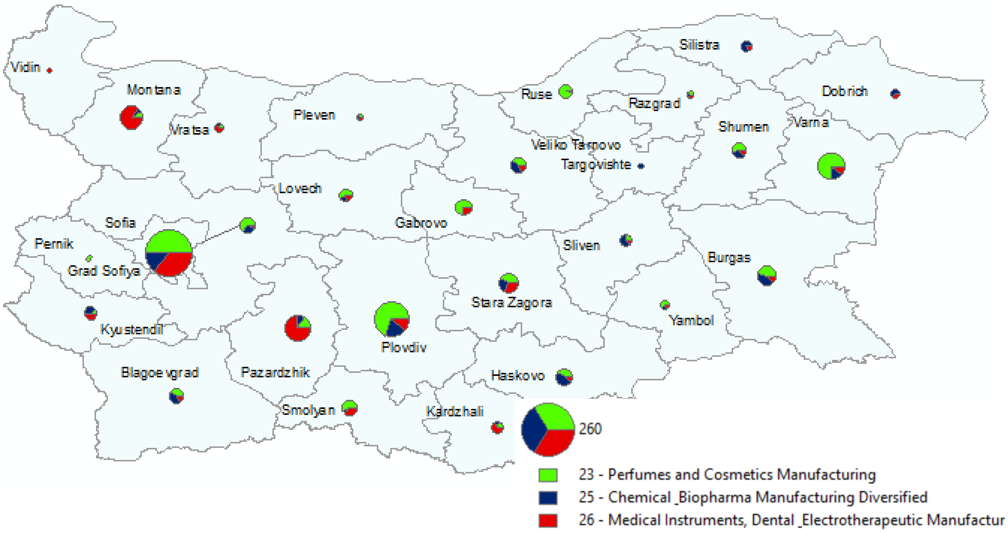


Map 6. Distribution of R&D and manufacturing firms in Bulgaria

Source: Bespoke Bulgarian biopharma dataset (2015).
Note: Size of the dot indicates number of firms.

66 Map 6.

Regarding the spread of other strategic capabilities related to the biopharma sector, Sofia, Montana and Pazardzhik are the main centres for *medical instruments, dental & electrotherapeutic manufacturing* (total 176 firms). Sofia, Plovdiv and Varna show strong concentration of *perfumes and cosmetics manufacturing* (265 firms in total), while Sofia and Plovdiv show relatively strong capabilities in *chemical with biopharma diversified* (total 120 firms)[67].



Map 7. Location and concentration of biopharma capabilities in Bulgaria

Source: Bespoke Bulgarian biopharma dataset (2015).
Note: Leading segments of the biopharma value chain; Size of the dot indicates number of firms.

The case of mapping Bulgarian biopharma capabilities and positioning these within the global value chain demonstrates that the country has good potential to implement its smart specialisation strategy – related to developing 'Healthy life and biotechnology'[68]. While the bespoke dataset shows diversified capabilities, the subsequent analysis demonstrates fragmentation of the value chain in the country. Providing opportunities for value chain integration through matchmaking will enhance the competitiveness of the sector as a whole. In addition, the large number of small biopharma firms, identified through the value chain analysis, offer strategic opportunity for acceleration of the technological entrepreneurship at country and regional level. The concentration of specialised capabilities in three particular areas further offers new investment opportunities in the sector[69].

[67] The strategic group on chemicals and biopharma diversified includes only part of this sector, i.e. firms that have diversified across organic chemicals with pharma.
[68] 'Healthy life and biotechnology' is one of the strategic priorities in the Bulgarian smart specialisation strategy.
[69] Map 7.

4. Case study: biomedical and biopharma value chain in the Greater South East of England, UK

Regional economies are embedded into national political and economic environment and exhibit both characteristics of the region and of the country. Regional boundaries are politically constructed and regional policies are enacted by the authorities that govern given territory. Following the restructuring of the regional authorities in the UK (2012), there are currently eleven subnational regions in England. Five of these correspond with what was previously known as the Greater South East (GSE), or inner London, outer London and the three surrounding regions - East, South and South East of England. It is known from the regional development literature that large metropolitan cities hold concentration of educated labour and hence, attract economic activities. London as a large global city has attracted significant international biopharma business, but the distribution of biopharma capabilities has occurred in a wider regional context.

4.1. Cluster overview

Research undertaken just before the financial crises of 2008 identified that London and the combined surrounding regions command over 4 700 core companies in the biomedical and biopharma sector, generating revenues of almost £100 billion p.a. and around 11 400 supply and delivery companies, generating additional £32 billion. All the world's top pharmaceutical companies are represented in the GSE, among which are the top 115 multi-diversified biopharma companies, with over 200 000 employees generating revenues in excess of £51 billion.

The GSE has a superb research base with over 60 research active universities, including 4 out of the world's top 10 universities, which attracted a total of over £4 billion in public sector and charity funding from 2000 – 2007. The GSE has an excellent well diversified health technologies sector with depth and very good supply chain opportunities - from basic research and development through to customers (Todeva, 2008). In this context, the aim of this case was to identify the concentration and dispersion of biopharma capabilities within the value chain and their geographic dispersion surrounding London.

Although the two areas of inner and outer London hold a large proportion of the biopharma cluster activities, Map 8 shows a very good distribution of operations throughout the entire region. The number of firms near Oxford and Cambridge, which are known to host biopharma clusters, is comparable with the concentration of firms in Guildford, Milton Keynes, Chelmsford, or Canterbury. The size of operations in Reading – Slough even exceeds the concentration in Oxfordshire and Cambridgeshire[70].

Overall, the biopharma and biomedical technology cluster in the GSE is a market driven cluster, and exists as a powerful industry house for innovation and growth[71]. It holds a mature cluster environment, as the region commands capabilities in all segments of the biomedical and biopharma global value chain. The specific value chain that is constituted in the GSE demonstrates large breath and scope of biopharma capabilities[72].

4.2. Capability mapping methodology overview

The proposed methodology for mapping the biomedical and biopharma cluster in the GSE originates from the '*Multi-stage methodology for cluster mapping*' and aims to build a bespoke dataset of firms that represent the entire population (within selected industry

[70] Map 8.
[71] Todeva, 2015.
[72] Figure 9.

and geographic boundaries)[73]. The steps of this methodology aim to allocate all firms in strategic value chain groups according to their activities and operations, and to analyse the structure of capabilities within the biomedical and biopharma value chain. The cluster boundaries are revealed through the administrative boundaries and through the location choices of the firms operating in the region. The collection of performance data of all firms for a period of 4 years enabled additional performance analysis, which was undertaken at the level of strategic value chain groups within the value chain.

Step 1: **Identifying core industry and regional boundaries**

We established specific selection criteria that describe the leading technologies and product fields in order to demarcate the boundaries of the health technology sector. The selection criteria refer to 236 key words and selected industry codes from UK SIC, US SIC, NACE, NAICS, CSO - that represent: biotechnology, diagnostics, surgical / medical instruments and devices, pharmaceuticals, and medical research. A firm is included in the dataset if it satisfies at least one of our selection criteria. The regional boundaries include 20 administrative sub-regions within SEEDA, EEDA and LDA.

Step 2: **Building a comprehensive dataset of firms**

The bespoke GSE biomedical and biopharma dataset contains the entire population of firms that correspond with our geographic and sectoral definitions, and are registered in Amadeus data source (or have submitted tax returns for the period 2005-March 2008). The population of firms in the dataset was enlarged with additional 95 SMEs that have no Amadeus record for the UK, but have been identified by experts from the three regional development agencies (SEEDA, EEDA and LDA[74]). The complete Amadeus records for individual firms in the dataset contain registration details, description of activities, firm annual turnover, employment, and performance indicators, provided for the last available year and the previous 3 years of tax returns by these firms (2005-2007).

After cleaning the total population in the bespoke GSE biomedical and biopharma **output dataset** (2008) contained 16,260 firms registered in the region, of which inner and outer London contained the largest part (7,619 firms), followed by South East of England – including Oxford, Kent, Reading and Milton Keynes clusters (5,587 firms) and by East of England – including Cambridge, Bedford and Hemel Hempstead clusters (3,054 firms)[75].

After a thorough examination, it was decided to select a subsample from our dataset, containing the core groups most closely related to the biopharma value chain. This selection produced our **derivative dataset** (4,783 firms in the core VCGs), which was used for further substantial cluster mapping, network analysis and comparative performance analysis[76].

Step 3: **Categorisation of firms in core value chain groups**

The categorisation of firms followed the multi-stage methodology for cluster mapping developed in 2006 for the mapping of regional capabilities in the South East of England[77]. For the statistical clustering we used K-means algorithm developed under the SPSS software, which is applicable to large data sets with large number of variables. All

---

[73] Todeva, 2006.
[74] South East of England Development Agency (SEEDA), East of England Development Agency (EEDA), and London Development Agency (LDA).
[75] Table 22.
[76] Table 22 documents this selection of the derivative dataset and Table 23 provides further details on employment and revenue for each of the core VCGs.
[77] Todeva, 2006.

cluster groups (or VCGs) were defined in 4 stages and reviewed by looking at the text description of activities. During the review, priority was given to text description and industry text, compared with industry codes.

Step 4: **Mapping of the industry value chain**

Each VCG obtained through the categorisation procedure resembles a unique bundle of capabilities, and a unique pattern of diversification of firms that aim to maximise on their specialisation and synergies from complementarity. The definitions of each VCG represent a synthesis from the constituting industry codes[78]. All VCGs were visualised on a value chain map, representing their multi-faceted links across the sector[79]. This graphic visualisation shows the connectedness to the biomedical sector, and reveals for the first time the existence of two distinctive R&D groups – traditional *R&D*[80], and *drug development support* which includes diversified R&D support services[81]. All VCGs from the original study have been transposed to global biopharma value chain map[82] .

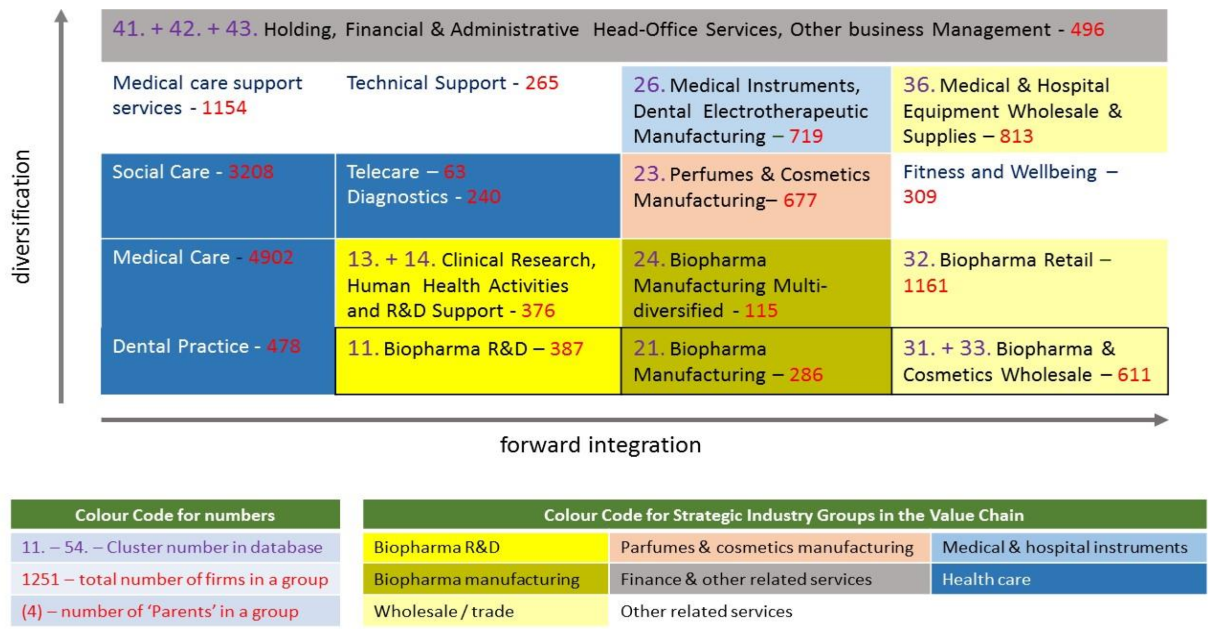


Figure 9. Strategic value chain groups in the biomedical & biopharma cluster in the Gr. South East

Source: Bespoke GSE biomedical and biopharma dataset (2008).
Note: Leading segments of the biopharma value chain in the GSE. The number of firms in each VCG indicates the concentration of capabilities. The colour code in the diagram indicates different types of activities.

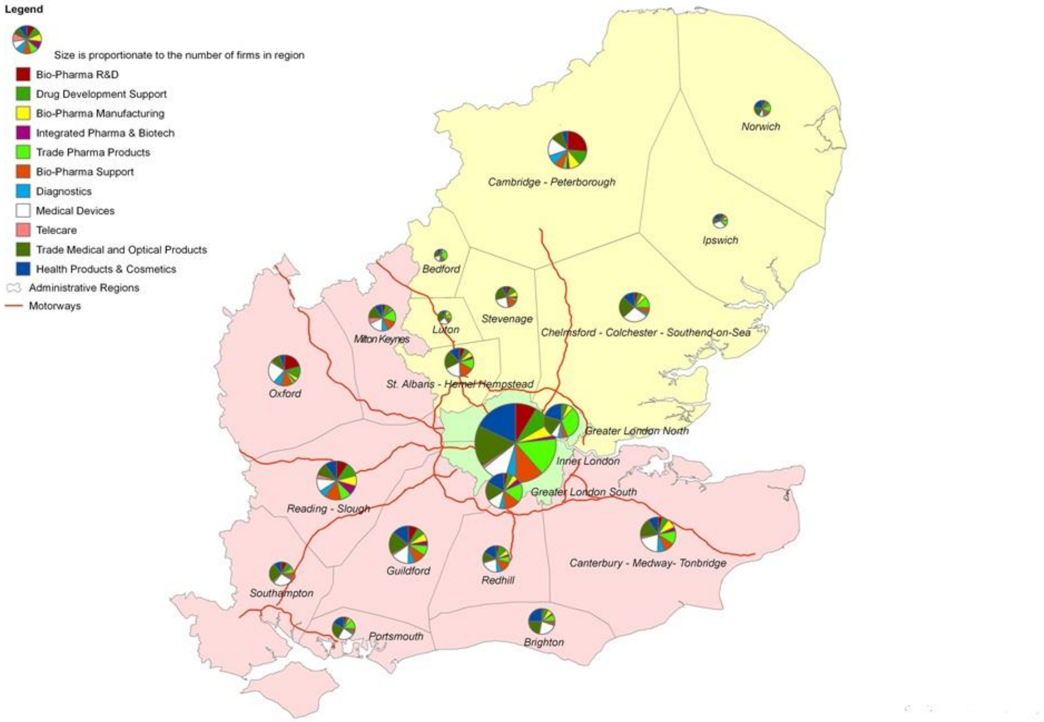
4.3. Analysis of the value chain structure of biomedical and biopharma cluster in the Greater South East of England

The value chain on Figure 9 indicates clear and strong presence of health products and cosmetics (677 firms), medical devices (719 firms), diagnostics (240 firms) and emergent telecare (63 firms). The presence of these capabilities provides opportunity for a strategic leadership in biopharma innovation and indicates strategic potential for integration of new technologies, products and services into the biopharma value chain.

---

[78] Table 24.
[79] Figure 18.
[80] Represented with NACE 7211.
[81] Represented with industry codes for testing laboratories, technical testing and analysis, computer related services, management consulting, and social sciences.
[82] Figure 9.

Biopharma manufacturing capabilities exhibit maturity and scope, where there are two distinctive VCGs – specialised biopharma manufacturing (286 firms), and integrated multi-diversified biopharma manufacturing (115 firms)[83]. The geographic map of the region[84] indicates a good distribution of these capabilities across the entire GSE, indicating maturity, specialisation and integration of the value chain.



Map 8. Dispersion of biomedical and biopharma activities throughout the GSE

Source: Bespoke GSE biomedical and biopharma dataset (2008).
Note: The dot represents number of firms and the portfolio of capabilities in a location.

Further analysis into the concentration of capabilities across sub-regions reveals certain preferences, which are clearly associated with the structure of the regional economy in micro-locations. The three sub-regions with shipbuilding and sea-port activities (Chelmsford, Portsmouth, and Southampton), for example exhibit strong concentration of capabilities in medical instruments and devices[85]. The diagnostics VCG is clearly associated more closely with the two biopharma R&D VCGs and firms are located in close proximity to university medical hospital research. An interesting observation is that telecare capabilities are not closely related to medical devices, but to other engineering industries, which are co-located around Milton Keynes. The areas of Inner and Outer London exhibit strong specialisation in health products and cosmetics and in wholesale / trade of pharmaceuticals, both of which require strong marketing capabilities[86]. The geographic spread of capabilities also demonstrates that the highest concentration of firms is not around Oxford and Cambridge, as previously claimed, but at the intersection of the three regions (East of England, South East of England and London)[87].

---

[83] Table 22.
[84] Map 8.
[85] Figure 10.
[86] Figure 10 and Map 9.
[87] Map 9.

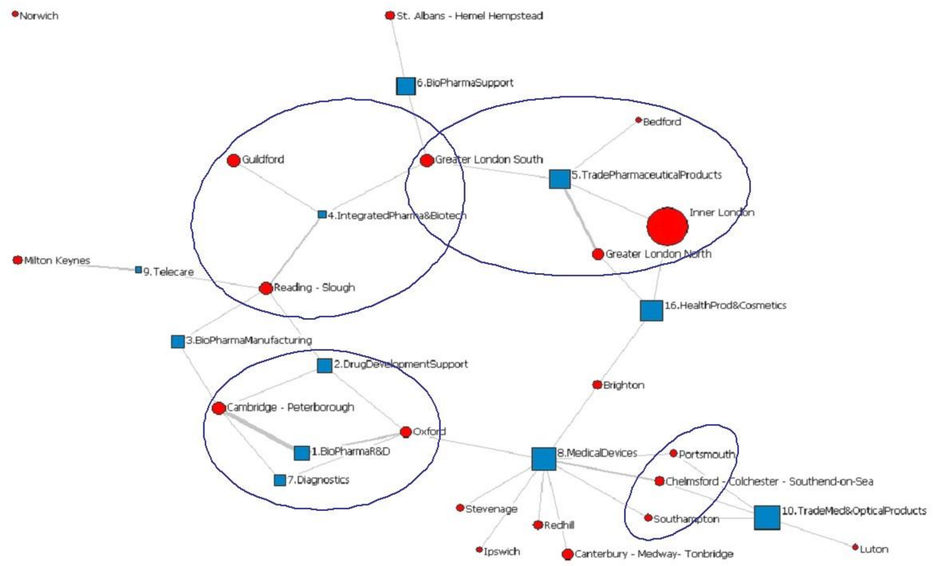
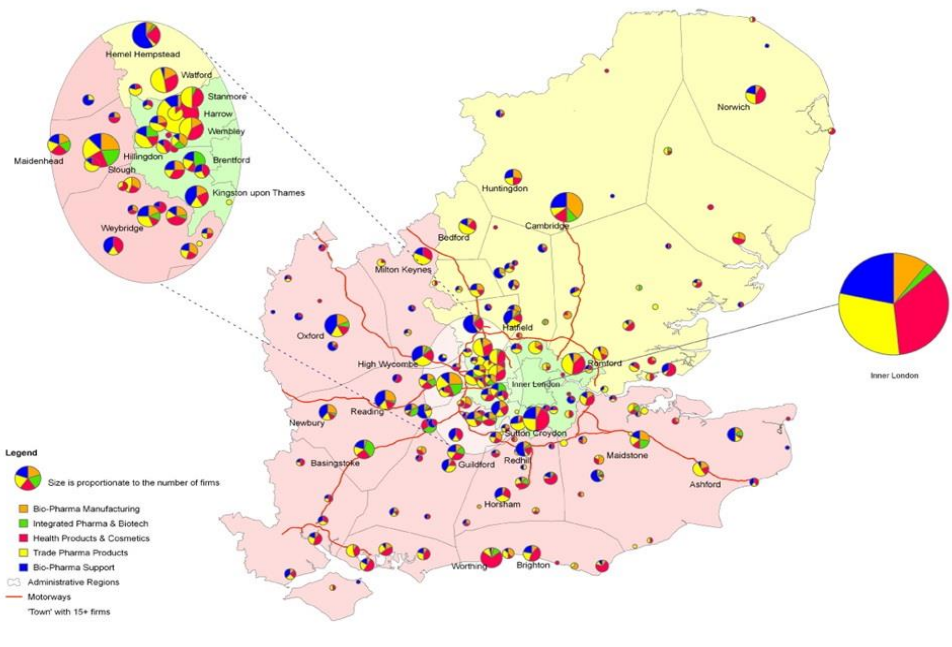


Figure 10. Regional capabilities within biopharma value chain

Source: Bespoke GSE biomedical and biopharma dataset (2008).
Note: RED circles represent individual value chain groups; BLUE squares represent sub-regions within GSE; the size of the dots and squares is proportionate to the number of firms in each value chain groups and sub-region; ties indicate significant relationship of concentration of capabilities.



Map 9. Regional distribution of biopharma capabilities in the GSE

Source: bespoke derivative GSE biomedical and biopharma dataset (2008).
Note: Pie-charts without the name of the location represent a small number of firms (less than 15 per value chain group); Comprehensive lists of locations, or firms in locations, are available in the dataset.

The geographic Map 9 demonstrates also that significant biopharma activities in the UK are located in small and remote residential areas, and not only around major metropolitan cities.

Table 7. Comparative performance within the value chain

Strategic value chain Groups	Median Profit Margins						Coefficient of Variance of Profit Margins					
	t	t-1	t-2	t-3	t-4	t-5	t	t-1	t-2	t-3	t-4	t-5
1.BioPharma R&D	4.5%	3.7%	4.8%	0.7%	3.5%	3.1%	23.2	11.0	11.3	20.6	8.7	11.1
2.Drug Development Support	5.3%	6.8%	6.6%	6.2%	7.4%	6.7%	4.9	3.5	2.9	3.0	3.1	3.0
3.BioPharma Manufacturing	10.5%	7.7%	7.3%	7.2%	7.2%	6.1%	2.0	4.6	3.6	1.6	3.7	6.0
4.Integrated Pharma& Biotech	7.3%	7.8%	7.3%	7.2%	6.9%	5.3%	5.5	17.6	5.1	3.6	2.5	4.6
5.Trade Pharmaceutical Products	2.9%	2.7%	2.7%	3.0%	3.3%	3.4%	2.7	11.7	4.7	4.3	4.4	3.0
6.BioPharma Support	15.6%	15.8%	13.9%	13.5%	13.0%	8.1%	1.5	1.4	1.6	1.9	1.5	2.6
7.Diagnostics	6.5%	6.2%	4.3%	3.4%	5.7%	4.5%	2.8	5.1	10.7	6.0	3.4	2.8
8.Medical Devices	5.6%	5.4%	4.2%	5.2%	5.1%	4.8%	5.5	4.8	5.0	4.4	4.7	2.8
9.Telecare	1.0%	3.1%	-0.3%	0.8%	2.1%	1.3%	-12.1	11.5	-4.0	15.9	9.4	2.3
10.TradeMed & Optical Products	5.8%	5.8%	5.9%	5.8%	4.9%	5.3%	2.9	2.5	2.2	2.8	3.6	2.4
16.Health Prod & Cosmetics	4.0%	5.6%	4.2%	5.65	5.6%	4.8%	37.4	4.9	9.8	5.1	6.2	3.1

Source: bespoke derivative GSE biomedical and biopharma dataset (2008).
Note: For the performance analysis we have used the *median* to counteract the strong asymmetric distribution of data and the presence of extreme cases.

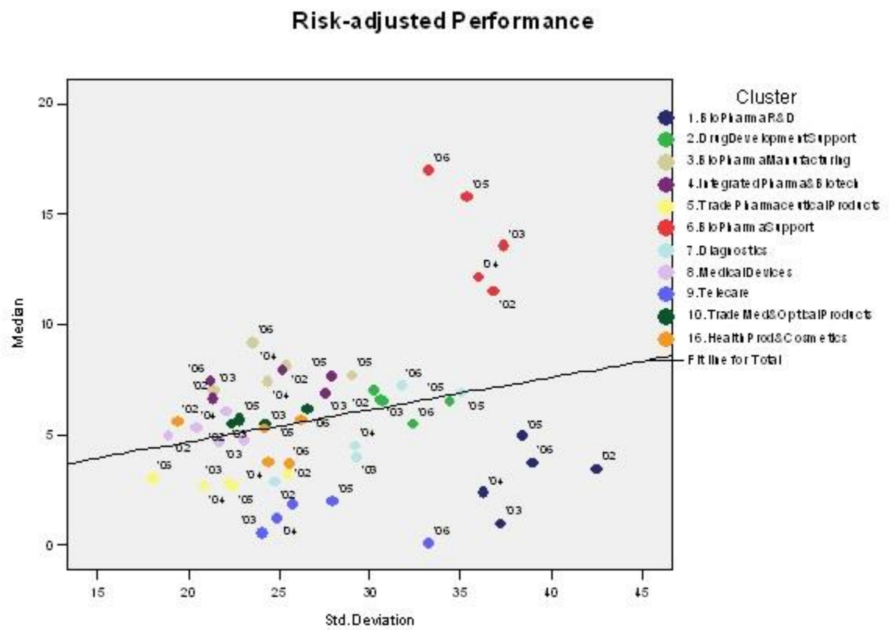


Figure 11. Risk-adjusted performance within biopharma value chain

Source: Bespoke derivative GSE biomedical and biopharma dataset (2008).
Note: The matrix uses the model of 'sharp ratio' (or mean by the standard deviation); The fit line represents the theoretical expectation for a balance between risk and reward; Each observation indicates the risk-adjusted performance for an individual cluster group for a specific year (02, 03, 04, 05, 06); Observations below the fit line indicate relatively higher risk related to received reward; Observations above the fit line indicate relatively higher performance for the risk associated with it.

Table 7 and Figure 11 both indicate that consistently over the 6 reported years (2002-2007) drug development support firms have exhibited higher performance than the biotech R&D firms. In addition, the high coefficient of variance in the biopharma R&D group indicates very high level of risk for this type of activity within the value chain. The consistent underperformance of biopharma R&D is more clearly exhibited on Figure 20, where there is a very clear contrast between biopharma R&D and biopharma management services. Telecare and diagnostics both appear on Figure 20 to be underperforming, while integrated pharma and specialised biopharma manufacturing demonstrate good performance results.

This comparative performance analysis of different segments of biopharma value chain is possible only with a bespoke, comprehensive and clean dataset with firm activity and performance data, which has been recommended with this methodology paper. The challenge of mapping value chains is best addressed with firm data, as it is the firms make strategic choices to specialise within the value chain, or to diversify across segments. Each VCG represents a pattern, or similarity in how firms strategically maximise efficiencies and optimise performance. The use of VCGs, hence, is recommended as a unit that represents both geographic concentration and industry specialisation of capabilities. On the basis of these critical observations, the final section of this report outlines a set of policy recommendations related to enhancement of value chain connectivity and maximising impact of policy interventions and regional and cluster level.

We applied different performance metrics for the performance evaluation, i.e. market performance metrics (return on equity and return on capital), economic development performance metrics (employment and revenue growth), and accounting performance metrics (profit margins, cash flow, and operating revenue).

Working with a comprehensive database of firms in a particular industry sector enables us to use firm performance data and to analysis the distribution of profits along the value chain comparing directly the value added and value extraction that is taking place along the value chain. Table 8 compares performance of different strategic value chain groups within the biomedical and biopharma cluster in the GSE.

Overall the value chain mapping of the GSE case demonstrates the advantages of using bespoke sector datasets of firms at regional level, as this enables insightful analysis of the pattern of diversification in a cluster and the concentration of specialised capabilities. The analysis of the biomedical and biopharma value chain in the GSE provides evidence for the maturity of the sector and the integration of the value chain within the administrative boundaries of Greater South East of England. The comparative performance analysis of different value chain groups provides insight both for strategic positioning by firms and for regulatory intervention in cases of underperforming segments. The details of specialised capabilities are essential for effective selection of firms for matchmaking events.

5. Recommendations for policy makers

The entrepreneurial discovery process (EDP) which is an essential step towards building smart specialisation strategies, requires stakeholder mapping and detailed knowledge of the key industry players and knowledge providers at regional level. Building an effective triple helix of proactive public authorities, universities and business enterprises is a prerequisite for the development and implementation of smart specialisation strategies through interregional cooperation at European level. The mapping exercises that have already taken place across European regions demonstrate diversity and lack of consistency. How to categorise stakeholders is important, but what is more important – is to develop a better fine-tuned methodology for categorising the industry specialisation in individual regions and clusters.

Mapping of regional capabilities within selected priority sectors and identifying the location of these capabilities within the GVC is an essential tool in the implementation of a number of EU policies.

5.1. Smart specialisation strategy implementation

Smart specialisation as a new growth strategy within the EU can be characterised by regional level entrepreneurial discovery, identification and development of cross-sectoral activities, selection and prioritisation of the activities under development, and experimentation. The challenge for policy makers is to select the right priority areas, where there is existing concentration of capabilities, and where policy intervention can enhance the regional competitiveness in these areas. Statistical analysis rarely gives an insightful picture on regional capabilities. **Mapping regional capabilities with firm level data** is a new method that empowers cluster, regional and national authorities to see who are the key stakeholders, what is their contribution to economic growth, and what is the scope for policy intervention to enhance the regional competitiveness.

In order to formulate smart specialisation policies, government agencies need to circulate a vision – how their specialisation will connect to wider European and global markets. Smart specialisation strategies and implementation process should be driven by facts as well as strategic vision, where the amalgamation of public and private interests has to be carefully orchestrated. Export-led growth is nothing new, and the policy instruments have a long history of application and cases. Value chain connectivity via exports, however, is new and requires a profound understanding of the scope of positioning strategies that can lead endogenous growth.

The proposed methodology strongly supports the practical implementation of all principles that are essential for the smart specialisation strategy. First, the granularity approach is very difficult to achieve, if governments do not have a detailed knowledge of the structural composition of a particular priority sector. The use of single cases as examples and anecdotal evidence as a justification of selection choices are quite inadequate. Hence, **a GVC mapping with a comprehensive dataset of firm-level data** offers a way to gain insights into the structural composition of already prioritised sectors.

> Categorisation of industrial and technological specialisation in firms is an essential prerequisite for mapping of regional capabilities and analysis of the position of regions and clusters within established and emerging value chains.
>
> The translation of knowledge from **specialisation of individual leading** firms into **concentration of capabilities in strategic value chain groups** is an essential step forward towards scaling up of pan-European collaborative ventures.
>
> The proposed methodology gives details on: how to develop a bespoke industry dataset for **mapping concentration of capabilities** within value chains and at specific locations and how to identify **active R&D firms in a particular industry segment.**

The entrepreneurial discovery principle requires obtaining a comprehensive list of innovative SMEs, which can be achieved with the proposed new methodology. The firm-level data collected for the entire population of firms enables both – match-making for the smallest entrepreneurial firms, and observation of agglomeration effects at regional level.The proposed mapping technique enables to collect data also on measuring spill overs and measuring structural changes. As an inclusive strategy, smart specialisation strategy requires implementation activities at micro-firm level, or down to market. Essential part of the implementation of smart specialisation strategy should be **identifying concentrations of capabilities** and **linking capabilities** with markets in Europe and abroad.

5.2. Cluster growth

Recent report from the European Secretariat for Cluster Analysis advocates that cluster organisations should provide additional services to their members, such as: promotion of the cluster location and facilitating media visibility, support for the internationalisation of cluster members, collaborative technology development and technology transfer, matchmaking and networking with external partners (ESCA, 2013). All of these activities require knowing the entire population of firms in the cluster, and targeted promotion of different firms from different strategic value chain groups. In fact, **promoting strategic value chain groups** brings a higher value added to clusters and avoids the well criticised 'cherry picking', enhancing collaborative advantage for businesses. Innovation dynamics at cluster lever requires that innovation outputs are promoted throughout the entire population of member firms, rather than for champions only.

Smart specialisation priorities at cluster and regional level require co-alignment of firm strategies and incentivising the entire population of firms. Bespoke datasets of firms focused on an area of specialisation can reveal existing concentrations of specialised capabilities and new networking opportunities. Categorisation of firms and analysis of value chain groups can point at **complementarity and synergies along established value chains and supply networks**, contained in the cluster. Value chain maps enable cluster members to enhance their self-awareness of the externalised advantages of their co-location, suggestion new cluster cooperation possibilities.

The most recent reports on cluster performance and benchmarking, provide insightful observations for specialised clusters, but are not capable to measure the depth of the cluster in terms scale and scope of diversification, or structural position and value chain participation, and hence, cannot offer a reliable method to monitor the long-term position and upgrade of firms and clusters (European Cluster Observatory, 2014a, b).

The smart guide to cluster policy clearly indicates that linkages across related industries are critical for cluster growth, and mapping these linkages within specific location boundaries is essential to mobilising cluster activities and building the necessary critical mass. Most current cluster initiatives require both:

a) knowledge and insight in the underlying value chains within clusters, as well as how they connect to other related industry activities; and

b) detailed and exhaustive list of firms (including SMEs) that have capabilities in a particular specialised area.

The value chain mapping methodology described in this paper enables **mapping of cluster capability** and offers the next step of the Vanguard learning methodology - from listing of key players, to maintaining a database with firms co-located in segments and strategic value chain groups. Bespoke datasets of firms enable **performance measurement across segments** of the value chain and inform key players how to progress from 'Learn' to 'Connect', 'Develop' and 'Commercialise'. Cluster internationalisation and match-making do require envisioning **buyer-supplier relationships** and facilitating the **connectivity across input and output markets**, which are best described by elaborate value chain maps.

European strategic cluster partnerships and consortia also can make use of the proposed methodology for value chain mapping. Coordination of collaboration activities across firms, regions and sectors that stand behind partnering clusters, require mapping at multiple levels. Each partnership embraces inter-sectoral business developments that cross and re-combine numerous value chains. Each partnership, hence, needs to articulate its emerging value chain, as well as value chains in transformation. For example, there are no blue prints for recombining the multitude of environmental technologies products, processes and services, pursuit by the WIINTECH cluster consortium, but a combined **value chain mapping across their core technologies and markets** can enable to identify the critical competences and bridges that can enhance the circulation of value added across all value chains, and will enable the consortium to scale up their activities. The combination of waste management, water and air treatment, transportation, construction and renewable energy is not accidental – from a value chain perspective. Knowing how to accelerate the transformation of traditional value chains and to re-combine with emerging technologies and markets, requires a lot of oversight and value chain mapping can provide a critical input.

Leadership in the biopharma value network requires enhanced capabilities and innovation thrust that attract companies either from the input or the output markets. Gaining connectivity within the value network is more likely for cluster concentration of entities, rather than for single players.

The European Cluster Collaboration Platform has currently 19 registered biopharma clusters from 8 EU member states, which hardly represents the full capacity of the European biopharma sector. The only registered UK biopharma cluster in the North East of England represents only a small fraction of the biopharma capabilities in the UK, exhibited by the case of Greater South East of England. It is important, hence, to enhance this picture with a comprehensive value chain map of all current capabilities located in EU member-states – to accelerate the connectivity and integration across regions and fragmented capabilities. Similar is the picture across all other sectoral agglomerations, where value chain mapping of capabilities can enhance both the self-awareness of the clusters themselves, and their ability to reach out for new partners across the European industry landscape.

5.3. SME support

The main orientation of the policy measures towards supporting SMEs is the development of business friendly environment, providing financial support, encouraging cluster growth, integration of SMEs in clusters, and support for internationalisation (EC Growth). All these measures require knowledge of the SME capabilities in the first instance, and adapting the policy instruments to accelerate existing entrepreneurial strengths. **Mapping the capabilities of SMEs in clusters and regions**, hence, is essential to providing support.

A new emergent policy framework suggests that the best way to deliver support to SMEs is if they are organised in clusters. This approach is based on the assumption that clusters are effective forms of organising capabilities and coordinating support measures. The matchmaking events aim at building strategic partnerships, although the methodology of what is matched to whom is still unclear.

There is clearly a need to translate the concept of GVC at a cluster, regional, or national level. The current list of strategic cluster partnerships in Europe demonstrates the weakness of the current cluster initiatives **to map complex technological linkages** and value added sequences. Comprehensive firm level datasets at regional and cluster level are necessary to understand and manage strategic cluster collaborations, and in particular to provide a platform for technological entrepreneurship. A comprehensive dataset of firms provides an opportunity to produce validated industry data for value chain groups, segments and patterns of strategic behaviour of firms, **enabling matchmaking and strategic partnerships** that can accelerate firm performance and regional growth.

5.4. Technology policy and key enabling technologies (KETs)

The Commission defines that the engine for growth in Europe are knowledge intensive sectors around key enabling technologies (KETs). The policy agenda is to support these knowledge intensive sectors and the 'technology bricks' that support them and enable a wide range of product application (COM, 2012: 341). The Commission has acknowledged that KETs feed into many different industrial value chains and sectors and provide value along the whole chains. The implementation of KETs technology and investment policy is envisaged through a number of policy tools such as the Commission's cluster policy and cohesion policy, both of which require inside knowledge of the industry as a key stakeholder. Yet, **knowing the industry requires firm-level data, including inter-firm connectivity within value chains**. The proposed mapping methodology and the associated with it comprehensive dataset of firms, hence is a key enabler in this process. Encouraging regions and clusters to develop comprehensive maps of the value chains that capture their regional capabilities will enhance all current policies of the European Executive Agency for SMEs, or policies that support the 'Industrial Renaissance in Europe'.

In essence, European policies for growth, such as: Industrial policy; innovation and competitiveness; key enabling technologies; industrial sustainability; or internationalisation of firms, all will benefit from a more transparent picture of the **concentration of capabilities in strategic value chain groups.** Facilitated co-specialisation and collaboration of firms across strategic value chain groups is expected to accelerate the optimisation of resources as well as spill-over effects from bridging.

Global value chains are at the intersection of numerous challenges for Europe 2020. Mapping of KET value chains and in general the value chains of the core European industries will provide a robust body of data in support of the core policy initiatives for growth. Seeking Complementarity across the European technology space requires comprehensive technology maps, as well as how these maps penetrate across firms.

5.5. Inter-regional cooperation networks

From its inception, the smart specialisation strategy initiative was envisaged to enhance capabilities at regional level. Although for small member states it makes sense to develop a smart specialisation strategy at a national level, the implementation process requires active regional authorities, pro-actively mobilising local public and private sector actors and adopting a multi-stakeholder approach to policy and strategy implementation. Leading example of effective inter-regional cooperation supported by political commitment at regional level is the Vanguard initiative, whereby a large interregional consortium of over 30 regions follows a 4-step methodology of learning – connecting – demonstration – commercialisation. The success of the vanguard initiative is partially due to its effective institutionalisation of cooperation through specific task groups focused on policy influencing, financial instruments, communication, monitoring and foresight. The entrepreneurial discovery process, however, takes place in substantially different way across connected regions, generating different implementation models. It is recognised the need to develop a more standardised framework to guide the implementation phase.

The new EDIP model (Figure 12) highlights that the implementation of interregional collaboration strategies and the successful interregional cooperation networks require more detailed mapping of industry and regional capabilities (strategic value chain groups and innovation networks), communication platform for inter-sectoral and cross-border stakeholder engagement that encompass industry-university and government (triple helix), elaborate business models across input and output markets (designing value chains and value added flows), and matchmaking within and across value chains (Figure 12).

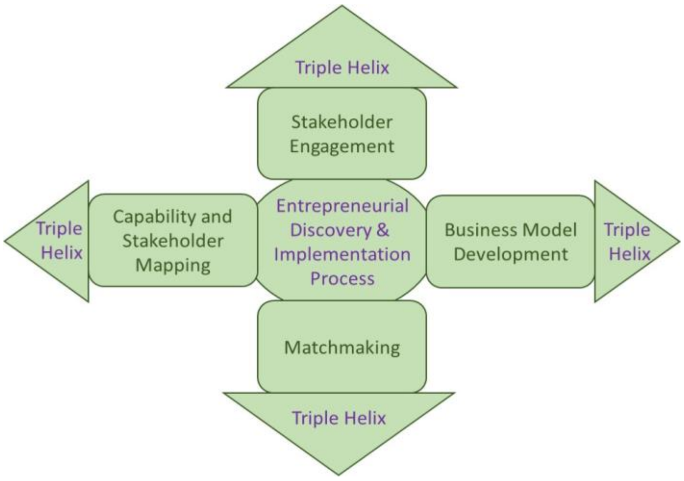


Figure 12. EDIP model for inter-regional cooperation

Note: EDIP Entrepreneurial discovery and implementation model.

The new thematic platforms for interregional cooperation clearly put emphasis on the need to enhance:

- knowledge of value chains in established and emerging industries;
- complementarities across regions based on more detailed mapping of regional capabilities;
- matchmaking of partners within and across complementary strategic value chain groups – to accelerate and scale up the development and commercialisation of new products, services and technologies.

The current mapping methodology, hence, offers a tool to identify concentration of capabilities in regions and industry segments, in order to facilitate the inter-sectoral and cross-border matchmaking, and to assist in the wider selection of active R&D performers.

5.6. Recommendations on how to map strategic capabilities and value chains

Although the methodologies presented in this paper encompass complex technicalities in building bespoke and comprehensive datasets, ultimately the approach rests on the simple principle that **mapping** (or visualisation) of concentration of capabilities in **strategic value chain groups** across geographies and industry segments. Firm level data on **Actors, Capabilities, Flows,** and **Co-location** enables strategic choices for partnerships on a larger scale then single firm matchmaking. Firm data on scale and scope of value chain operations is now available and the global coverage is comprehensive at the level of the largest corporations and their subsidiaries worldwide.

A**nalysis of patterns of specialisation vs. diversification and inter-industry connectivity** enables selecting groups of firms for matchmaking and extending complementarities. A value chain is constituted not by single suppliers, but by technologically connected input and output markets with multiple specialised and diversified firms. Hence, the analytical insights from the bespoke dataset support directly the design of new emerging value chains. Comparative analysis of financial and operating data effectively delivers insight into the drivers for competitiveness for individual value chain groups.

This paper outlines a 'how-to-do' approach for mapping and orchestration of GVCs which can be described as a strategic effort to develop analytical products and practice that assist in the design of value chain networks and in the positioning and upgrade of countries, regions, clusters and firms. The approach includes the following elements (Figure 13):

a) **mapping of industry value chain groups -**provides evidence of dynamic capabilities at inter-sectoral and regional level;
b) **mapping of regional concentration of capabilities** across the EU at NUTS2/3 level - enables regional authorities and cluster managers to scale up the matchmaking in established and emerging value chains;
c) **comparative performance of value chain groups** – provides evidence of the distribution of profits and incentives within the value chains;
d) **mapping specialised suppliers and lead R&D firms -** empower cluster managers, lead firms and small R&D firms – to connect to each other and generate synergies across complementary activities;
e) **empowering triple helix actors, cluster partnerships and knowledge networks** – to create effective match-making events and scale up the impact of innovation;
f) **using data to orchestrate the design of emerging value chain networks** and to optimise the entrepreneurial discovery and implementation process.

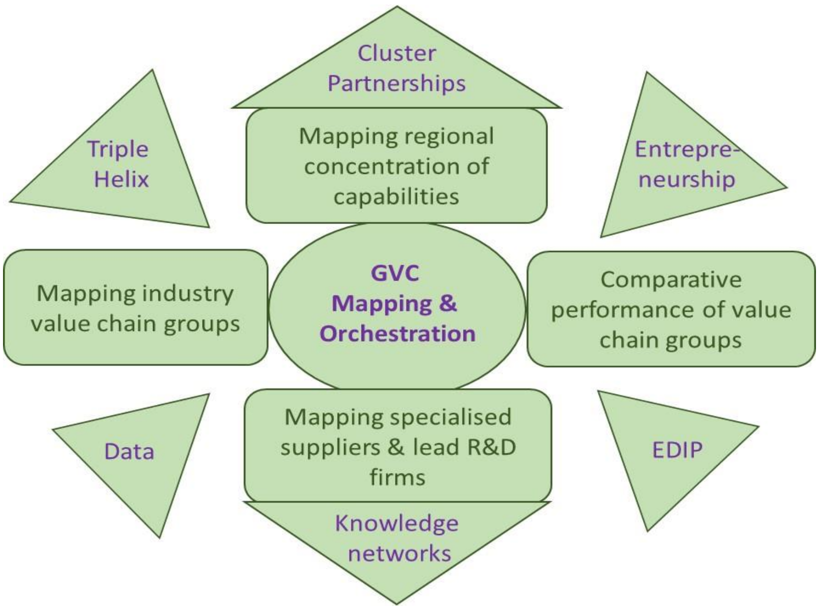


Figure 13. The complexity of GVC orchestration

Note: EDIP Entrepreneurial discovery and implementation model.

Orchestrating GVCs is also known as **governance**, or mechanisms for coordination and control of the value added flows and the value extraction process. **Managing GVC** requires in-depth knowledge of the technology drivers that create cross-sectoral connectivity and facilitate innovation and commercial links. Overall orchestrating value chain connectivity can focus independently on products, technologies, industry segments, or locations, exploring future scenarios, challenging established trajectories, and outlining new investment choices.

6. References

Baldwin, R. and Lopez-Gonzalez, J. (2015) Supply-chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses, The World Economy, 38 (11): 1682-1721.

Caves, R. E and Porter, M. E. (1977) From Entry Barriers to Mobility Barriers: Conjectural Decisions and Contrived Deterrence to New Competition, Quarterly Journal of Economics, 9 (3): 241-261.

Caves, R. E. (1982) Multinational Enterprise and Economic Analysis. Cambridge, UK: Cambridge University Press.

Delgado, M., Porter, M. and Stern, S. (2016) Defining Clusters of Related Industries, Journal of Economic Geography, 16 (1): 1–38.

Eisenhardt, K. and Martin, J. (2000) Dynamic Capabilities: What Are They?, *Strategic Management Journal*, 21 (10/11): 1105-1121.

European Commission COM (2012) 341 Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions - 'A European Strategy for Key Enabling Technologies – A Bridge to Growth and Jobs', European Commission.

European Cluster Observatory (2014a) Cross-sectoral Trends and Geographic Patterns in the Biopharmaceutical Industry: Report, European Commission, DG Enterprise and Industry.

European Cluster Observatory (2014b) Cross-sectoral Trends and Geographic Patterns in the Medical Devices Industry: Report, European Commission, DG Enterprise and Industry.

Gereffi, G. and Korzeniewicz, M. (eds.) (1994) Commodity Chains and Global Capitalism, Westport: Praeger.

Gereffi, G., Humphrey, J. and Sturgeon, T. (2005) The Governance of Global Value Chains, Review of International Political Economy, 21 (1): 78–104.

Grant, R. (1996) Towards a Knowledge-Based Theory of the Firm, *Strategic Management Journal*, 17: 109-122.

Kearney, A.T. (2013) Unleashing Pharma from the R&D Value Chain, Innovation: Ideas and Insights, https://www.atkearney.com/innovation/ideas-insights/article/-/asset_publisher/VHe1Q1yQRpCb/content/unleashing-pharma-from-the-r-d-value-chain/10192?_101_INSTANCE_VHe1Q1yQRpCb_redirect=%2Finnovation%2Fideas-insights; Accessed on 10.10.2015.

Kogut, B. (1984) Normative Observations on the International Value-Added Chain and Strategic Groups, Journal of International Business Studies, Fall 1984, 151–167.

Kogut, B. and Zander, U. (1992) Knowledge of the Firm. Combinative Capabilities, and the Replication of Technology, *Organization Science*, 3: 383-397.

Mudambi, R. (2008) Location, control and innovation in knowledge-intensive industries. *Journal of Economic Geography*, 8(5): 699-725.

Porter, M. (1980) Competitive Strategy. Techniques for Analyzing Industries and Competitors, New York: Free Press.

Shin, N., Kraemer, K. and J. Dedrick, J. (2012) Value Capture in the Global Electronics Industry: Empirical Evidence for the 'Smiling Curve' Concept, *Industry and Innovation*, 19 (1): 1–19.

Todeva, E. (2015) Market Driven Clusters as Prerequisites and Consequences of Smart Specialisation, *Journal of the Knowledge Economy*, 6: 250-269.

Todeva, E. and Rakhmatullin, R. (2016) Industry Global Value Chains, Connectivity and

Regional Smart Specialisation in Europe. An Overview of Theoretical Approaches and Mapping Methodologies, European Commission, Institute for Prospective Technological Studies.

Todeva, E. (2006) Business Networks: Strategy and Structure, New York: Taylor & Francis.

Todeva, E. (2008) Health Technology Cluster in the Greater South East, SEHTA-BIT Report for SEEDA, EEDA, LDA, O2C.

Todeva, E. (2013) Governance of Innovation and Intermediation in The Triple Helix Interactions, *Industry and Higher Education*, 27(4): 263-278.

Todeva, E., Knoke, D. and Keskinova, D. (2016) Multi-Stage Cluster Methodology with Complementary Structural Analysis of 2-mode Networks, forthcoming in *International Journal for Social Research Methodology*.

Todeva, E. and Keskinova, D. (2006) Clusters in the South East of England, University of Surrey, ISBN: 1-84469-011-3.

Todeva, E. and Keskinova, D. (2013) The Studies of Blogs and On-Line Communities: From Information to Knowledge and Action, in: N. Agarwal, R. T. Wigand, & M. Lim (Eds.), Online Collective Action: Dynamics of the Crowd in Social Media, Springer.

Todeva, E. and Rakhmatullin, R. (2016) Industry Global Value Chains, Connectivity and Regional Smart Specialisation in Europe. An Overview of Theoretical Approaches and Mapping Methodologies, JRC Science for Policy Report, European Union.

Data Sources

Bespoke Bulgarian biopharma dataset (2015)

Bespoke global biopharma MNE output dataset (2015)

Bespoke global biopharma MNE derivative dataset (2015)

Bespoke GSE biomedical and biopharma dataset (2008)

Bespoke regional South East of England dataset (2005)

Orbis: international corporate database. Link: http://www.bvdinfo.com/en-gb/our-products/company-information/international-products/orbis?gclid=CJebneLdu8sCFUKZGwodSd4G8Q

Web-links to resources

Agro-food - http://s3platform.jrc.ec.europa.eu/-/agri-food-s3-platform-information-day?inheritRedirect=true&redirect=http%3A%2F%2Fs3platform.jrc.ec.europa.eu%2Fhome

Circular economy policy - http://ec.europa.eu/growth/industry/sustainability/circular-economy/index_en.htm

Cluster facilitated projects for new industrial value chains - http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/6084-innosup-01-2016-2017.html

Cluster internationalisation - http://ec.europa.eu/growth/smes/cluster/internationalisation/index_en.htm

Clusters and emerging industries - http://ec.europa.eu/growth/smes/cluster/emerging-industries/index_en.htm

Competitiveness in the healthcare industries - http://ec.europa.eu/growth/sectors/healthcare/competitiveness/index_en.htm

COSME programme for SME support (DG GROWTH) - http://ec.europa.eu/growth/smes/cosme/index_en.htm

EC COM: For a European industrial renaissance - http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0014

EC Growth: Internal Market, Industry, Entrepreneurship and SMEs - http://ec.europa.eu/growth/index_en.htm

ESCP, 2016 - http://www.clustercollaboration.eu/sites/default/files/Table%20of%20European%20Cluster%20Strategic%20Partnerships-4i_VF%20for%20publication.pdf

EU R&D Scoreboard 2014 - http://iri.jrc.ec.europa.eu/scoreboard14.html

European Cluster Collaboration Platform - http://www.clustercollaboration.eu/cluster-list

European cluster consortia - http://archive.clustercollaboration.eu/european-strategy;jsessionid=C10FA959B1E6FA9DE91B618C6E0BCF9D

European cluster panorama – http://ec.europa.eu/growth/smes/cluster/observatory/about/index_en.htm

European Executive Agency for SMEs (EASME) - http://ec.europa.eu/easme/en

European strategic cluster partnerships - http://www.clustercollaboration.eu/escp-list

European Strategic Cluster Partnerships - http://www.clustercollaboration.eu/eu-cluster-partnerships

EYE@RIS3 search tool - http://s3platform.jrc.ec.europa.eu/map

Industrial modernisation - http://s3platform.jrc.ec.europa.eu/-/information-day-industrial-modernisation-s3-platform?inheritRedirect=true&redirect=http%3A%2F%2Fs3platform.jrc.ec.europa.eu%2Fhome

Industrial Renaissance in Europe - http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0014

RECONFIRM Initiative for Regional Co-Operation Networks - https://ec.europa.eu/easme/en/tender/8029/regional-cooperation-networks-industrial-modernisation-reconfirm-initiative

Regional Innovation Monitor Plus (2015) Mapping advanced manufacturing networks and exploring new business Opportunities, TECHNOPOLIS & FRAUNHOFER, https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/sites/default/files/report/RIM%20Plus_Mapping%20Advanced%20Manufacturing%20Networks_Thematic%20Paper.pdf

Regional Innovation Monitor Plus, 2015 - https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/sites/default/files/report/RIM%20Plus_Mapping%20Advanced%20Manufacturing%20Networks_Thematic%20Paper.pdf

Regional smart specialisation strategies - http://s3platform.jrc.ec.europa.eu/home

Smart guide to cluster policy - http://ec.europa.eu/DocsRoom/documents/16903/attachments/1/translations/en/renditions/native

Smart regions conference (2016) - http://ec.europa.eu/regional_policy/en/conferences/smart-regions/

Smart Specialisation Strategy - http://s3platform.jrc.ec.europa.eu/home

Thematic Platforms - http://s3platform.jrc.ec.europa.eu/s3-themes

Towards industrial renaissance –

http://ec.europa.eu/growth/industry/policy/renaissance/index_en.htm

US cluster mapping initiative - http://clustermapping.us/about

Vanguard initiative - http://www.s3vanguardinitiative.eu/ambitions

Vanguard initiative methodology - http://s3platform.jrc.ec.europa.eu/documents/20182/170991/2.1+Wim+de+KinderenSSP+Industry+Modernisation+Info+Day+-+ppt+Vanguard+FINAL.pdf/564e3431-ee25-4033-a494-0a5df01ac54e

List of tables

List of figures

List of maps

Appendix: additional tables, figures and maps

Table 8. Biopharma industry codes and industry segments for measuring outputs (NACE, NAICS, ISIC)

CODES	Code Description
NACE	
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
2110	Manufacture of basic pharmaceutical products
2120	Manufacture of pharmaceutical preparations
72	Scientific research and development
721	Research and experimental development on natural sciences and engineering
72 11	Research and experimental development on biotechnology
7219	Other research and experimental development on natural sciences and engineering
7220	Research and experimental development on social sciences and humanities
NAICS	
325199	All Other Basic Organic Chemical Manufacturing
325411	Medicinal and Botanical Manufacturing
325412	Pharmaceutical Preparation Manufacturing
325413	In-Vitro Diagnostic Substance Manufacturing
325414	Biological Product (except Diagnostic) Manufacturing
334510	Electro-medical and Electrotherapeutic Apparatus Manufacturing
423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
423460	Ophthalmic Goods Merchant Wholesalers
424210	Drugs and Druggists' Sundries Merchant Wholesalers
446110	Pharmacies and Drug Stores
446120	Cosmetics, Beauty Supplies, and Perfume Stores
446130	Optical Goods Stores
446191	Food (Health) Supplement Stores
541711	Research and Development in Biotechnology
541712	Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)
621492	Kidney Dialysis Centres
621511	Medical Laboratories
621512	Diagnostic Imaging Centres
621991	Blood and Organ Banks
623312	Assisted Living Facilities for the Elderly
ISIC	Division 21: Manufacture of pharmaceuticals, medicinal chemical and botanical products
2100	Manufacture of pharmaceuticals, medicinal chemical and botanical products
0128	Growing of spices, aromatic, drug and pharmaceutical crops
1079	Manufacture of herb infusions
2310	Manufacture of glass and glass products (including manufacture of laboratory, hygienic or pharmaceutical glassware)
3250	Manufacture of medical, surgical and dental instruments and supplies (including 34 major product groups such as: bone reconstruction cements, dental, ophthalmic orthopaedic and laboratories goods, appliances, devices and instruments)
4649	Wholesale of other household goods (including wholesale of pharmaceutical and medical goods)
4772	Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles in specialised stores
7210	Research and development for pharmaceuticals and biotech pharmaceuticals
8292	Packaging activities (including security packaging of pharmaceutical preparations)

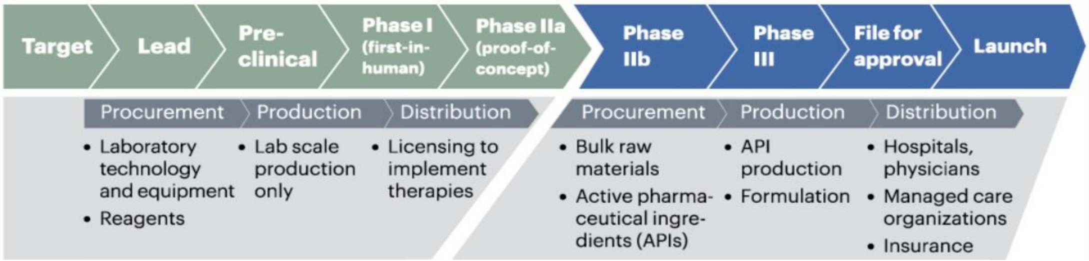


Figure 14. The two ends of the R&D process in biopharma value chain

Source: Adopted from Kearney (2013).

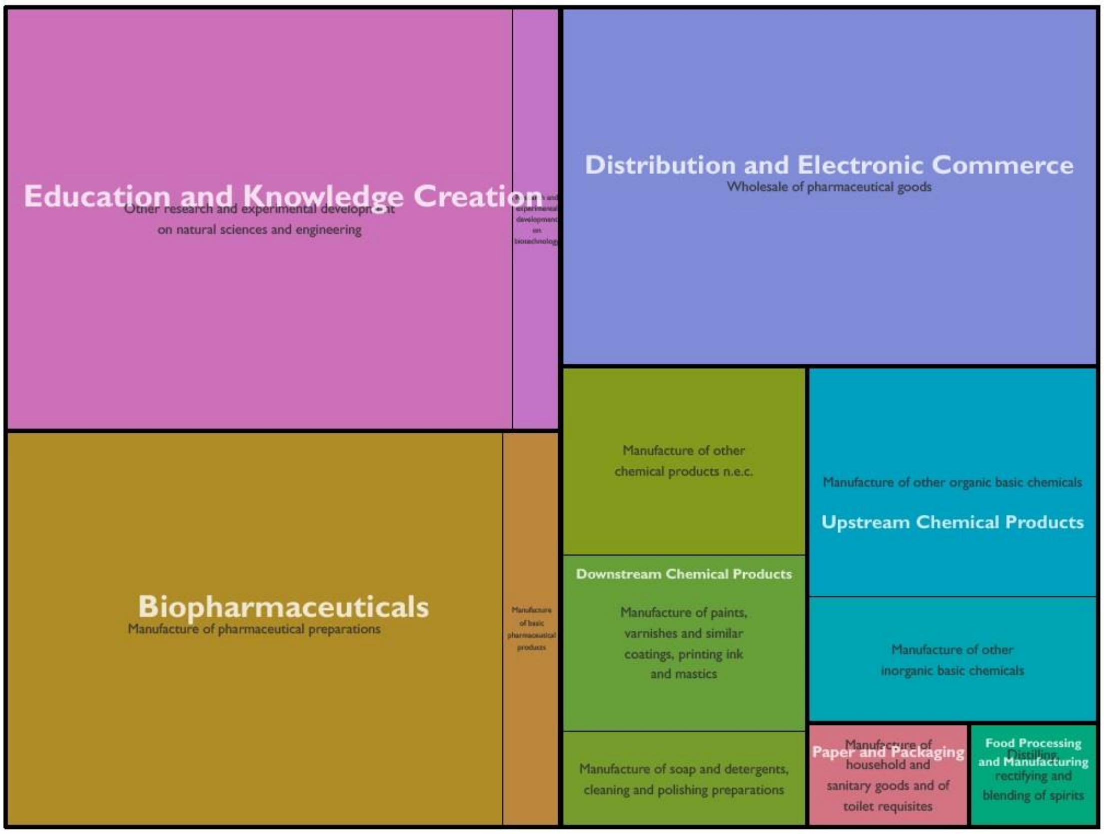


Figure 15. Biopharma and related cluster categories

Source: Adopted from European Cluster Panorama, 2014.

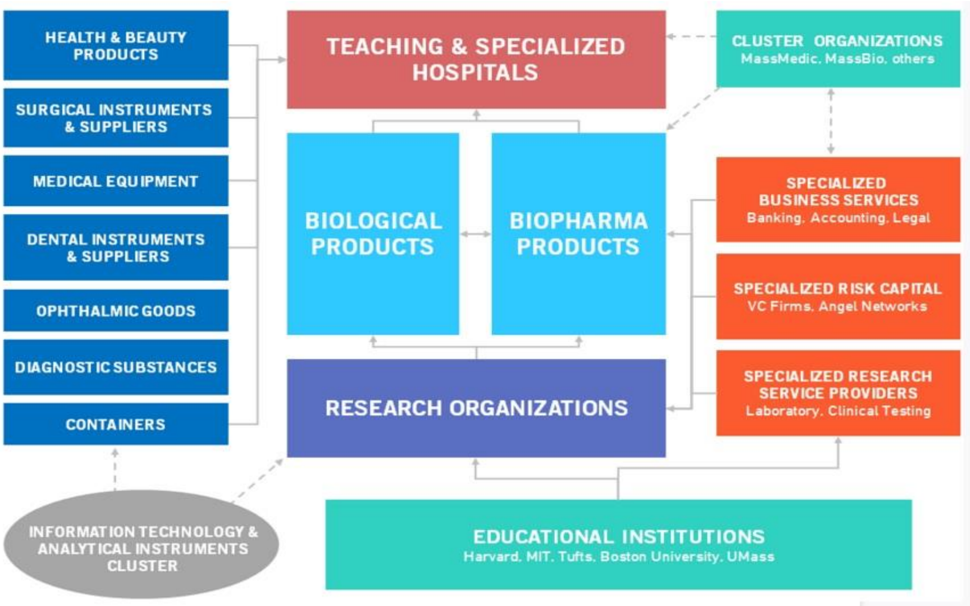


Figure 16. Boston bio-pharmaceuticals cluster

Source: Adopted from US Cluster Mapping Initiative, Cluster 101.

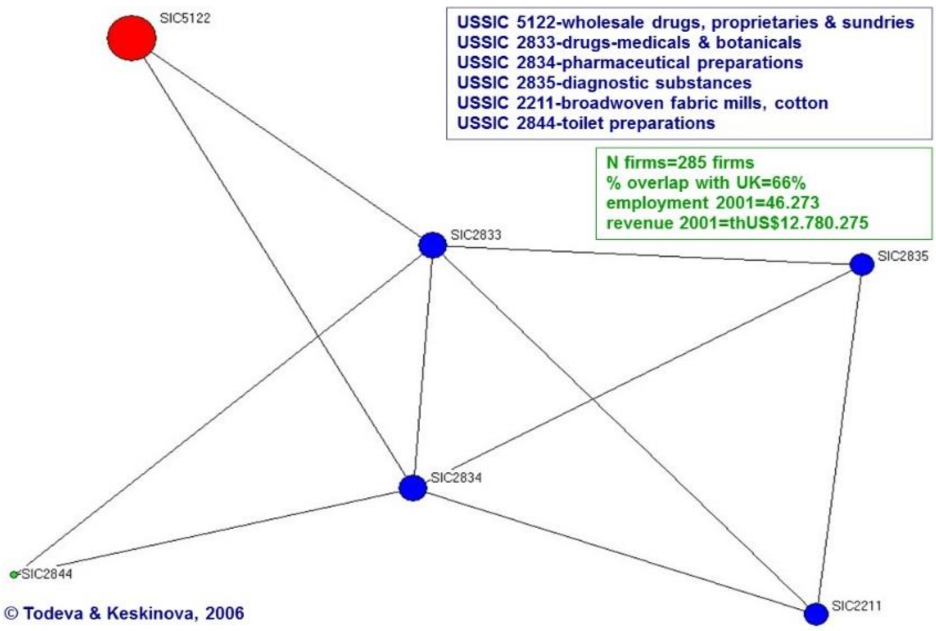


Figure 17. South East of England pharmaceuticals cluster map

Source: Adopted from Todeva and Keskinova (2006).
Note: Data from Amadeus (2005); Bespoke regional South East of England dataset (2005); network map is based on 5% of ties, or > 6 firms; Size of the dot indicates number of firms; Links indicate cross-sectoral complementarities in value added (based on US SIC codes).

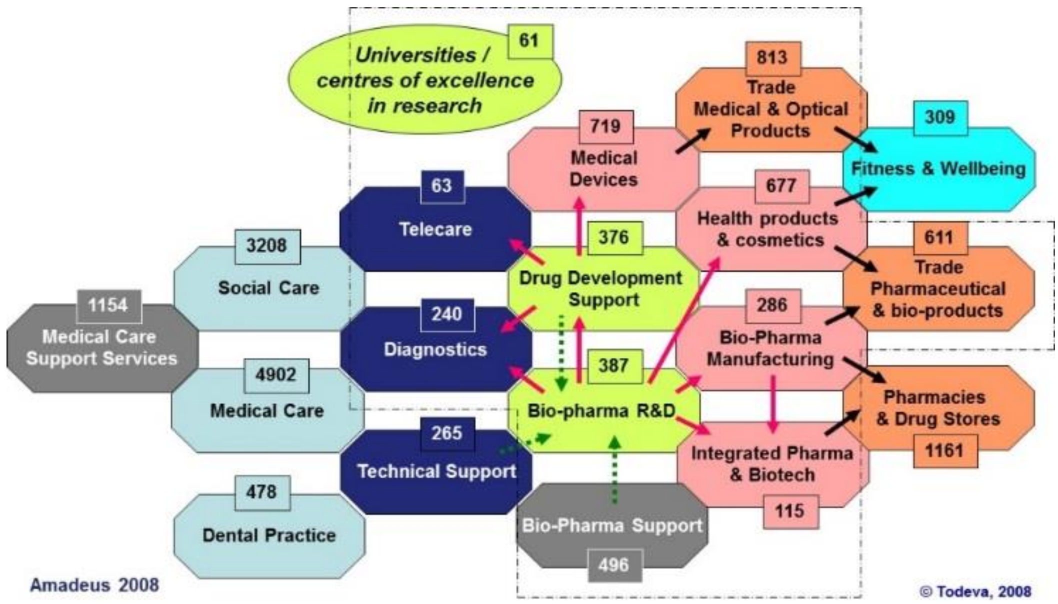


Figure 18. Greater South East of England biomedical and biopharma cluster map

Source: Adopted from Todeva (2008).
Note: Bespoke GSE biomedical and biopharma dataset (2008); Data from Amadeus (2008); numbers indicate firms in each strategic value chain group; Links indicate input-output relationships; Colours discriminate between different type of activity.

Table 9. Top biopharma MNEs - activities in related and unrelated industries

NACE Codes*	Count	%
2120 - Manufacture of pharmaceutical preparations	1 395	30%
4646 - Wholesale of pharmaceutical goods	1 392	30%
7219 - Other research and experimental development on natural sciences and engineering	450	10%
4645 - Wholesale of perfume and cosmetics	404	9%
2110 - Manufacture of basic pharmaceutical products	385	8%
7211 - Research and experimental development on biotechnology	351	8%
6420 - Activities of holding companies	280	6%
7010 - Activities of head offices	259	6%
4690 - Non-specialised wholesale trade	185	4%
8299 - Other business support service activities n.e.c.	180	4%
4618 - Agents specialised in the sale of other particular products	136	3%
7022 - Business and other management consultancy activities	122	3%
4675 - Wholesale of chemical products	118	3%
3250 - Manufacture of medical and dental instruments and supplies	114	2%
2059 - Manufacture of other chemical products n.e.c.	110	2%
4773 - Dispensing chemist in specialised stores	104	2%
8690 - Other human health activities	85	2%
7320 - Market research and public opinion polling	80	2%
7490 - Other professional, scientific and technical activities n.e.c.	79	2%
7311 - Advertising agencies	73	2%
2042 - Manufacture of perfumes and toilet preparations	50	1%
2660 - Manufacture of irradiation, electromedical and electrotherapeutic equipment	44	1%

NACE Codes*	Count	%
2014 - Manufacture of other organic basic chemicals	42	1%
4774 - Retail sale of medical and orthopaedic goods in specialised stores	41	1%
2013 - Manufacture of other inorganic basic chemicals	38	1%
2020 - Manufacture of pesticides and other agrochemical products	33	1%
7120 - Technical testing and analysis	32	1%

Source: Bespoke global biopharma MNE derivative dataset (2015); sub-sample of large and very large firms (4656).
Note: Pre-selected NACE codes for the categorisation procedure are highlighted in red; *Count* measures the number of firms in each industry in the dataset.

Table 10. Structure of the bespoke global biopharma MNE datasets: *(A) output dataset; (B) derivative dataset; (C) sub-sample of all very large and large firms*

A) Output dataset – parents with their subsidiaries without duplicate		
Extracted cases of subsidiaries		37 793
Removed all duplicate cases by parent BvD ID number & subsidiary BvD ID number (these are cases in which the subsidiary appears on more than one level)		*4 140*
A) Final output dataset – parents with their subsidiaries without duplicate		**33 653**
of which firms with activity data		23 280
B) Derivative dataset – ALL parents and subsidiaries with activities data and no duplicates		
Parents		293
Subsidiaries from output dataset (subsidiaries can occur more than 1 time in the dataset, when they have more than 1 parent)		33 653
Initial derivative dataset		*33 946*
Removed all duplicate cases		*4 349*
Removed cases of subsidiaries with ownership and location data, but no activities data		*9 089*
B) Derivative dataset - All parents and subsidiaries with activities data and no duplicates		**20 508**
of which	parents	293
	subsidiaries	20 215
C) Sub-sample from (B) of the large and very large firms		**4 656**

Source: Bespoke global biopharma MNE derivative dataset (2015).
Note: Dark fields represent sums; italic represents data cleaning.

Table 11. Strategic value chain groups in the biopharma GVC

Strategic Value Chain Groups	All Parents	EU Parents	Parents & Subsidiaries	EU Parents & Subsidiaries
11 - Biopharma R&D	19	9	903	553
12 - Biopharma R&D & Manufacturing	90	2	180	13
13 - Biopharma R&D & Services Diversified	8	3	262	126
14 - Clinical Research & Human Health Activities	2	0	475	194
21 - Bio-pharma Manufacturing	71	20	6 271	761
22 - Biopharma Manufacturing and Wholesale	41	9	282	145
23 - Perfumes and Cosmetics Manufacturing	1	1	64	23
24 - Biopharma Manufacturing Multi-diversified	23	4	173	95
25 - Chemical & Biopharma Manufacturing Diversified	6	4	459	168
26 - Medical Instruments, Dental & Electrotherapeutic Manufacturing	4	0	306	91
27 - Manufactured Goods, Electronics and Instruments	0	0	162	47
28 - Special Purpose Machinery and Equipment	1	0	105	39
31 - Specialised Biopharma Wholesale	3	2	1 424	1 098
32 - Biopharma Retail	0	0	1 829	215
33 - Biopharma & Cosmetics wholesale	3	0	1 251	43
34 - Pharma Wholesale Trade & Services Diversified	0	0	71	60
35 - Chemical & Biopharma Wholesale	0	0	119	52
36 - Medical & Hospital Equipment Wholesale & Supplies	0	0	355	53
41 - Holding, Financial & Administrative Head-Office Services	14	8	1 517	974
42 - Other Business and Management Services	3	3	854	555
43 - Finance & Insurance Services	0	0	574	152
44 - Miscellaneous Services	3	2	1 267	519
51 - Agriculture, Food Processing & Drinks of Bio-products	1	1	589	115
52 - Miscellaneous Goods	0	0	111	11
53 - Electricity, Gas and Water Supply & Services	0	0	290	238
54 - Other Miscellaneous Wholesale	0	0	615	165
Total	**293**	**68**	**20 508**	**6 505**

Source: Bespoke global biopharma MNE derivative dataset (2015).

Table 12. Strategic biopharma value chain groups by parents and subsidiaries

Strategic Value Chain Groups	Parents				Subsidiaries			
	EU		Other Global		EU		Other Global	
	Count	Row %	Count	Row %	Count	Row %	Count	Row %
11 - Biopharma R&D	9	47%	10	53%	544	62%	340	38%
12 - Biopharma R&D & manufacturing	2	2%	88	98%	11	12%	79	88%
13 - Biopharma R&D & services diversified	3	38%	5	63%	123	48%	131	52%
14 - Clinical research & human health activities	0	0%	2	100%	194	41%	279	59%
21 - Bio-pharma manufacturing	20	28%	51	72%	741	12%	5 459	88%
22 - Biopharma manufacturing and wholesale	9	22%	32	78%	136	56%	105	44%
23 - Perfumes and cosmetics manufacturing	1	100%	0	0%	22	35%	41	65%
24 - Biopharma manufacturing multi-diversified	4	17%	19	83%	91	61%	59	39%
25 - Chemical & biopharma manufacturing diversified	4	67%	2	33%	164	36%	289	64%
26 - Medical Instruments, dental & electrotherapeutic manufacturing	0	0%	4	100%	91	30%	211	70%
27 - Manufactured goods, electronics and instruments	0	0%	0	0%	47	29%	115	71%
28 - Special purpose machinery and equipment	0	0%	1	100%	39	38%	65	63%
31 - Specialised biopharma wholesale	2	67%	1	33%	1 096	77%	325	23%
32 - Biopharma retail	0	0%	0	0%	215	12%	1 614	88%
33 - Cosmetics & biopharma wholesale	0	0%	3	100%	43	3%	1 205	97%
34 - Pharma wholesale trade & services diversified	0	0%	0	0%	60	85%	11	15%
35 - Chemical & biopharma wholesale	0	0%	0	0%	52	44%	67	56%
36 - Medical & hospital equipment wholesale & supplies	0	0%	0	0%	53	15%	302	85%
41 - Holding, financial & administrative head-office services	8	57%	6	43%	966	64%	537	36%
42 - Other business and management services	3	100%	0	0%	552	65%	299	35%
43 - Finance & insurance services	0	0%	0	0%	152	26%	422	74%
44 - Miscellaneous services	2	67%	1	33%	517	41%	747	59%
51 - Agriculture, food processing & drinks of bio products	1	100%	0	0%	114	19%	474	81%
52 - Manufactured misc. goods	0	0%	0	0%	11	10%	100	90%
53 - Electricity, gas and water supply & services	0	0%	0	0%	238	82%	52	18%
54 - Other misc. wholesale	0	0%	0	0%	165	27%	450	73%
Total	**68**	**23%**	**225**	**77%**	**6 437**	**32%**	**13 778**	**68%**

Source: Bespoke global biopharma MNE derivative dataset (2015).
Note: Data for parents and subsidiaries is from the derivative dataset of 20508 categorised firms with activity data. 9 European parents are located in non-EU member states.

Table 13. Core Biopharma GVC agglomerations

Value Chain Agglomerations	Parents	Subsidiaries	Total
Biopharma R&D	119	1 701	1 820
Biopharma Manufacturing	135	6 591	6 726
Biopharma Trade	6	4 688	4 694
Perfumes & Cosmetics	1	63	64
Chemicals Diversified	6	453	459
Finance & Related Services	20	4 192	4 212
Medical & Hospital (instruments equipment and supplies)	5	923	928
Agriculture & Food Processing	1	588	589
Unrelated Goods & Services	0	1 016	1 016
Total	**293**	**20 215**	**20 508**

Source: Bespoke global biopharma MNE derivative dataset (2015).

Table 14. European biopharma value chain agglomerations

Value Chain Agglomerations	All Parents	EU Parents	All Parents & Subsidiaries	EU Parents & Subsidiaries
Biopharma R&D	119	14	1 820	886
Biopharma Manufacturing	135	33	6 726	1 001
Biopharma Trade	6	2	4 694	1 468
Finance & Related Services	20	13	4 212	2 200
Perfumes & Cosmetics	1	1	64	23
Chemicals Diversified	6	4	459	168
Medical & Hospital (instruments equipment and supplies)	5	0	928	230
Agriculture & Food Processing	1	1	589	115
Unrelated Goods & Services	0	0	1 016	414
Total	**293**	**68**	**20 508**	**6 505**

Source: Bespoke global biopharma MNE derivative dataset (2015).

Table 15. European biopharma value chain agglomerations by parents and subsidiaries

Value Chain Agglomerations	All Parents				All Subsidiaries			
	EU		Other Global		EU		Other Global	
	Count	Row %	Count	Row %	Count	Row %	Count	Row %
Biopharma R&D	14	12%	105	88%	872	51%	829	49%
Biopharma Manufacturing	38	26%	108	74%	1 245	17%	6 164	83%
Biopharma Wholesale/Trade	2	33%	4	67%	1 684	30%	3 974	70%
Biopharma Services	11	65%	6	35%	1 670	57%	1 258	43%
Biopharma Other Input / Output Industries	3	60%	2	40%	966	38%	1 553	62%
Total	**68**	**23%**	**225**	**77%**	**6 437**	**32%**	**13 778**	**68%**

Source: Bespoke global biopharma MNE derivative dataset (2015).
Note: Categorised 20508 firms. The category 'Other Input / Output Industries', contains all VCGs in Perfumes and cosmetics; Medical & hospital instruments, equipment and supplies; Agriculture and food processing; Unrelated goods and services.

Table 16. Best performers in the biopharma global R&D strategic groups

Industry group	Company name	Country	City	Last avail. year	Revenue th EUR	Employees
11	ILLUMINA INC	USA	SAN DIEGO	2014	1 533 118	3 700
11	QIAGEN NV	Netherlands	VENLO	2013	947 176	4 015
11	GENUS PLC	United Kingdom	BASINGSTOKE	2014	464 228	2 314
11	INCYTE CORPORATION	USA	WILMINGTON	2014	421 296	588
11	MUNDIPHARMA RESEARCH LTD	United Kingdom	CAMBRIDGE	2013	124 173	271
12	GILEAD SCIENCES INC	USA	FOSTER CITY	2014	20 500 782	7 000
12	AMGEN INCORPORATED	USA	THOUSAND OAKS	2014	16 524 998	17 900
12	ABBVIE INC.	USA	NORTH CHICAGO	2014	16 440 161	26 000
12	ELI LILLY AND COMPANY	USA	INDIANAPOLIS	2014	16 156 494	39 135
12	BIOGEN INC	USA	CAMBRIDGE	2014	7 992 195	7550
13	SHIRE PLC	United Kingdom	ST. HELIER	2014	4 967 466	5016
13	PAREXEL INTERNATIONAL CORP	USA	WALTHAM	2014	1 659 351	15 560
13	JAZZ PHARMACEUTICALS PLC	Ireland	DUBLIN	2014	9 660 445	870
13	CK LIFE SCIENCES INTERNATIONAL (HOLDINGS) INC	Cayman Islands	GEORGE TOWN	2014	531 440	1 675
13	SIMCERE PHARMACEUTICAL GROUP	Cayman Islands		2012	255 878	4 046
14	WEST PHARMACEUTICAL SERVICES, INC.	USA	EXTON	2014	1 170 744	7 000
14	NEUROCRINE BIOSCIENCES INC	USA	SAN DIEGO	2014	0	94

Source: Bespoke global biopharma MNE derivative dataset (2015).
Note: Industry groups 11 (R&D); 12 (R&D and manufacturing); 13 (R&D and Services); 14 (Clinical research and human health activities).

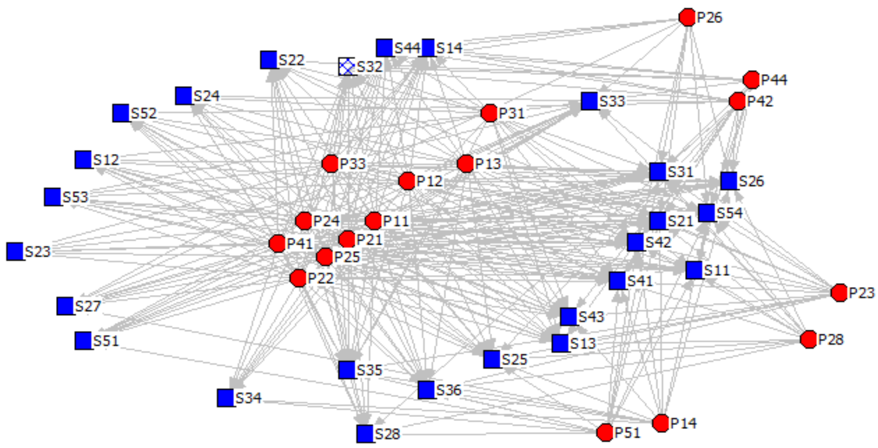


Figure 19. Ownership ties in the biopharma global value chain (B)

Source: Bespoke global biopharma MNE output dataset (2015).
Note: Links between parents and subsidiaries; all ownership ties based on 23280 firms with activity data (Table 10); Parents in the centre of the diagram control subsidiaries across the entire GVC, while parents at the periphery have more specialised portfolio.

Table 17. Structure of the bespoke Bulgarian biopharma datasets: *(A) output dataset; (B) derivative dataset*

(A) Output Dataset – parents and their subsidiaries		
Parents		6 266
Subsidiaries		2 454
Total		8 720
Removed all duplicate cases by BvD ID number		*1 142*
Removed foreign firms		*79*
Removed firms with no activity data		*343*
Final output dataset – parents and their subsidiaries		**7 156**
(B) Derivative dataset		
Initial Derivative Data set		7 156
Removed firms with generic services codes but no biopharma codes (4 NACE codes in brown)		*145*
Removed firms with generic R&D codes but no biopharma codes (5 NACE codes in blue)		*5 018*
Removed firms that do not have any of the selected 20 codes (Table 17)		*698*
Final Cases of parents and subsidiaries		**1 295**
of which	parents	1 058
	subsidiaries	237

Source: Bespoke Bulgarian biopharma dataset (2015).

Table 18. Distribution of firms by industry in the Bulgarian biopharma dataset

NACE Codes	Core biopharma		Services	R&D	Total
	Parent	Subsid			
2014 - Manufacture of other organic basic chemicals	106				106
2041 - Manufacture of soap and detergents, cleaning and polishing preparations	181				181
2042 - Manufacture of perfumes and toilet preparations	173				173
2053 - Manufacture of essential oils	4				4
2110 - Manufacture of basic pharmaceutical products	26				26
2120 - Manufacture of pharmaceutical preparations	77				77
2660 - Manufacture of irradiation, electro-medical and electro-therapeutic equipment	218				218
2670 - Manufacture of optical instruments and photographic equipment	40				40
3250 - Manufacture of medical and dental instruments and supplies	86				86
4646 - Wholesale of pharmaceutical goods	82				82
7211 - Research and experimental development on biotechnology	212				212
6420 - Activities of holding companies	3	3	10		16
6430 - Trusts, funds and similar financial entities		3	14		17
6499 - Other financial service activities, except insurance and pension funding n.e.c.		2	11		13
7022 - Business and other management consultancy activities	4	2	110		116
7120 - Technical testing and analysis	11	2	43	1 341	1 397
7219 - Other research and experimental development on natural sciences and engineering	148	5	18	640	811
7220 - Research and experimental development on social sciences and humanities	8	3	5	354	370
7490 - Other professional, scientific and technical activities n.e.c.	7	13	3	100	123
8690 - Other human health activities	131	11	33	2 894	3 069

Source: Bespoke Bulgarian biopharma dataset (2015).

Table 19. Availability of activity data in the Bulgaria biopharma dataset

Number of codes	Firms
1	642
2	435
3	150
4	53
5	12
6	1
7	2
Total	**1 295**

Source: Bespoke Bulgarian biopharma dataset (2015).

Table 20. Distribution of biopharma capabilities in Bulgaria by size of firms

Strategic Value Chain Groups (VCGs)	Type of company				
	VL	LA	ME	SM	Total
11 - Biopharma R&D	0	2	10	160	172
12 - Biopharma R&D & Manufacturing	0	2	1	6	9
13 - Biopharma R&D & Services Diversified	0	2	11	28	41
14 - Clinical Research & Human Health Activities	1	4	30	96	131
21 - Bio-pharma Manufacturing	4	5	17	41	67
22 - Biopharma Manufacturing and Wholesale	2	1	5	1	9
23 - Perfumes and Cosmetics Manufacturing	11	28	102	124	265
24 - Biopharma Manufacturing Multi-diversified	0	6	2	5	13
25 - Chemical & Biopharma Manufacturing Diversified	3	7	18	91	119
26 - Medical Instruments, Dental & Electrotherapeutic Manufacturing	5	8	13	138	164
27 - Manufactured Goods, Electronics and Instruments	0	0	2	0	2
31 - Specialised Biopharma Wholesale	40	0	0	0	40
33 - Biopharma & Cosmetics wholesale	7	0	0	0	7
41 - Holding, Financial & Administrative Head-Office Services	1	0	0	0	1
44 - Miscellaneous Services	0	1	0	0	1
51 - Agriculture, Food Processing & Drinks of Bio-products	1	0	0	0	1
54 - Other Miscellaneous Wholesale	0	0	1	0	1
Total	**75**	**66**	**212**	**690**	**1 043**

Source: Bespoke Bulgarian biopharma dataset (2015).

Table 21. Agglomerations of strategic groups in the Bulgarian biopharma value chain

Strategic Value Chain Groups	Count	%
Biopharma R&D	369	28%
Biopharma Manufacturing	93	7%
Biopharma Trade	76	6%
Perfumes & Cosmetics	266	21%
Chemicals Diversified	120	9%
Finance & Related Services	111	9%
Medical & Hospital (instruments equipment and supplies)	186	14%
Agriculture & Food Processing	16	1%
Unrelated Goods & Services	58	4%
Total	**1 295**	**100%**

Source: Bespoke Bulgarian biopharma dataset (2015).

Table 22. Distribution of biomedical and biopharma capabilities in the GSE

Distribution of Firms in Strategic Value Chain Groups in GSE Sub-regions		EEDA	LDA	SEEDA	Total
Core VCGs	1.Bio-Pharma R&D	115	132	140	**387**
	2.Drug Development & Support	82	140	154	**376**
	3.Bio-Pharma Manufacturing	70	105	111	**286**
	4.Integrated Pharma & Biotech	17	36	62	**115**
	5.Trade Pharma & Bio Products	87	352	172	**611**
	6.Bio Pharma Support	92	212	192	**496**
	7.Diagnostics	44	91	105	**240**
	8.Medical Devices	192	188	339	**719**
	9.Telecare	3	17	43	**63**
	10.Trade Medical & Optical Products	174	338	301	**813**
	16.Health Products & Cosmetics	96	356	225	**677**
	Total	***972***	***1 967***	***1 844***	***4 783***
Periphery VCGs	11.Technical Support	49	98	118	**265**
	12.Medical Care	953	2 183	1 766	**4 902**
	13.Dental Practice	92	216	170	**478**
	14.Social Care	629	1 616	963	**3 208**
	15.Medical Care Support Services	154	621	379	**1 154**
	17.Fitness & Wellbeing	47	136	126	**309**
	18.Pharmacies & Drug Stores	158	782	221	**1 161**
	Total	***2 082***	***5 652***	***3 743***	***11 477***
Total		**3 054**	**7 619**	**5 587**	**16 260**

Source: Bespoke GSE biomedical and biopharma dataset (2008).
Note: Distribution of firms by sub-regions and by VCGs in the output and the derivative dataset.

Table 23. Size of biomedical and biopharma VCGs in the GSE cluster

Strategic Value Chain Groups	Firms	Employees Last Year		Operating Revenue / Turnover Last Year *(in thousands GBP)*	
	Count	Sum	Mean	Sum	Mean
1.Bio-Pharma R&D	387	8 911	61	5 167 390	31 897
2.Drug Development Support	376	29 934	249	2 924 008	15 805
3.Bio-Pharma Manufacturing	286	24 470	275	4 595 224	41 775
4.Integrated Pharma & Biotech	115	215 717	2 876	51 063 865	719 209
5.Trade Pharma & Bio Products	611	18 450	148	10 971 274	54 046
6.Bio-Pharma Support	496	5 439	71	1 034 648	3 749
7.Diagnostics	240	18 239	253	1 851 291	14 132
8.Medical Devices	719	75 704	362	8 750 634	30 490
9.Telecare	63	3 157	105	673 203	19 234
10.Trade Med & Optical Products	813	17 595	139	3 175 035	8 795
16.Health Prod & Cosmetics	677	55 745	680	9 568 695	33 340
Total	**4 783**	**473 361**	**411**	**99 775 267**	**47 332**

Source: Bespoke GSE biomedical and biopharma dataset (2008).
Note: Size measured by number of firms, employment and revenue; data for 2007 provided by firms in their tax returns; derivative dataset.

Table 24. Definitions of strategic value chain groups in the GSE cluster

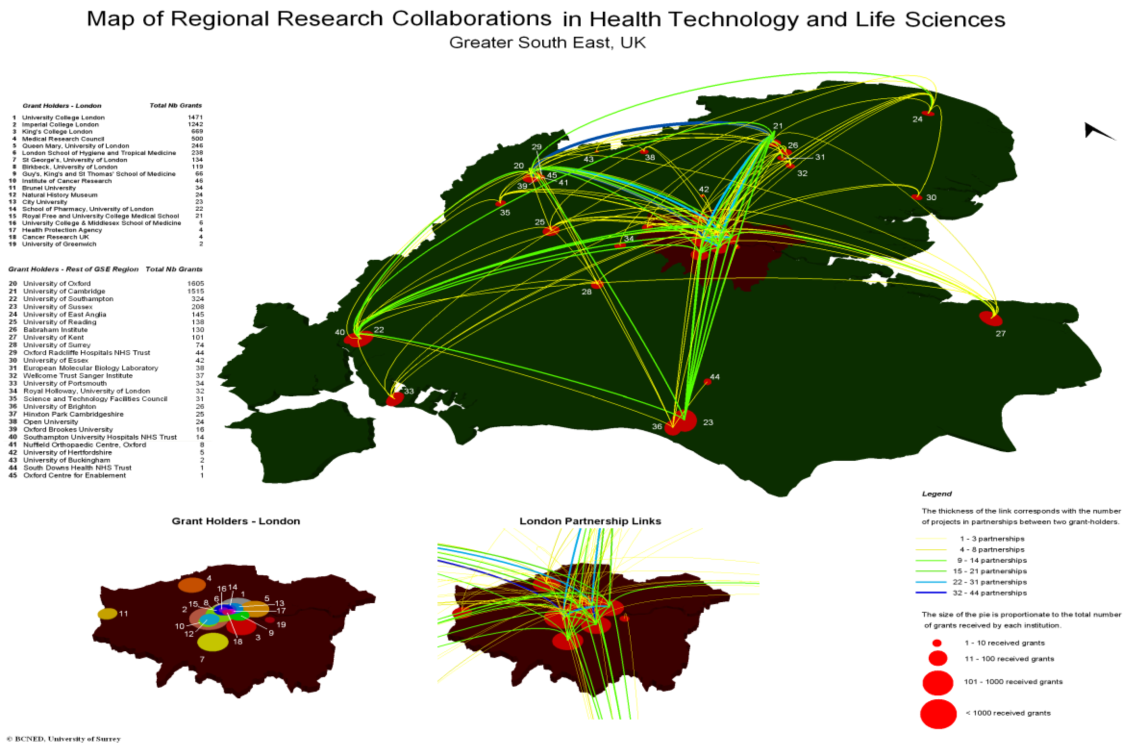
	Value Chain Groups	Definition	Type
1	Bio-Pharma R&D	Research and development resulting in a pharmaceutical or biotechnology product	Core
2	Drug Development Support	Research supplies, contract research, platform technology, medical-related research, nano-biotech, clinical trials, supportive research foundations, other related engineering R&D	Core
3	Bio-Pharma Manufacturing	Companies with primary activity being the manufacture of biopharmaceutical products	Core
4	Integrated Pharma and Biotech	Pharmaceutical R&D Companies which also manufacture and market medicines developed in house	Core
5	Trade Pharmaceutical Products	Companies providing pharmaceutical products, including wholesalers, retailers and marketers	Core
6	Bio-Pharma Business Support Services	Consulting, market research, finance, patents and regulatory for health technology sector, incubators, recruitment, leasing ie. NO products on sale	Core
7	Diagnostics	Diagnostic kits, equipment, reagents, imaging technologies, development, manufacturing, marketing	Core
8	Medical Devices	Development, manufacture, sales of medical devices including laboratory equipment, optical and drug delivery devices	Core
9	Telecare	Companies engaged in assistive technology	Core
10	Trade Medical and Optical Products	Companies selling medical and optical products and equipment, including wholesalers and retailers	Core
11	Technical Support and Equipment	Installation, maintenance of medical equipment, software solutions, specialised IT, sale of equipment, data management	Peripheral
12	Medical Care	Companies providing medical care, including medical clinics and hospitals, ambulance services, eye care, osteopaths, chiropractors	Peripheral
13	Dental Practice	Companies providing dental care and services	Peripheral
14	Social Care	Counselling, care homes, hostels	Peripheral
15	Medical Care Business Support Services	Consultancy, management, external supportive services for primary and secondary care, recruitment, transport	Peripheral
16	Health Products and Cosmetics	Companies developing, manufacturing and providing cosmetics and health products, and cosmetic services.	Core
17	Fitness and Wellbeing	Companies providing fitness, wellness and lifestyle services including Pilates, gym, yoga	Peripheral
18	Pharmacies and Drug Stores	Drugs and Druggists	Peripheral

Source: Bespoke GSE biomedical and biopharma dataset (2008).
Note: Definitions are based on the outcome from categorisation of the bespoke GSE biomedical and biopharma output dataset.

Table 25. Distributions of Operating Revenue / Turnover (th GBP) in Sub-regions in the GSE cluster

Operating Revenue in Amadeus Sub-regions		In Core Value Chain Groups			Total in Sub-Region		
		Sum	%	Mean	Sum	%	Mean
EEDA	Cambridge - Peterborough	1 834 888	2	12 398	1 970 389	1	9 706
	Chelmsford - Colchester - Southend-on-Sea	1 882 728	2	28 100	2 639 196	2	10 035
	Ipswich	624 617	1	48 047	644 915	0	14 331
	Luton	580 840	1	30 571	1 245 889	1	32 787
	Bedford	433 118	0	30 937	669 316	1	27 888
	Norwich	117 420	0	5 591	351 012	0	5 572
	St. Albans - Hemel Hempstead	2 102 315	2	28 031	2 515 232	2	18 770
	Stevenage	1 057 417	1	25 177	1 359 064	1	14 157
	Total	***8 633 343***	***9***	***21 637***	***11 395 013***	***9***	***13 158***
LDA	Greater London North	1 093 912	1	12 155	1 365 470	1	4 391
	Greater London South	37 591 266	38	250 608	41 482 405	31	89 595
	Inner London	26 411 086	26	41 527	48 195 404	36	25 870
	Total	***65 096 264***	***65***	***74 311***	***91 043 279***	***69***	***34 525***
SEEDA	Milton Keynes	1 551 969	2	19 645	1 915 842	1	11 270
	Brighton	418 220	0	6 337	476 031	0	3 071
	Canterbury - Medway-Tonbridge	4 727 727	5	48 242	5 884 964	4	19 551
	Guildford	2 845 252	3	19 897	3 807 368	3	11 399
	Oxford	1 196 068	1	12 205	1 546 161	1	10 040
	Portsmouth	960 699	1	24 633	993 267	1	11 550
	Reading - Slough	12 895 584	13	70 468	13 672 054	10	36 951
	Redhill	1 155 366	1	14 442	1 265 990	1	7 536
	Southampton	294 775	0	6 272	372 743	0	4 096
	Total	***26 045 660***	***26***	***31 267***	***29 934 420***	***23***	***16 367***
Total		**99 775 267**	**100**	**47 332**	**132 372 712**	**100**	**24 826**

Source: Bespoke GSE biomedical and biopharma dataset (2008).
Note: Definitions are based on the outcome from categorisation of the bespoke GSE biomedical and biopharma output dataset.



Map 10. University collaborations in biomedical research across the GSE

Source: Bespoke GSE biomedical and biopharma dataset (2008).

List of abbreviations

COSME	European programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises
FDI	Foreign Direct Investment
GTAP	Global Trade Analysis Project
GVC	Global value chain
ICT	Information and Communication Technologies
ISIC	International Standard Industrial Classification
JRC	Joint Research Centre
KET	Key Enabling Technology
MNE	Multinational Enterprise
NACE	European Classification of Economic Activities
NAICS	North-Atlantic Industry Classification System
OECD	Organisation for Economic Cooperation and Development
R&D	Research and Development
S3	Smart Specialisation Strategy
SIC	Standard Industrial Classification
SIGs	Strategic Industry Groups
SME	Small and Medium Enterprises
UNCTAD	United Nations Conference on Trade and Development
VCG	Value chain group
VCGs	Value Chain Groups
WTO	World Trade Organisation

LF-NA-28085-EN-N

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub
ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

Joint Research Centre

EU Science Hub

Publications Office

doi:10.2791/273290

ISBN 978-92-79-61507-8