Towards Sustainable Integration into European Industrial Development: Diversities of Innovative Transformation

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Transformation for sustainability in a changing global context - Executive Summary

By Ulrich Hilpert, Francesco D. Sandulli and Torsten Schunder

Many regions and some countries face situations of being affected by crisis and the need for industrial innovation, on the one hand, and being squeezed between the competition of countries with low labour costs and weak regulations and those with high industrial technological competences, on the other hand. Several regions in East Germany faced these challenges after the reunification, while Spanish regions are currently stressed by the competition of regions in Poland and the Czech Republic with lower labor costs and similar labor skills. As shown by the industrial transformation of German regions in the Ruhr area after the oil crisis, there is demand for *short term activities* coping with the current effects and *long-term strategies* to allow for a sustainable industrial future. While doing so, the existing competences and advantages of established enterprises, experience with products and capabilities of workers are to be considered. Strategies need to aim at higher values added to provide for secure jobs and enterprises as well as good incomes and profitable firms. When realizing such aims it is important that the labour is available to supply production, processes and industry-related services. Such labour forms an essential basis of industrial competences.

Crisis in the light of potential innovative transformation. Industrial development demands for constant modernization and innovation over the long run. For instance, almost 50 after the oil crisis, Spanish and German Regions such as the Ruhr Area or the Basque Country that were highly specialized in heavy industries are still struggling with industrial transformation. Low production costs and weak regulations are under constant change. While these conditions are changing and ask for a rearrangement of supply chains and manufacturing in countries such as Spain, there are existing investments in plants, labour force, transportation, and existing relationships between MNEs and SMEs. Thus, there are *established potentials* which need to be identified regarding the potential which are also *required when higher value-added products are manufactured*.
It is important to understand which products and opportunities can be arranged or realized when the existing competences and structures are modernized. A crisis shows that an existing situation does not align with newly emerged structures. Nevertheless, the successful example of the reconfiguration of traditional embroidery competences in the highSTICK growth pole in Saxony should raise awareness for the opportunities of new and different uses of the potentials. This can help building unique features.

Diversities of regional opportunities and demand for collaboration. Regions and metropolises are highly divergent when it comes to industrial capabilities, structures of enterprises, size of enterprises, integration into supply chains and value chains, innovative and research capabilities and, last not least, a skilled, educated and competent labour force. Consequently, opportunities are different and enterprises may watch out for matching competences. There are companies of divergent competences which can build synergy when collaborating with others which bring in complementary competences. There is clearly a need for divergent strategies to match the situations which exist within individual regions. But the *competences and regions which match can be quite different* because they need to build *synergy from divergent points of departure*. It is important to open the ideas about innovative transformation towards the competences which are required. Those did provide the basis for the products and development which needs to be changed now, but it is not bound to these products exclusively. A screening for both is required to identify areas where such competences are exploited or can be applied and what would suit as a complement to allow for further activities. As shown by the Innoregio program in Germany, regions shall leverage the development of modern competences on the development of cross-industry and inter-regional networks. Otherwise, there is the risk of developing excessively narrow or path dependent innovation and industrial strategies such as those implemented by some of the RIS3 plans developed in Spain. In this sense, the first generation of RIS3 plans developed in Spain were significantly biased towards local knowledge and closed innovation strategies, lacking the mechanisms to favor knowledge co-creation either with local together with institutions located in other regions or countries. Saxony shows how to adopt an open approach to regional competence building will be more effective. For instance, the Technical University of Dresden in particular did benefit from a decision to strengthen their competences in information and communication technologies and to focus on related engineering departments. This specialized orientation together with the search for international collaborations helped participating in leading-edge development. Spin off enterprises as well as additional research institutions supported federally or by the State of Saxony are complementing the Technical University. Similarly, the Technical University of Cottbus was established in Brandenburg having a strong focus on robotics which was established in close collaboration with the department at the Technical University of Berlin. Also, the University of Magdeburg engaged in several departments of high technological importance. It is important to see that the success of the technical University of Dresden is built upon expertise of both the university and the surrounding industries which did exist already before 1990 providing an appropriate basis for modernization on an established level of competence. Frequently, such universities were also complemented by top-research carried out at institutes of the Max-Planck-Society for the Advancement of Science and the Fraunhofer Society. Further particularly strong research competences were located in East Germany by the Leibnitz Foundation which also helped to develop a wide area of research.

The ZIM (Zentrales Innovationsprogramm, Central innovation Program), is another example of innovation policy aimed at collective knowledge creation. The program is designed to support the innovativeness of SME through non-refundable subsidies. The program emphasizes especially the cooperation between corporations and R&D institutions and the formation of networks including the establishment of international linkages.

There are some programs in some Spanish regions that try to foster cooperation between different local actors, but they typically are not supported by a clear strategy to integrate the regional knowledge system into international networks.

Completing incomplete innovative arrangements; starting a dynamic process. Industrial capabilities of regions are characterized by the innovative opportunities of their industrial structures and suppling services. Change and transformation needs to adjust to new demands, markets, production and to explore the potential within the existing innovative arrangements. For instance, in the mid-1990s

Bavaria, in response to its textile crisis, emphasized technology investments especially in ITC and microelectronics. These new industries took advantage of the existing networks for knowledge co-creation and exchange between R&D institutes and firms that were established for the old Bavarian industries. While strong R&D-capabilities are concentrated in Central and Northern Europe (e.g., France, Germany, the Netherlands and Scandinavia), in contrast, more peripheral regions and countries are related as suppliers rather than to be frontrunners in innovation. Consequently, their innovative potential is limited although there are industrial capabilities which provide a basis for transformation. Some Spanish regions have these seminal industrial capabilities such as the Basque Country inthe machine-tool industry, Catalonia in the chemical industry or Madrid in the automotive industry. There are *investments in plants which are ready to be continued and there are competences of the workforce ready to be both updated and advanced*. This includes areas of industrial competences which are employed also at places of leading innovative regions.
This points to the potential and to the need to find missing and matching elements which can make these peripheral arrangements to become complete when it comes to innovation. Building relationships with such additional competences and applying such processes can make incomplete innovative arrangements a location of dynamic processes. The application of research and merging it with existing industrial competences asks for limited budgets only when transforming such arrangements and can make it to become dynamic processes.

Traditional competences and capabilities as a basis of transformation. It is important to become aware that such existing situations contain specific opportunities and potentials when compared with other regions and arrangements. Throughout Europe there are regions and metropolises which have developed as well-known centres for specific industries, products and services. Some areas have built traditions which are continued for long periods of time and managed to match with R&D and new products, other regions are challenged by finding matching opportunities to make their traditional competences a basis for transformation. While such processes of transformation are frequently related with introducing new technologies, changing products or attracting new firms, there are examples such as the ceramic competences in Valencia, the stone carving competences in Galicia or the embroidery and optic competences in Saxony which *clearly indicate such processes can start from the point of exploiting traditional competences when these are matched with new areas of application.* For instance, although some of the regions in East Germany produced products that were either not state of the art or due to prices no longer marketable, there were competences in these areas ready to modernise. The introduction of the system of Applied Science Universities (Fachhochschulen) helped because it was addressed to bring research competences and higher education to less central regions and to interlink such competences with innovation-oriented enterprises of the regions. Thus, 27 Applied Science Universities were founded in Thuringia and Saxony, all East Germany now has 90 (only 49 excluding Berlin) of these institutions of higher education. The orientation varies and often it is oriented in the specific industrial competences of regions and their enterprises or meant to add additional competences which may help for further competences and innovation.

Such *re-modernisation of traditional competences* helps to continue existing structures and capabilities and provide for a sustainable basis of transformation. While this may provide for a perception of far-ranging change and new structures, in fact, based on the application of traditional competences these can turn into new areas of activities. Many new products contain highly traditional roots.

Institutions of applied research and training to provide for innovative transformation. The increasing knowledge-basis of industrial development and new products is related with a growing basis in applied research and more competences are required within the enterprises. While large companies are prepared for research, SMEs and suppliers frequently can neither afford such R&D nor is there a broad body of experience established. Similarly, often a systematic training is not established which helps to cope with the new requirements. *Institutions need to be designed and established to the extent that they can provide for research and training as required within individual situations.* Innovative transformation is widely dependent on availability and exploitation of such competences. For instance, Baden-Württemberg developed these research and training institutions to build these competences in its vast SME landscape with various policy programs, applied science initiatives, and transfer institutions. For example, among industry concerns of obtaining sufficient skilled labour, Baden-Württemberg established in the early 70s proactively dual study programs combining academic with vocational training (till 1995 not recognized as academic degree) and founded in 2009 an applied science university focusing on such programs. Technology transfer is also a key aspect of SME focused policies. One of the largest actors in technology transfer is the Steinbeis Foundation present with approximately 600 transfer offices in Baden-Württemberg mainly serving the SMEs of the state with consulting, engineering, and other services related to enhancing competences of SMEs.

Spanish regions have some kind of applied science institutions (*Institutos de Formación Profesional de Grado Superior*) that have much weaker ties with the industrial sector and weak research capabilities. Some regions in East Germany had after the reunification the same problems with the competences of their industrial sector that most Spanish regions show today. These regions tried to apply the lessons learned from these examples (SME funding, workforce development, public research and applied sciences, technology transfer) in the form of institutions. While for example Thuringia developed these institutions in form of a foundation, Saxony organized the program within its Aufbaubank mostly providing funding for SMEs to work with transfer institutions (e.g., Steinbeis, Fraunhofer).

Consequently, industrial policies need to make appropriate organization and institutions available. A positive and appropriate transfer of research and knowledge needs to suit the situations and fit with the opportunities of the enterprises to modernize their products or engage in new products by learning from such transfers. Similarly, the competences of the workforce need to be increased to prepare for innovative transformation but also to make this process sustainable by providing a foundation for future modernization. Also, management needs to learn and apply successful methods of running such modernized and constantly improving processes. Most Spanish regions suffer when they have to develop new and updated competences, because of the lack of integration and the large divergence between the public and the private innovation systems. Institutions that systematically connect public and private innovation systems are scarce in Spain, and the few existing have not been very effective. The severe bias of Spanish university policies and institutions towards publication rather than innovation, the weak tractor effect of large corporations which b and the limited capability of Spanish industrial SMEs to transform knowledge into business opportunities undermine the overall performance of the innovation process. As shown by the regions in East Germany, publicly funded institutions are important to connect enterprises and applied research, and, in addition, establishing schools of training blue-collar workers and management are important activities of industrial policies.

Matching bottom-up strategies and top-down coordination. Situations vary strongly between different regions or different metropolises. Some, such as Madrid or Catalonia in Spain, may be characterised by the engagement of MNEs while others, such as the Basque Country, Community of Valencia or Bayern may have a cluster of SMEs, in other situations they may be the home of start-ups while others may be the home of suppliers for larger firms. There are also situations where there are clusters of vital collaboration among the firms at the location or with others from elsewhere matching for further development. In addition, *individual industries provide for different activities* (e.g. chemical or pharmaceutical industries are clearly different from mechanical engineering or automobile industries) *as well as new centres of software and computing allow for different activities*. Clearly, strategies need to match these situations and need to be appropriate for industrial competences available or ready for innovative transformation.

Existing problems and competences are best known by people, organisations and institutions at the place. They know about the potentials and capabilities and they know which activities do not match their situations or which will help modernizing the structures.

While doing so, there is of course the question of competing enterprises already well-placed in the markets or whether such strategies may not meet the window of opportunity. While the design of bottom-up strategies is important to take advantage of knowledge starting at the shop-floor level to associations located in the regions or metropolises, in addition, there is top-down coordination and budgeting required for both to allow for collaboration and networking. This helps to increase effectiveness or efficiency and to avoid activities which may not provide for innovative transformation. Smart budgeting and strategic coordination of support are fundamental for sustainable transformation.

A joint trans-European initiative. Europe provides a rich diversity of competences and opportunities. The potential of matching capabilities, potentials and opportunities helps for new processes of development and finding new opportunities to apply the competences. A wider range of potential partners or collaborators provides more opportunities which can be exploited. A limitation on situations within individual countries or regions needs to be avoided. Investments of enterprises and the integration into supply chains is frequently discussed regarding costs and potential profits. This has caused strong competition from countries with low wages and weak regulations which are also located south of the Mediterranean Sea. While seeking opportunities in wage dumping is not a suitable strategy *there are opportunities of improvement of both products and production which can be realized by increasing the knowledge contributed and required*.

When considering trans-European collaborations there is an increasing range of potentials and competences which allow for new applications and products. Countries and regions find more opportunities when knowing about the rich diversities which can be used to complement incomplete innovative arrangements based on existing potentials of traditions in industries and research. Such transformation based on tradition, competences, and new application of R&D can help for innovative transformation in Europe despite the growing competition based on low wages and weak regulations.

When taking these socio-economic opportunities into consideration it is obvious that strategies of innovative transformation are fundamentally related with a labour force which is both ready and prepared to make its contribution to modernizing and strengthening industrial competences. Strategies of industrial policies need to make sure that ideas can be realized in manufacturing and process industries by simultaneously enabling labour to cope with changes. *With similar relevance this includes blue-collar labour as well as engineering, management and research oriented labour in applied science*. Existing areas of competences need to be considered concerning their traditional strength and the potential modernization when matching with new skills and education. Building a competent labour force which covers an increasing range of capabilities allows for sustainable adaptation of transformation, acquiring new knowledge and providing for modernization which helps to avoid risks of narrow specialisation. This process requires a collective effort, and will not be successful if several players are not committed towards its implementation. For instance, the Optics cluster in Jena worked together to successfully create an education and qualification centre (Jena Education Centre) to continuously qualify their current workforce and develop the skills of their future workforce.

Such comprehensive attempts can help establishing an attractive position which is to be arranged between low-cost locations and countries and those which are most advanced in technology, research and manufacturing. *Building a specific range of institutions which complement the potentials and opportunities is important and often widely fundamental.* There is clearly a demand for diversified institution building which corresponds with the existing structures and opportunities. The areas of industries which the enterprises are engaged in, their size and competences, and the demand for research are highly diverse across sectors and even within identical sectors. There might be a demand for particular areas of research findings which needs to be transferred to enterprises which are suppliers to larger firms, while others face the need of particular competences of blue-collar labour or there might be a change in management needed to modernize the firms and link them with wider networks and competences which remained unexplored before. While aiming at sustainable transformation industrial strategies need to be complemented by institutions engaged in modernizing skills and management, applied science and technology transfer. The better these can link up with traditional competences and strengths, the stronger is the effect on socio-economic development and labour markets which provide for the work force required.

An increasing integration into advanced supply chains and value chains will change the context of many activities and rearranges the context of industrial strategies and socio-economic development. A collaboration across industries by matching competences, an increased transfer of knowledge and technology, supplying new markets and meeting new demands, and engaging in new and better products and services allows for a deeper and more attractive integration into European social and economic development while simultaneously re-focusing on activities which help realizing higher values added. Aiming at a more attractive place alongside the value chains based on *developing new and improved competences clearly asks for a supportive industrial policy which is oriented towards collaboration and networking for higher values added*. New and additional partners for development or which might be supplied with high quality products need to be identified and approached based on convincing competences, products and ideas. Such replacement within Europe's socio-economic development can be realized when improving both the skilled and educated labour force and simultaneously building and identifying modernised institutions as important agents of innovative transformation.

While such industrial policies ask for a strong national initiative one needs to take into consideration that the situations are very different when it comes to industrial sectors and regions. Despite the fact of a general need for innovative transformation related with new institutions, competences, and capabilities, clearly, the individual regions need to employ divergent strategies. Industrial policies can help building mixed and flexible structures by supporting divergent opportunities according to industrial sectors and regional situations. Thus, divergent demands for skills and education, institutions and structures need to be considered as well as the opportunities and needs of different industries, services, and size of enterprises. Regions know about their situations and shall be encouraged for more collaboration and participation in networks. This helps to gain additional competences when merging with those from abroad and to make these new opportunities part of the national strategies of transformation. It is important to understand that such a *comprehensive policy can be successful only if the regional situations are identified and exploited for the benefit of innovative transformation of a national situation*.

Table of Contents

List of Tables

List of Figures

Chapter 1

1.1 Introduction

Globalisation and the enlargement of the European economic space towards former Eastern Europe has brought along many changes which differ widely between regions and countries. While some were strong due to their modern and highly innovative industries and firms and based on a continuingly improving highly skilled and trained labour force others have made their way to link up with the European division of labour, but they lack strong and widespread innovative capabilities and the labour required for modernisation as in the innovative centres. Thus, strong regions and countries can build upon their innovative arrangements to continue their position in contrast, those regions and countries which did benefit from their position contributing to supply chains based on cheap labour and weak regulations have to face competition from within the European Community and from competitors based elsewhere, particularly from south of the Mediterranean Sea. Consequently, countries like Spain face challenges from the Balkans and countries such as Morocco or Tunisia based on both even cheaper labour and weaker regulations.

Having passed through a long period of industrialisation and participation in supply chains providing MNEs predominantly from France and Germany there are industrial capabilities which also represent competences and experiences in manufacturing, processes and management. In addition, the plants of MNEs in Spain also refer to a network of suppliers which are, in general, SMEs. These firms may not be widely interrelated with others or engaged in joint activities, nevertheless, they form clusters and a regionalisation of competences. Consequently, when concentrating on modernisation and innovative change in Spain this is a process of transformation, but it cannot be realised by simply introducing new technologies. As the cases of Industry 4.0 and digitisation indicate, many products can be manufactured cheaper by combining advanced technologies with unskilled labour. This would match with situations of countries south of the Mediterranean Sea. Thus, there is the question of how to find a strategy that suits the situation but allows for rather unique arrangements and opportunities which, in addition, can provide a basis for further and sustainable development. Clearly, there is the need for both to widen the scope of development and to reduce the dependency of MNEs and decisions taken abroad – in a way which makes Spain even more interesting as a location of processes of innovation, creativity and industrial development which are based on the competences available and to be arranged.

This relates to transformation that is based on diversities of opportunities and innovation: regions, industries, research institutions, government policies and, last not least, capable labour forces jointly are forming the arrangements which allow for products of higher values added. While economic development is frequently associated with cutting costs and making arrangements more profitable, the examples of Central and Northern Europe indicate that an orientation in products of higher values added allow for successful strategies which allow for profits, income and better working conditions. It is important to see, how fundamental the contribution of skilled and educated labour is. There is a misunderstanding which assumes that labour is always available, while, in contrast, industrial advancement can be realised with an improved labour force only. Improving the capabilities of workers constantly by activities on skills and education allows for better products and higher values added. When taking into consideration that many improvements or innovative contributions are identified while manufacturing or processing it is critically important to aim at skills and education of employees. Such a labour force can contribute to innovative transformation and provide the ideas and creativity required.

Consequently, sustainable transformation and innovation demands for comprehensive and complete strategies which include the labour which helps to translate innovative ideas into valuable products. Such design of industrial policy demands such a full understanding of processes of innovation and change, and, in addition, needs to be aware of the diversities they have to face regarding industries, size of enterprises, traditions of industrial competences, and of opportunities which can be arranged when considering the match of capabilities and competences across industrial sectors. Clearly, chemical and pharmaceutical industries face divergent situations when compared with automobile industries or mechanical engineering. Suppliers also vary a lot between the industries. And so do the demands for skills and education when it comes to a labour force related to the different industrial sectors, enterprises, and products. There are divergent challenges and capabilities allowing for different opportunities and processes of innovative transformation. Frequently, the application of a new materials or the change of processes or manufacturing because of new industrial engineering open new areas of application and thus provide for new markets and higher values added. The re-combination of industrial competences different from previous experiences may provide for creativity as a basis of innovation that is realised in new and advanced products.

Innovation and innovative products are not exclusively related with leading edge research, but new findings can also be made when thinking about new applications or merging existing competences. This provides for a divergent area of innovation which explicitly includes to think about the value of traditional competences and existing capabilities. When comparing such situations with European countries and regions leading in areas of top research and its application in high tech products, there are little opportunities for Spain to transform into such arrangements. The long period of techno-industrial development has established a system of applied research, highly skilled and educated labour, institutions to support innovation and, last not least an innovative workforce. While attempting to copy this system would introduce an almost complete change of the system which takes long and may not help to cope with the current challenges, different from that a modernisation of the system which helps to transform the current situation to suit with changing contexts is manageable.

There was a realisation of change of institutions and a mix of enterprises of different size as well as technological modernisation and introducing new forms of management, organisation and training which has taken place since the German unification three decades ago. Similarly, East Germany and its individual regions were squeezed between low cost and weak regulation countries and regions on one side and those of similar production costs but related with more modern and higher value products. Although the divergent structures were continued the modernisation of the innovative arrangements helped to establish new and appropriate structures which are widely based on traditional competences complemented by new institutions and aiming at modernised industries based on an up-to date skilled and educated labour force. This indicates based on creativity there are opportunities of innovative transformation providing for sustainable industrial development. New technologies can match traditional competences when applied, merged, or organised in a synergetic mode. It also points out clearly that such competences are concentrated at particular regions or locations.

The individual capabilities, competences and structures of regions indicate their specificity and thus show wide ranges of opportunities, conditions, and diversities of innovation. The multitude of situations and their arrangements, the different capabilities and competences, and the industries and labour forces which contain these potentials are forming the diversities, which in the end build a countries strength and flexibility of opportunities. Consequently, regions and industries are to sides of the same coin: industries are organised in chains and the suppliers contribute different products from different regions, and due to traditions and competences regions are characterised by their industrial structures and capable labour forces. But modern industries demand for more and well-known innovative regions are able to further elements of the arrangements, such as continuing training, applied research, innovative institutions, and their awareness of ongoing processes elsewhere. It is important to understand that modernisation, innovation, and transformation are continuous processes which may be more or less intensive and public awareness might differ, but, in principle, they do not end. These processes are fundamentally continuous.

Consequently, these highly diverse regional situations also demand for different arrangements as well as the flexibility to allow for such differences is important to take advantage of a regional situation. As the example of transformation and complementation of structures in East Germany indicates the elements missing or insufficient in a region are different. There might be more or less demand for applied research, regional or inter-regional networking may vary, there might be important MNEs as relevant for a region or clusters of SMEs, and the modernisation of technological and industrial structures and of manufacturing may have different impact on the training of the labour force or additional university educated personnel required. It is important to notice that there are already investments in production facilities and competences of the labour force which one can build upon. Clearly, the complementation of such arrangements is different and needs to be so because of the individual situations which exist.

The situations are highly diverse, and people of a region know best about their potential, but they may need some additional competences to make the arrangements to become complete and to flourish. Such complementary capabilities, increasingly, are to be found outside of the own region and their application requires a thinking out of the box. The openness of doing something new with the competences already known is important, because it allows for both new ideas and to learn more about how to combine traditional competences with new opportunities and technologies. The diversities of innovative transformation demands for a bottom-up contributions which helps to realise the general aims of national policies and may benefit from top-down funding as approved. Consequently, regional strategies and attempts are adding up to diversified national processes of innovative transformation which also needs to be embedded within the European situation by searching for a kind of uniqueness of the new arrangements. In doing so, existing networks of suppliers and collaboration can be continued while changing the level of the products. In addition, new markets can be entered with new products.

When taking advantage of the wide range of activities spending public money most efficient and effectively allows for smart budgeting which supports projects and approaches which need some additional money to transform the existing situations. These are based on already realised investments in equipment and competent labour which can also be complemented by appropriate institutions and inter-regional collaboration. Again, the individual arrangements to be met in a region play a critical role and always indicate the importance appropriate policies and strategies. Innovative transformation, consequently, covers many dimensions and includes stakeholders as well as different levels of government.

Researching opportunities of innovative transformation covers many relevant aspects and thus, this report covers the integration of Spain into European network of supply and trade, refers to individual regions in Spain and in West and East Germany, takes into consideration the role of institutions for innovation and, thus, comes to a discussion of innovative arrangements as well as to facing incomplete innovative arrangements. These particular Spanish problems and opportunities are discussed and the challenge of strategies and policies which need to be bottom-up strategy finding and top-down approval of appropriate funding. In the light of the diversities of the situations and the divergencies of innovative transformation in the regions a search for strategies is presented. This may provide a basis for further discussion and improvement. We follow the idea of how to make innovative transformation sustainable by short-term activities which may help for long-term development aiming at higher values added.

1.2 Process of Industrial Transformation: Context and Basic Elements

During recent decades, but particularly in recent years, the global situation of manufacturing, services, and the import and export of goods and services have changed. Similarly, the countries contributing to global processes and providing the locations for producing goods are forming new and constantly changing situations. There are new providers of mass-products and others have upgraded their situation during such processes. Consequently, the situation of European countries within a global economy and of their position within the European division of labour is characterized by change and new challenges. At least such fundamental changes were twice to be identified: the integration of the Iberian countries of Spain and Portugal into the European Union in 1986 and the changes in Europe in 1990 which did bring new members from former Eastern Europe to the European Union.

While there was international division of labour and an emerging European economic space in the 1980s the intra-European situation changed when the countries from Eastern central Europe and the Southern Balkan during the 1990s aimed at joining the EU and became members in 2004 and 2007. This period is characterized by major changes globally which had different impacts within Europe. Industries became heavily characterized by new breakthroughs in science and research and new technologies accordingly. Microelectronics, biotechnology, new materials, and most recently digitization and Industry 4.0 are characterizing these changes. New economic players in the global economy also were ready to enter markets with their products. China as the manufacturer for the world and India as another awakening power with strong expertise in services are most influential. Furthermore, these periods are also characterized by discussions on emerging economies, especially the BRIC-countries, and impressive increases in research and development expenditures outside of the traditional centres of expertise and science in North America and Europe.

Leading European countries became aware of both the challenges and opportunities related to these processes which until today allow them to enter and expand in new markets and those of potential competitors of their industries with their products. Mechanical engineering developed strongly in Taiwan, computers and electronics developed strongly in Korea, India developed software competencies, and most recently artificial intelligence is well underway in China. There are many more examples to be listed which indicate these new collaborators and competitors that are in or are entering competition with the strong and biggest European economies based in France, and Germany and competences in Scandinavia, Italy, The Netherlands, and Switzerland. While these countries, their Islands of Innovation, and their enterprises widely managed to adapt to new challenges and change, other locations increasingly had trouble to cope with changing situations.

The term of Islands of Innovation was formed and empirically identified in 1991 alongside with the EU research project Archipelago Europe – Islands of Innovation (FAST FOP 242, Brussels 1992) by Ulrich Hilpert which compared the EU and the US. Based the cases of biotechnology, artificial intelligence, aircraft industries, and textile industries 27 Islands of Innovation were identified. These did concentrate about 70 to 75 per cent of the national research funding in these areas. When the cases in Biotechnology were again investigated more than a quarter of a century later the same Islands of innovation did continue their dominant role, but the other regions could increase the funding received many times higher. With regard to collaboration which transfers the leading-edge knowledge Islands of Innovation of course did exchange these finding through collaboration, but the other regions did benefit from the Islands because the recruited personnel from these institutions and did benefit from the continuation of collaboration by the academics and researchers recruited (Hilpert 2013). In science-based industries these Islands continue to play an outstanding role which can also be considered for application elsewhere.

Locations in Spain and Portugal, which experienced rapid economic development after joining the EU, found themselves in a situation where they met competition from Eastern Central Europe and the Balkan. Lower wages made manufacturing in some of these countries economically more attractive and the skilled blue-collar labour in Poland, Czechia, or Hungary enabled these new locations to participate in European supply chains. The system of blue-collar training in particular together with some already established industries put them into a favourable situation in regards to processes of upgrading their contribution alongside the supply chains. This has squeezed many locations in Southern Europe and particular in Spain into a difficult situation characterized by declining manufacturing employment, which needs to be managed today. Competition based on low labour cost attractive for multinational enterprises is not an option for Spain as long as the countries of the Balkan are still more attractive by costs and regulatory environment. The production of more advanced products may be a way forward circumventing cost competition – but the ability to upgrade manufacturing processes and competencies to produce more advanced products requires a transformation of the industry and labour force but also of industrial, research and development, and other government policies.

In addition, regions are within different situations when they adjust to this challenge. Their divergences in industrial structures, labour force and their potentials in R&D are forming rather individual situations. Established industrial competences may create situations which allow for the exploitation of new technologies or such opportunities may not match with the established competences. Similarly, skilled and educated labour needs to match both industrial competences and technological opportunities. A deficit in such labour will not allow regions and industries to exploit such opportunities although the industries in general may be complementary to such new available technologies. And, last but not least, research findings may have a positive impact on industrial development only if the established competences and the labour force available are capable to make use of those findings by incorporating/transferring them into their production or product development processes. Clearly, this constitutes a multi-dimensional situation in which various elements need to match with each other to promote development. In addition, these situations need to suit the future market situation when the products are ready to be sold. Products need to become available when there is a demand and when the market is not already divided among other enterprises which offer similar products and have already established closer relationships with consumers.

Thus, the diversities among the opportunities which exist for the different locations also need to be understood under the condition of time-to-market and activities initiated elsewhere. There are enterprises and industrial competences which need to be considered within Europe and globally. Improvement of value added and upgrading the position in supply chains or value chains is a dynamic process which is constantly challenged by competing activities and new technological opportunities. Those need to match the situations and opportunities formed from a region's industrial competence, the labour force available and the research capabilities to support the constant transformation. The situation at Islands of Innovation, usually, is characterized by the outstanding techno-industrial competences, the highly skilled and educated labour force and their internationally highly recognized research capabilities. While research structures can be established based on attractive offers to academics and modernization of manufacturing equipment can be arranged by strong subsidies, due to the time for education and training it takes much longer to establish a highly skilled and educated labour force. Occasionally, there are cases of new Islands of Innovation associated with new technological breakthroughs (e.g., when micro-electronics or biotechnology newly became available). In addition, there are centres of expertise which link up with existing competences and match those with new technologies. These locations take advantage of diversities of innovation or development to form situations which are rather unique and allow them to enter supply chains or value chains. There incomplete innovative arrangements are matched with new technologies and provide opportunities for higher value-added products.

Government policies can be highly effective when such situations are arranged and meet a market context that is not challenged by already existing providers for such markets. In contrast, specific situations can provide for particular techno-industrial solutions which will be absorbed within the supply chains, but on a higher and economically more attractive level. These may also supply well paid jobs and sustainable development when the situation allows industries to keep their products innovative by constantly improving those. Consequently, although it might be difficult in existing markets and supply chains, there are opportunities for innovative transformation when the divergences of situations in regions, locations, and metropolises are taken into account. It is fundamentally important to understand the European situation as a socio-economic space which is extremely interlinked and characterized by the innovative strength which is contained in its chains. The final OEMs are designing their products and are driving innovation, but they are also forming the end of a chain where innovation is already contributed or can be contributed by the individual supplier. The rich diversities of the suppliers allow for sustainable integration into European industrial development, and their existing competences as well as complementing their incomplete innovative arrangements provides diversities of innovative transformation which meet existing opportunities of regions or metropolises. Thus, copying what was successful elsewhere can have a positive impact, but it can also mean to ignore the existing potential of a place. These potentials can create highly specific and individual contributions to an innovative European industrial development which includes competences and opportunities elsewhere and integrates them along supply chains and value chains.

Table 1: Areas of innovative Transformation

Areas of innovative transformation

Dimension	*Subject*	*opportunities and problems*
MNEs	key industries • Vehicle • Machinery • Chemistry • Pharmaceuticals • Agro-industry	*providing potential and capability* of innovation by manufacturing and *main drivers* of change due to their important position with the industrial structure
SMEs	clusters and suppliers	*lacking capabilities* trans-sectoral networks trans-regional exchange of competences
Labour force	skills training education	*lacking* modernization of human capital systematic upgrade

Institutions	R & D training skills matching competences	*lacking* close relationship with enterprises concerning their potentials and the workforce for training on the job: knowledge about competences to complement incomplete innovative arrangements.
Governments and levels of administration	national regional	*lacking* intergovernmental collaboration complementary action; appropriate programmes enabling existing capabilities; short-term and long-term perspectives of transformation

In general:

- Synergy and collaboration required
- Help competences to be exploited in new areas of economic activity
- Understand the innovative potential based on the existing capabilities, knowledge and skills
- Complement existing structures by additional knowledge by trans-regional transfer or even from abroad
- Strengthen the capabilities labour force as a major source of innovative transformation towards socio-economic development
- Understand the diversities of regions, their capabilities and arrangements, and their individual strategies for innovative transformation

1.3 The current situation in Europe: Chains and Locations

Europe has developed as a widely integrated economic space. Goods and services are provided throughout the European Union and the process has clearly intensified. Although national governments continue designing individual policies for their countries, they need to consider the level of integration within the European economic development. Industries also take advantage of different competences of different countries and individual locations. Highly developed transportation capabilities and established infrastructure to transfer information allow for the current level of integration into the intra-European division of labour. The continuation and intensification of such opportunities will boost this process even more. Simultaneously, for the benefit of the quality of the products and the profits realised European multinational enterprises (MNEs) select the economically most suitable locations to take advantage of regional competences, skills to provide manufacturing and high-quality services, and regulations and production costs.

The networks presenting export and imports of goods are EU centric and display Export and Imports of EU countries in 2018. The nodes in the network represent countries, the links export or import ties associated with a value in Euro. The networks display the top 80% of EU exports and imports measured in value of goods. The centrality of the network is based on the value in Euro of the links connecting nodes. The algorithm visualizes the networks automatically and arranges the most central countries in the centre of the circle – the further out a country lies, the less central is its position in the overall network; this is independent from geographical distance and approximates closeness of countries in trade relationships measured in the value of exchanged goods. Additionally the algorithm attempts to collocate countries with strong ties within the network. This is characterized by closeness in the graph and many connecting lines between closely related countries.

Supply chains are established to contribute manufactured parts from different places in Europe. These are complemented by value chains which give particular attention to the quality of critical parts of the final product. Since those parts can add particularly high value to the final product their quality, innovative relevance, supply reliability, and potential of further advancement and innovation are of importance and their production is concentrated at a small number of locations which meet these requirements. Consequently, the opportunities of locations and countries to contribute to such highly integrated supply chains and value chains are rather diverse and depend on the existing capabilities. These situations and the embeddedness in the different industries and chains are forming the individual context which allows for specific arrangements and processes of further development. The constant improvement of products and the competition they meet in the markets induces a permanent process of keeping locations attractive for contributions alongside the chains.

Locations of pure assembly of parts or manufacturing of low complexity components are always under the stress of being cost efficient. In contrast, a change of locations or replacement of contributors to the chains is difficult and can become critical when it refers to capabilities of research and design, manufacturing complex products needing a highly skilled and educated workforces, and those proving a high reliability in providing essential parts. Consequently, the most advanced countries referring to innovative industries and providing the basis for research and development as well as for Islands of Innovation will play a particularly important role for the development of the European economic space. This allows for value chains based on knowledge intensive products which also demand a supply of components of lesser value required to assemble the final product. Thus, the two layers of networks and chains are interrelated and provide the basis for the integration into the European economic space. The divergent situations and traditions in industry and research also provide for dynamic changes, in contribution, modernisation of products or new linkages in the networks.

Consequently, export or import of goods indicate existing contributions to networks and chains in terms of competences, quality, production cost and reliability of supply. Of course, industries are different with regard to building chains and networks. Some products refer to extraordinary many parts (e.g., automobile industries, aircraft, and mechanical engineering) while others do not show four tier supply chains (e.g., chemicals, pharmaceuticals, or food processing). Thus, export and imports show how countries, and their particular regions or metropolises, are embedded within the European division of labour. The contribution as well as the intensity of imports and exports refer to particular opportunities and competences which exist. These can refer to a nexus of costs and capabilities to manufacture particular parts, and these can also be based on quality of manufacturing, reliability, competences in research and design etc. Thus, there are competences available and often such competences are improved, and they allow upgrading the contribution to the networks and generating higher values added. Consequently, networks of exports and imports also show the potential of manufacturing and competences to modernise or transform the existing capabilities.

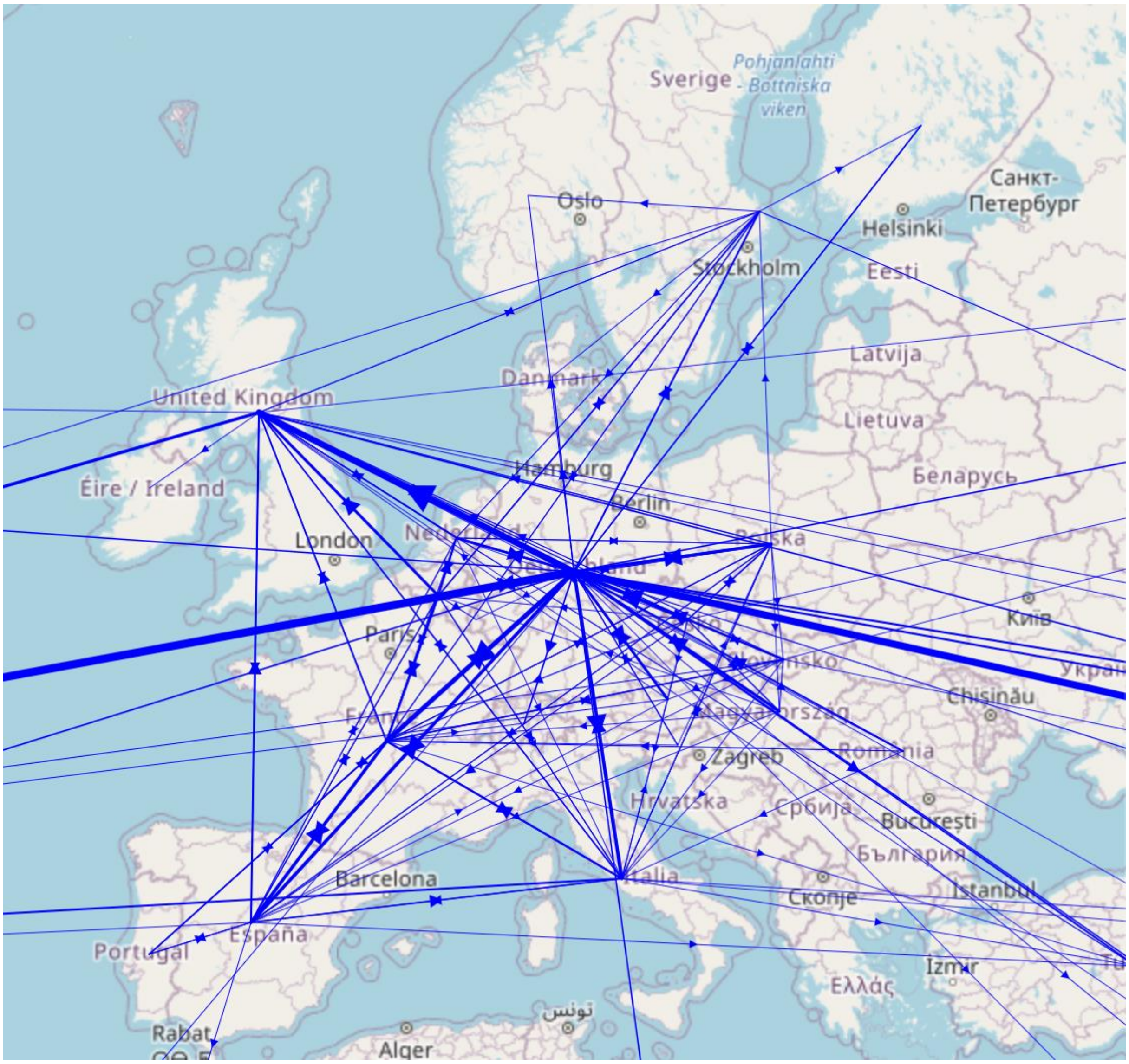

Figure 1: Vehicle Industry Exports of EU Countries in 2018

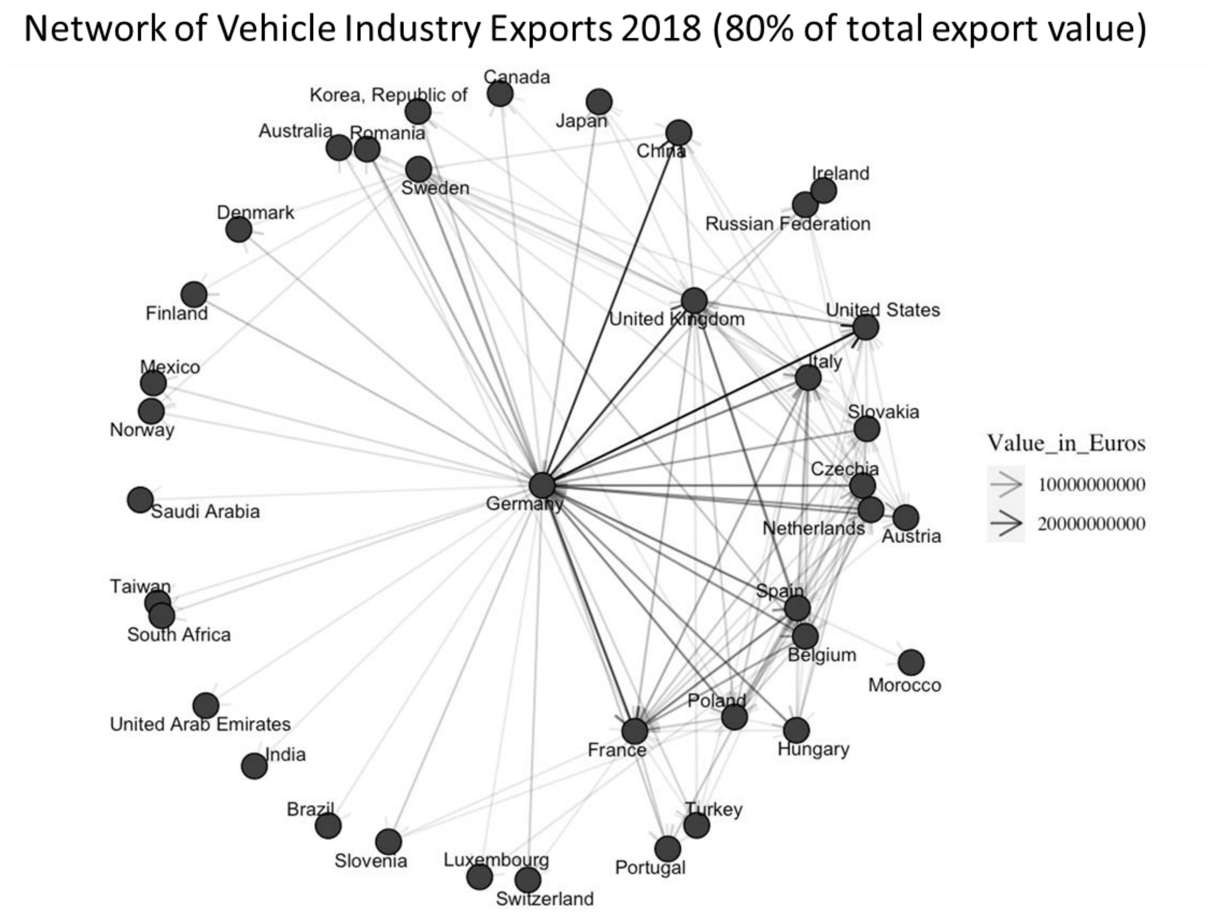

Figure 2: Network of Vehicle Industry Exports of EU Countries in 2018

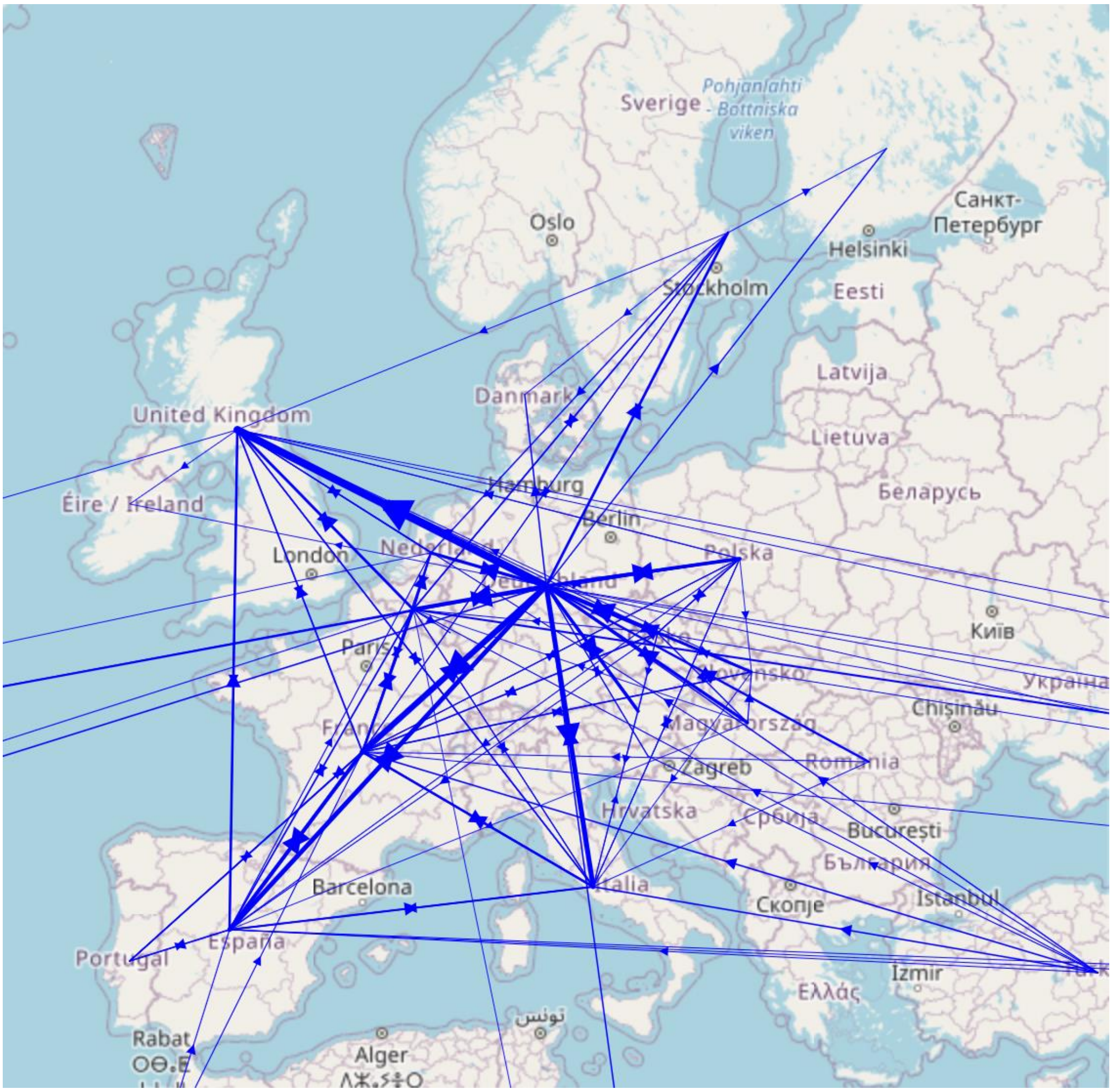

Figure 3: Vehicle Industry Imports of EU Countries in 2018

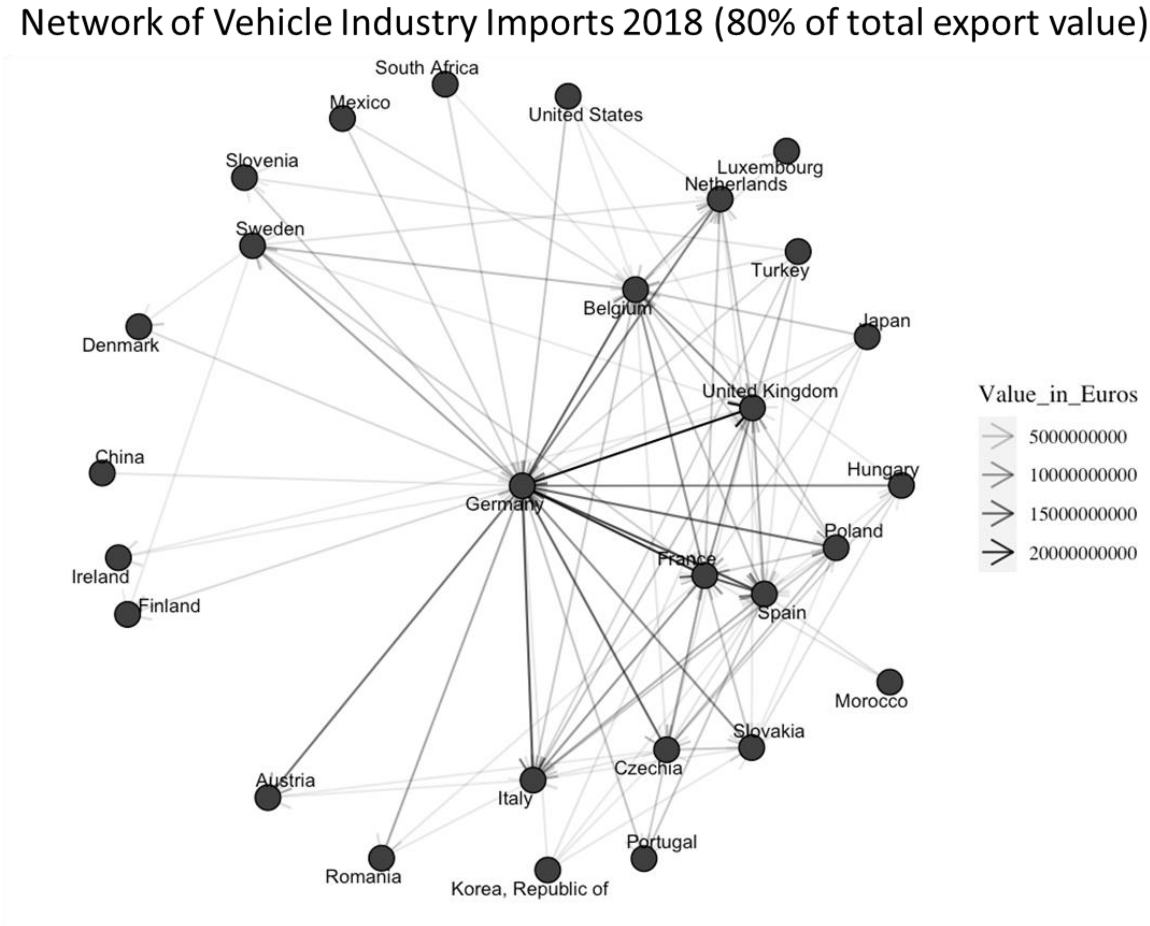

Figure 4: Network of Vehicle Industry Imports of EU Countries in 2018

The European automobile industry is dominated by a small number of OEMs located in France and Germany as well as Italy (Fiat) (see Figure 1-4). They own a number of brands which cater different markets and tastes but main components like engines, gear boxes, and many other parts are widely converging. Based on different competences and production costs these are produced at different places in different countries which is expressed in exports and imports. Looking at data on the overall vehicle industries (including automotive but also other motorized vehicles) in Europe these are dominated by countries with strong automotive industries. In addition to the home countries of the MNEs, Spain, the Netherlands, and Belgium are contributing particularly strong to these industries. Clearly, the countries with the strongest economies referring to capable industries are forming the centre of vehicle industries when it comes to providing vehicles, parts, and components measured as share at overall EU exports in the industry (Germany (34.2%), Spain (7.6%), France 7.5%), UK (7%), Belgium (5.5%, Italy (5.4%)). Consequently, Germany, France, and Italy are important nodes in the network as well as Spain, the United Kingdom, and Belgium. A similar picture emerges, when it comes to vehicle imports (Germany (20.7%), UK (11.1%), France (11%), Belgium (8.5%), Spain (7.8%), and Italy (7.6%)) which also considers parts and components as well as vehicles. This shows the strong position of countries with a strong automobile industry (e.g., Germany, France). Vehicles from other countries are less intensively imported as these brands are frequently produced for the home markets in Eastern and southern Europe. Thus, the export data show a significant share of delivery of parts to the countries with the strong industries (see Fig. 5-6). This shows the strong improvement of exports from countries such as Poland and the Czech Republic which can also rely on a rather skilled labour force. In regards to less complex components Southern European countries (e.g., Spain and Portugal) have to face the competition of countries from South-Eastern Europe (e.g., Rumania, Hungary). Given the long duration of participation in supply chains from Southern Europe industries realized over proportional growth based on their relationship with the European core countries (see Fig. temporal changes of intercountry vehicle imports and exports). This also indicates that the existing supply chains and the structures of import and export are based on attractive competences and production costs which were established long ago and continue until today. Such situations and positions within the European system provide the basis for transformation and modernisation.

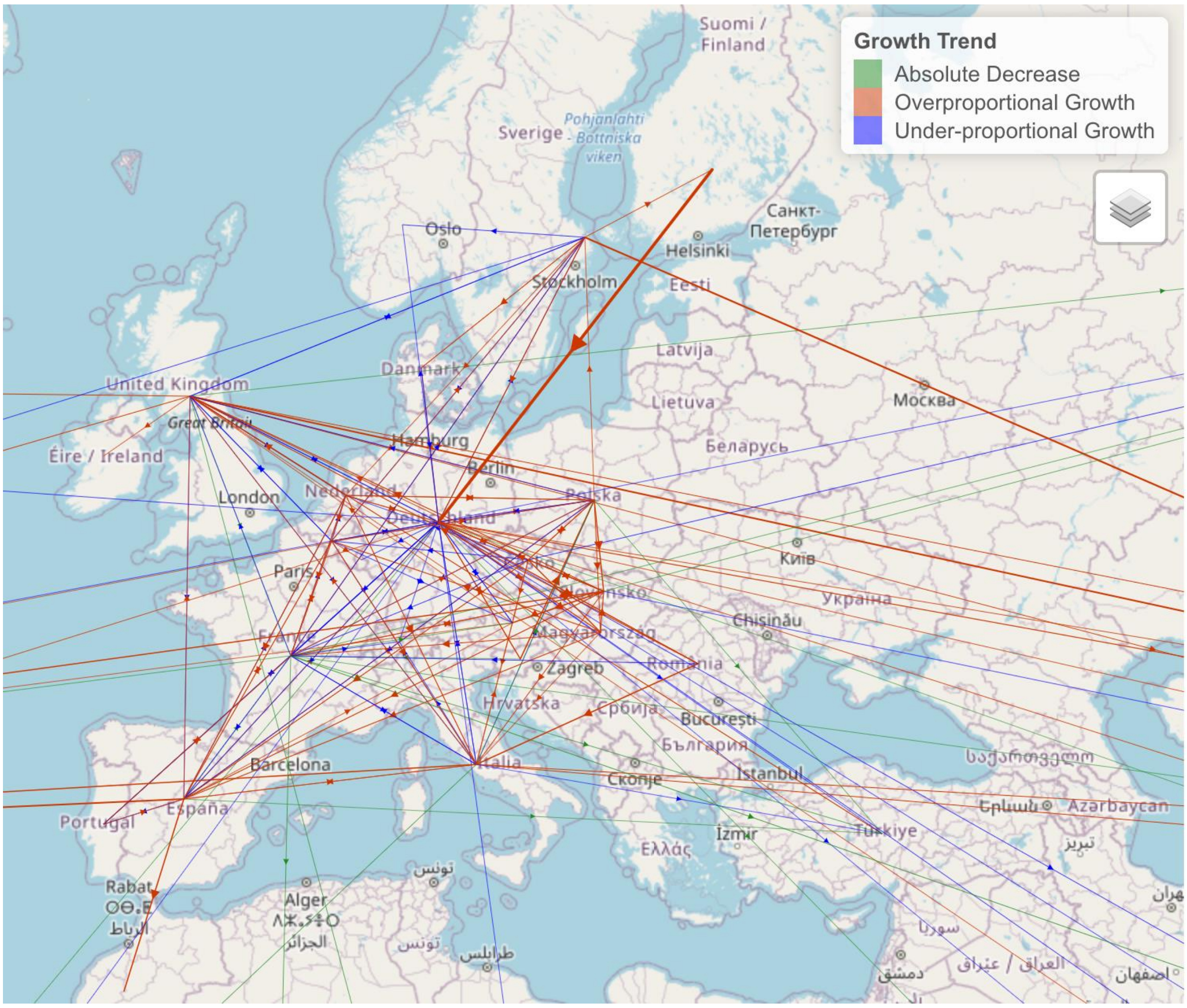

Figure 5: Temporal Trends of Vehicle Industry Exports of EU Countries 2010-2018

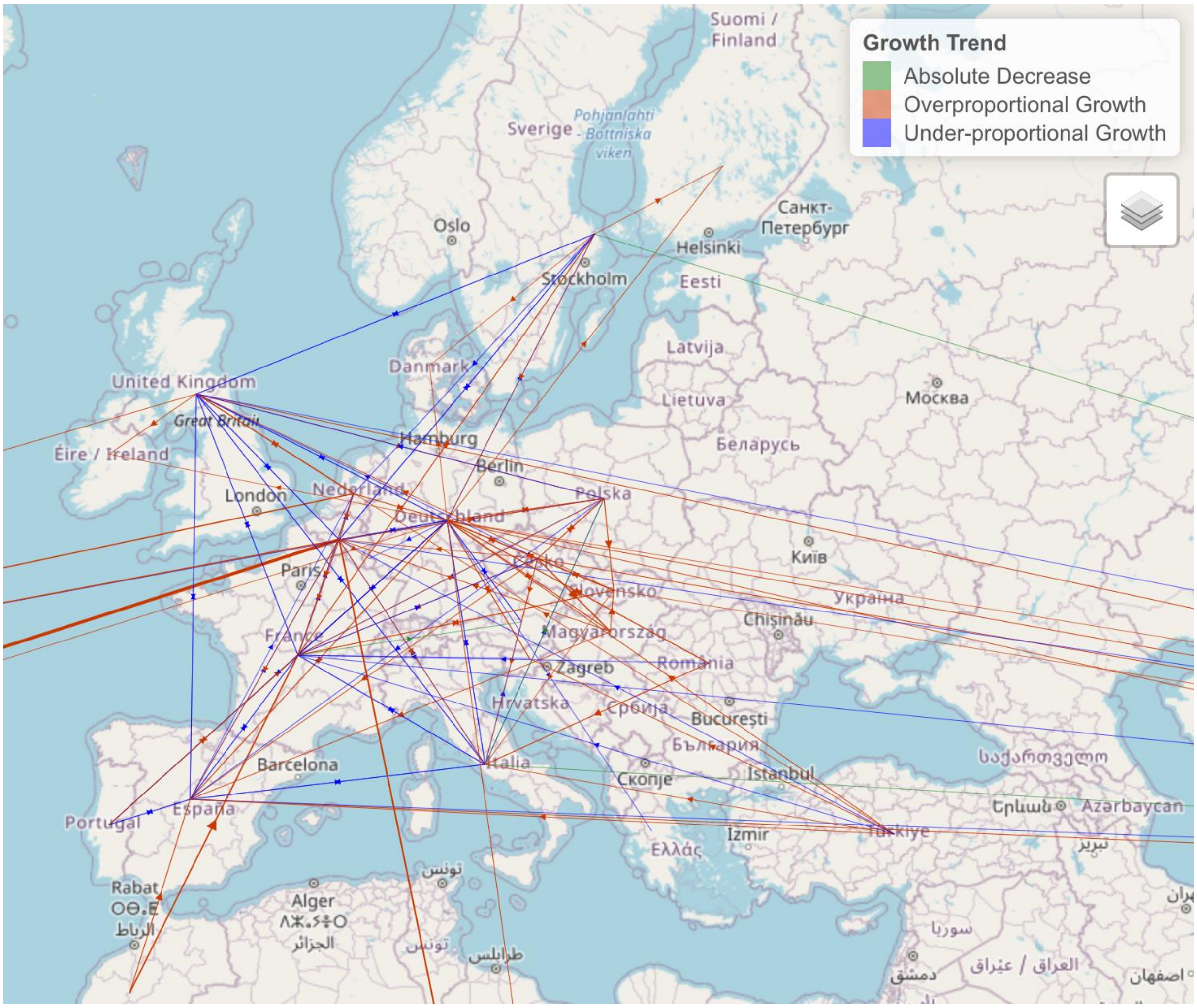

Figure 6: Temporal Trends of Vehicle Industry Imports of EU Countries 2010-2018

Figure 7: Machinery Industry Exports of EU Countries in 2018

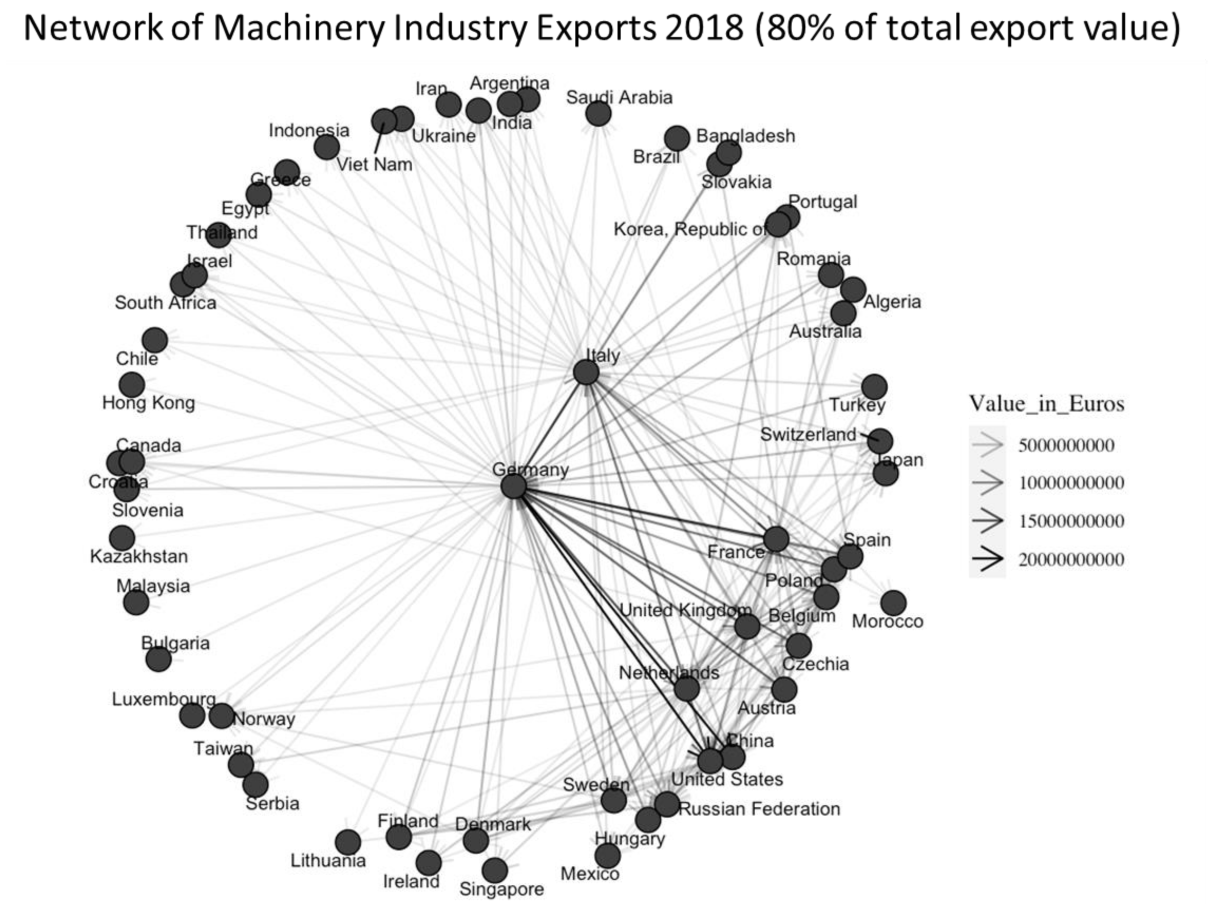

Figure 8: Network of Machinery Industry Exports of EU Countries in 2018

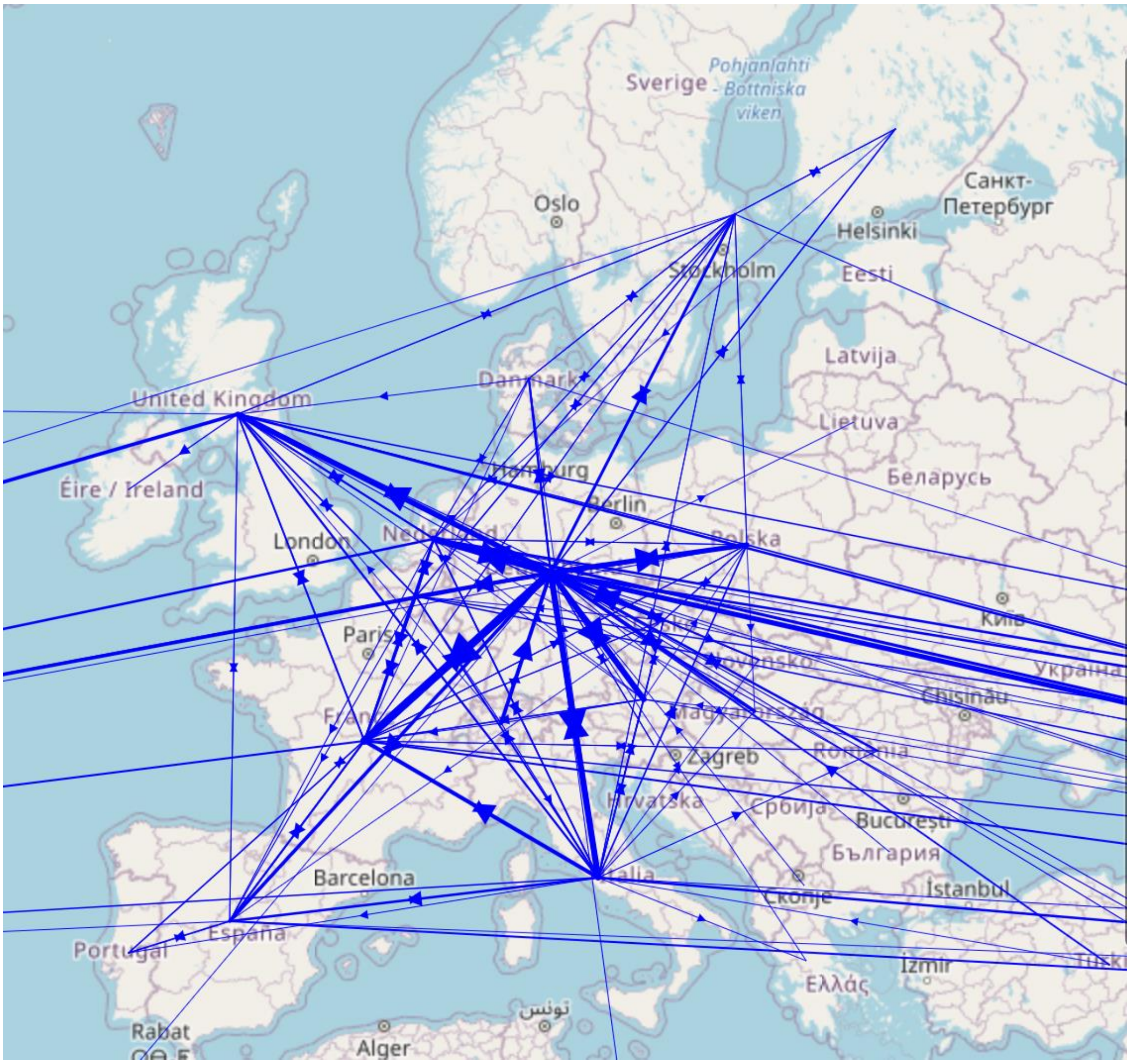

Figure 9: Machinery Industry Imports of EU Countries in 2018

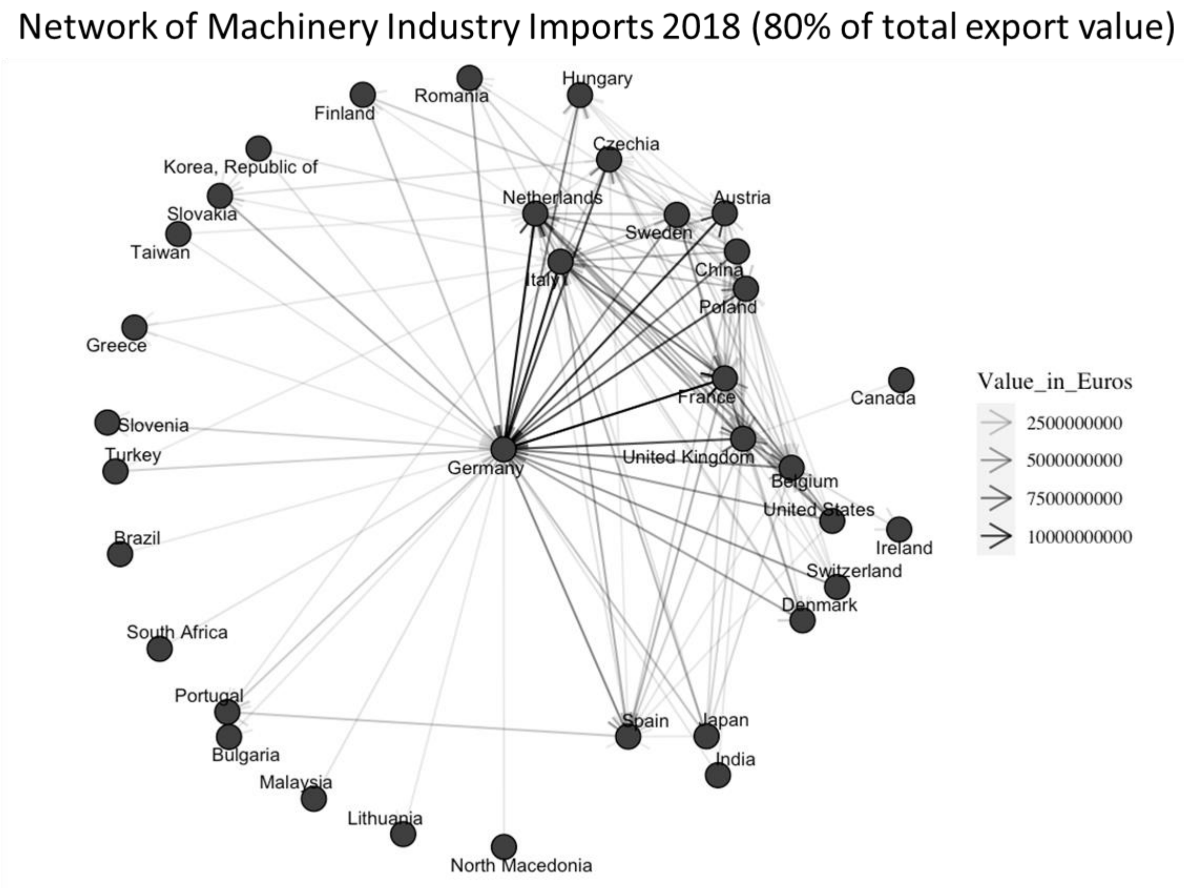

Figure 10: Network of Machinery Industry Imports of EU Countries in 2018

Similarly, the networks in machinery are highly developed. Consequently, they reach very far and take advantage of different competences and production costs (see Fig. 7 and 9). Simultaneously, there is a clear focus on Europe's important centres in Germany, and Italy complemented by France, the Netherlands and Britain. Chains and trade are directed to regions in these countries from suppliers which are based predominantly in other European countries such as Spain and Belgium (see Fig. 7-8; Germany (33.5%), Italy (14.3%), Netherlands (9%), France (6.6%), UK (6%), Belgium). When imports are taken into account, this network is continued also by the supply of parts and components, but, in addition, it shows the demand for final products putting countries such as Sweden, Poland, the Czech Republic, Austria, Belgium and Hungary closer to the network (see Fig. 9-10; Germany (21.3%), France (10.9%), UK (8.8%), Netherlands (8.8%), Italy (7.6%), Belgium (5.7%)). During the period of 2010 to 2018 there was also an over proportional increase of trade within Europe with a strong concentration on the exchange between Germany and Italy and a decrease with regard to many non-EU Countries (see Fig. 11-12). The wide inclusion of many countries and regions when it comes to final products, parts and components in machinery industries also highlight the opportunities to include a large diversity of competences and different production costs in these industries. The opportunities become characterized as a location of particular products or semi-finished products allow to contribute to these networks across Europe. Even SMEs can find their ways to be linked to these networks by individual products.

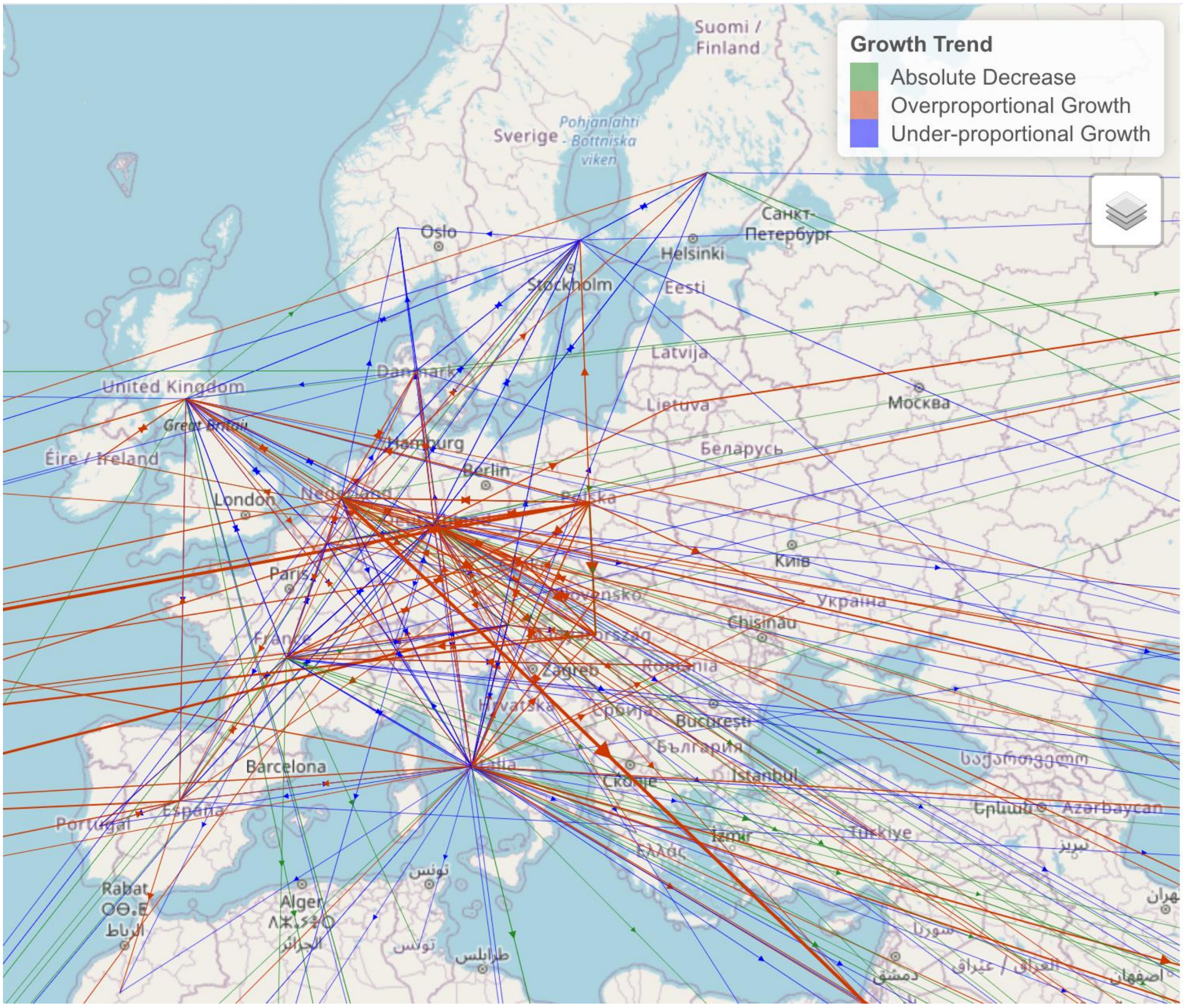

Figure 11: Temporal Trends of Machinery Industry Exports of EU Countries 2010-2018

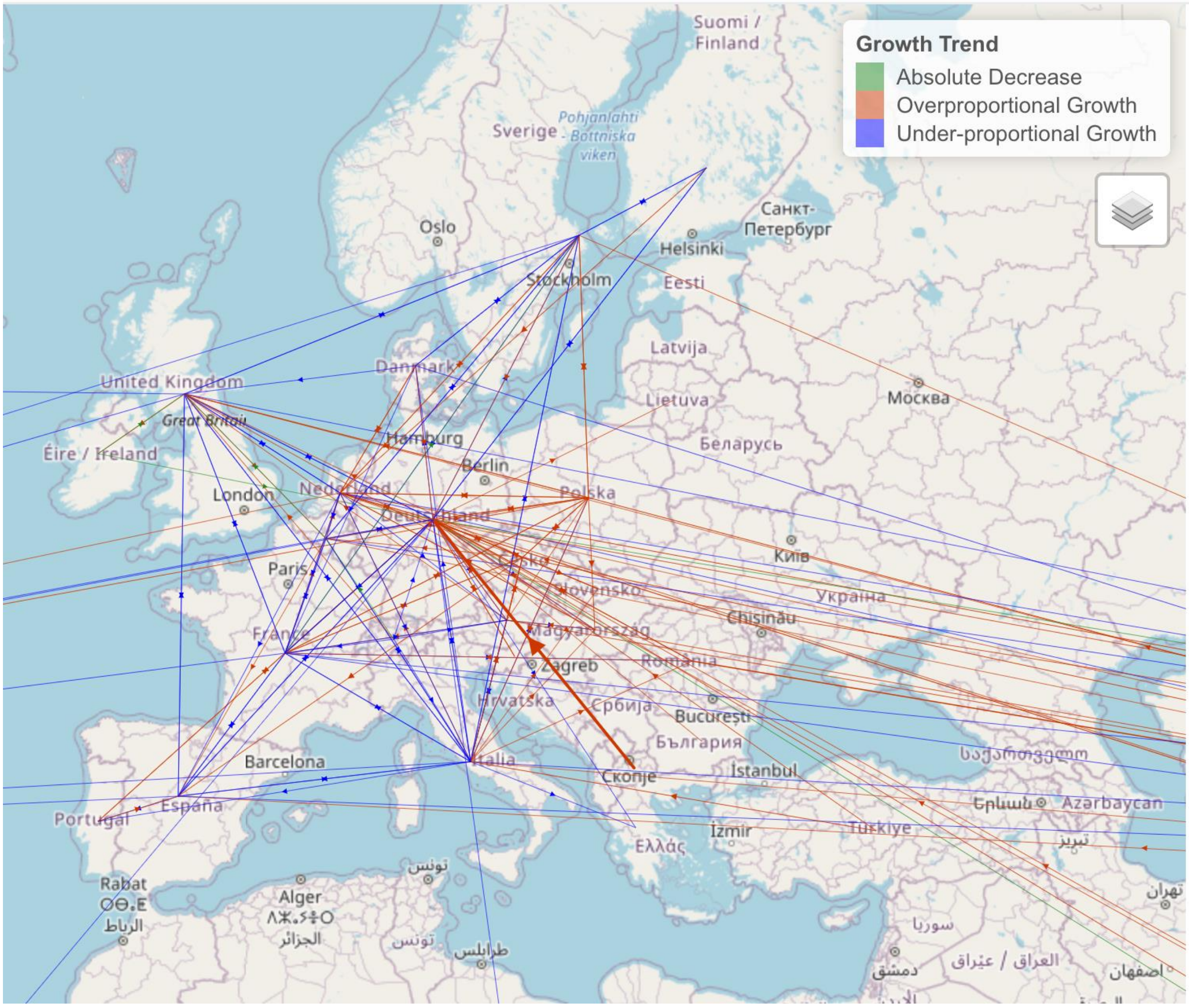

Figure 12: Temporal Trends of Machinery Industry Imports of EU Countries 2010-2018

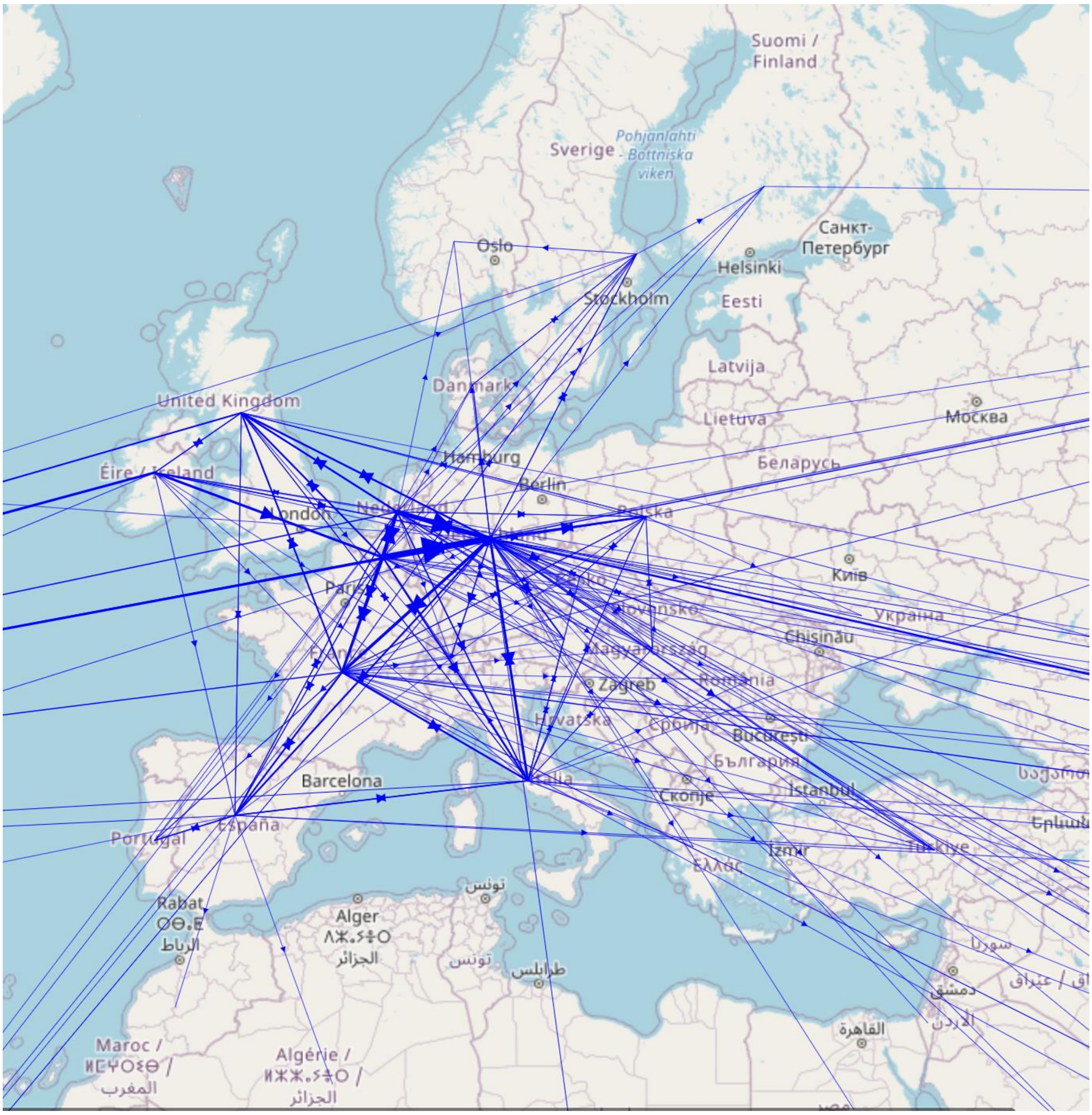

Figure 13: Chemical Industry Exports of EU Countries in 2018

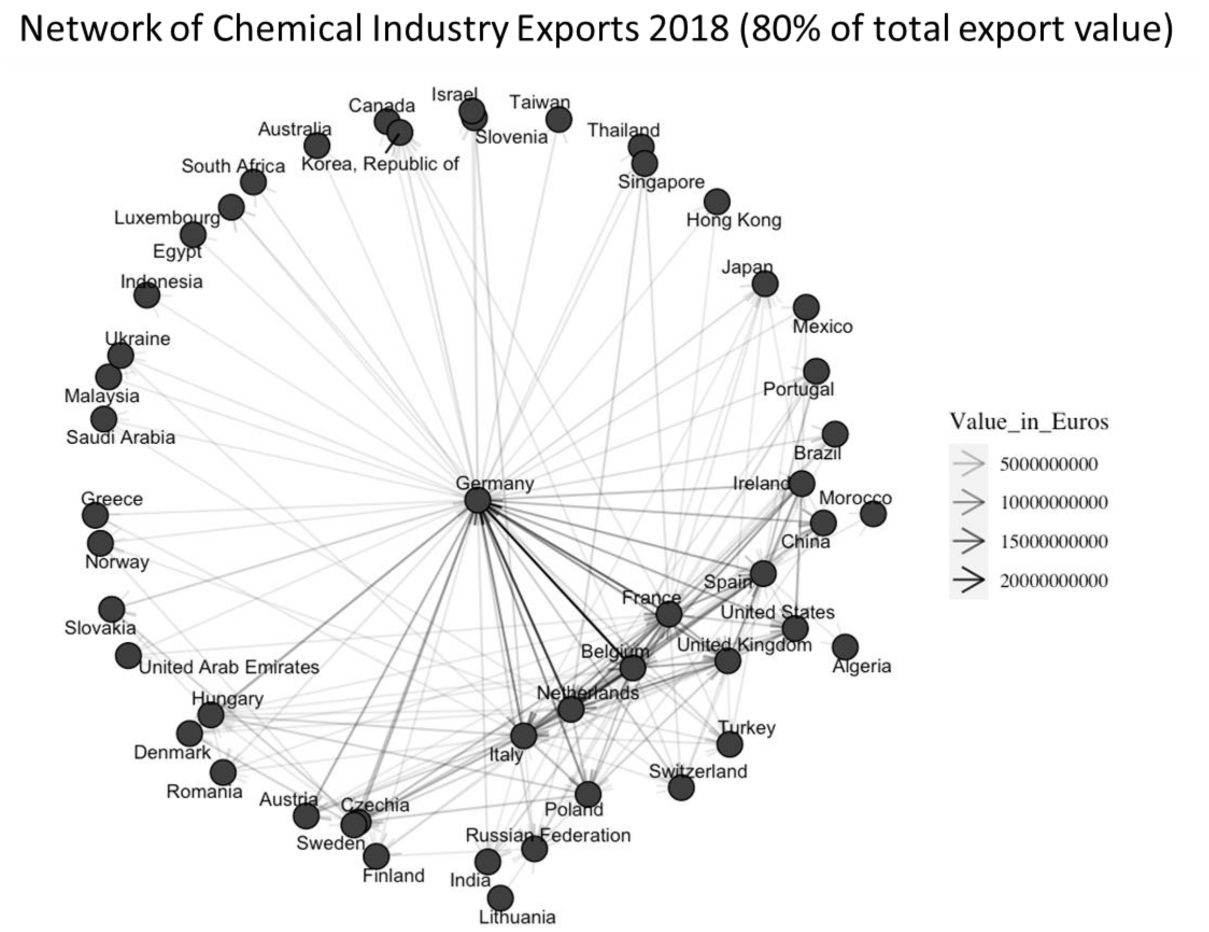

Figure 14: Network of Chemical Industry Exports of EU Countries in 2018

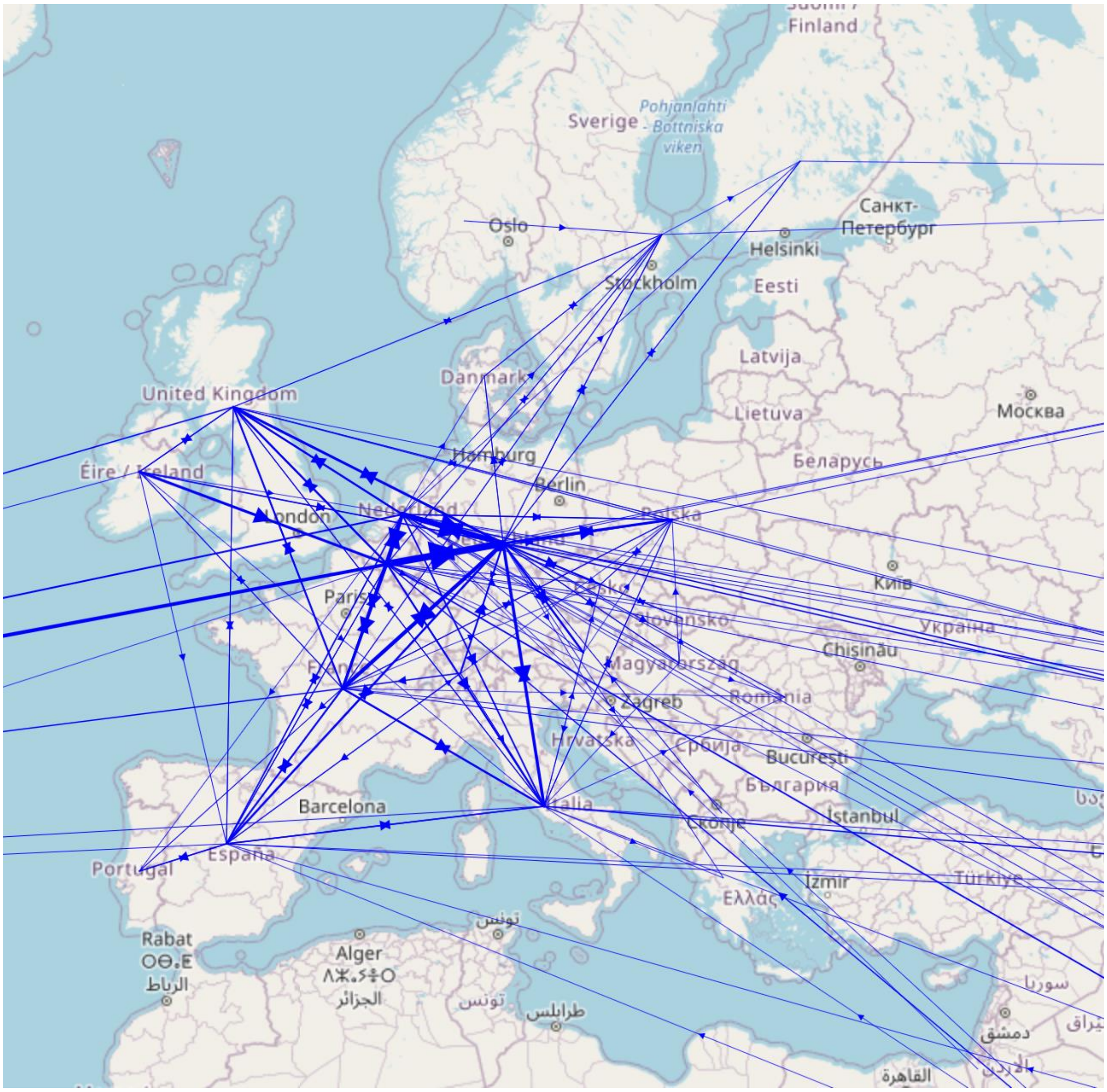

Figure 15: Chemical Industry Imports of EU Countries in 2018

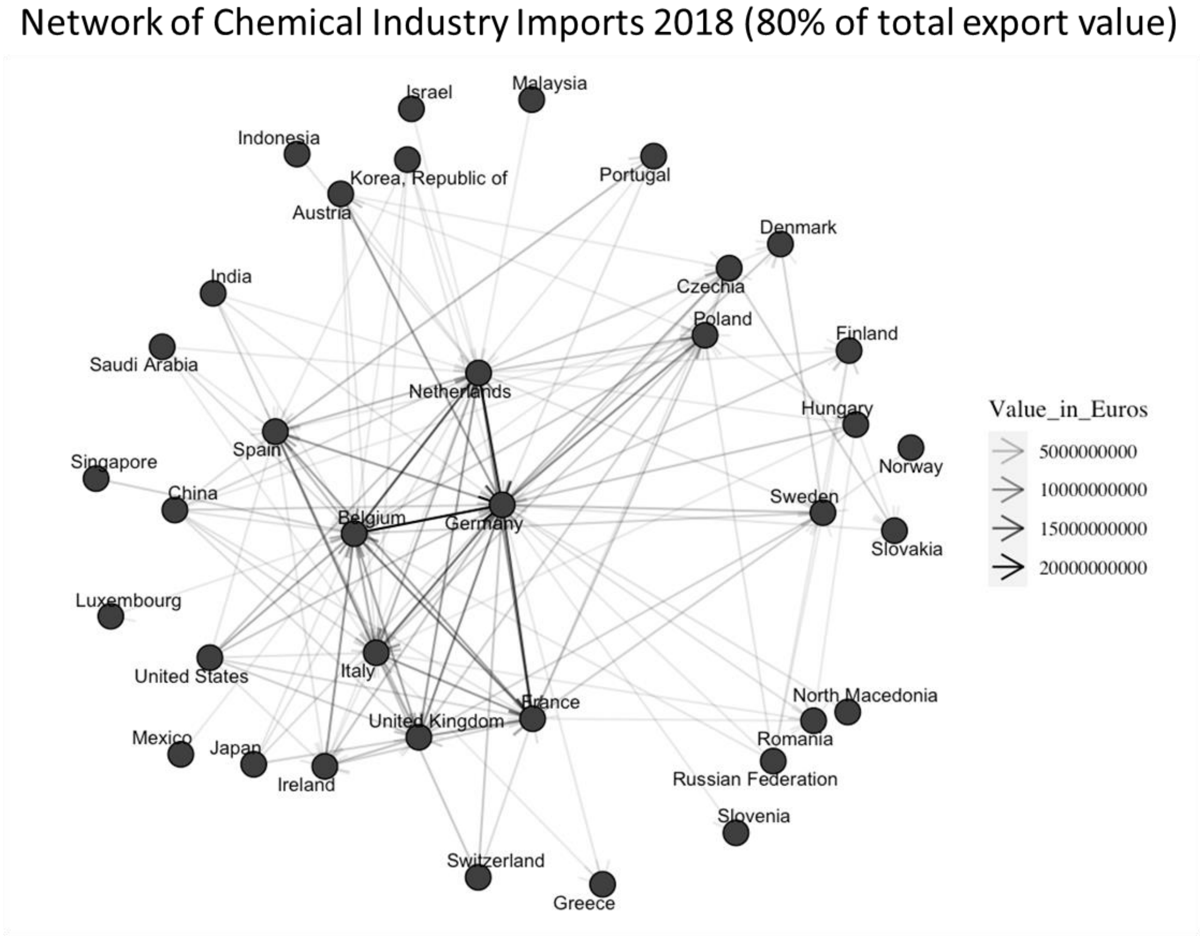

Figure 16: Network of Chemical Industry Imports of EU Countries in 2018

Industries which are based on processes, of course, show different supply chains and, consequently, different export and import networks. The number of links between countries is smaller than in the vehicle industry (see Fig. 13 and 15). Again, the big European countries are the main nodes in the networks. Considering the trade links constituting 80% of the total trade value Germany, France, Italy dominate and the Netherlands and Belgium are particularly important because of the important harbours. It is important to note the position of Spain and Poland (and the UK before Brexit) (see Fig. 13-14; Germany (22.6%), Belgium (15.2%), Netherlands (13.7%), France (10.6%), UK (6.2%), Italy (6.1%)). Both are very well embedded in the networks and show strong exports, but they are not part of the central core of these industries. Although the closeness of relations is slightly different when it comes to imports, again the same countries are the main locations in Europe (see Fig. 15-16; Germany (19.6%), Belgium (12.8%), France (10%), Netherlands (9.7%), Italy (8.6%), UK (7.3%)). Belgium, the Netherlands, and Germany are particularly close and there is a close relationship between France, the United Kingdom and Spain. Poland and Italy are also important nodes but do not show particular positioning. The European network again is dominated first of all by the countries mentioned with vehicle industries, but the structure is formed differently. When taking the changes from 2010 to 2018 into account it indicates under proportional growth of exports from Germany to many other countries but a rather diversified picture when over proportional growth is considered, which includes a number of European countries (see Fig. 17-18). The divergent processes of development also highlight different capabilities of countries and locations. Those which refer to over proportional growth until 2018 are also pointing to a contribution which is rather close to current requirements and provide a basis for future development.

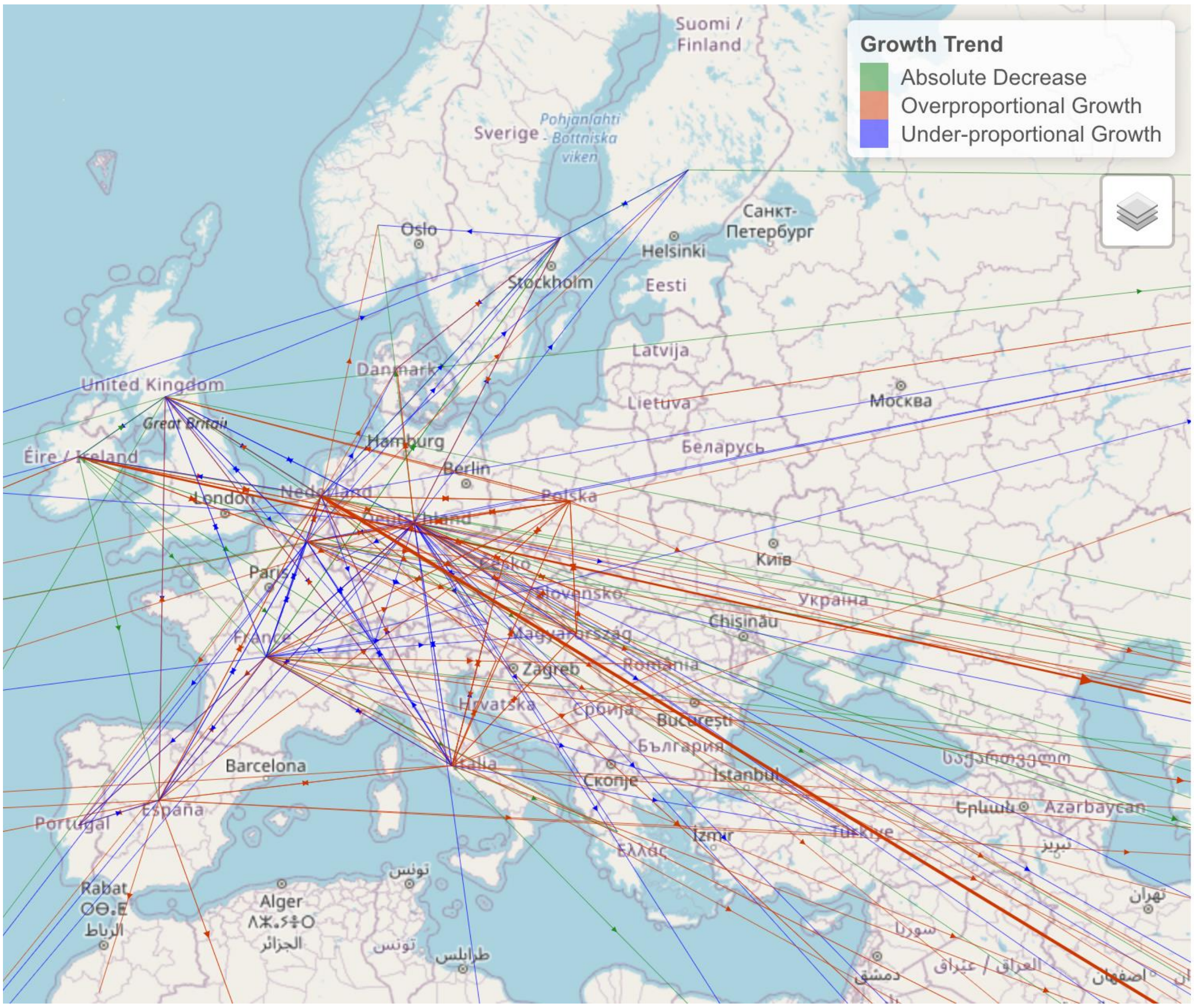

Figure 17: Temporal Trends of Chemical Industry Exports of EU Countries 2010-2018

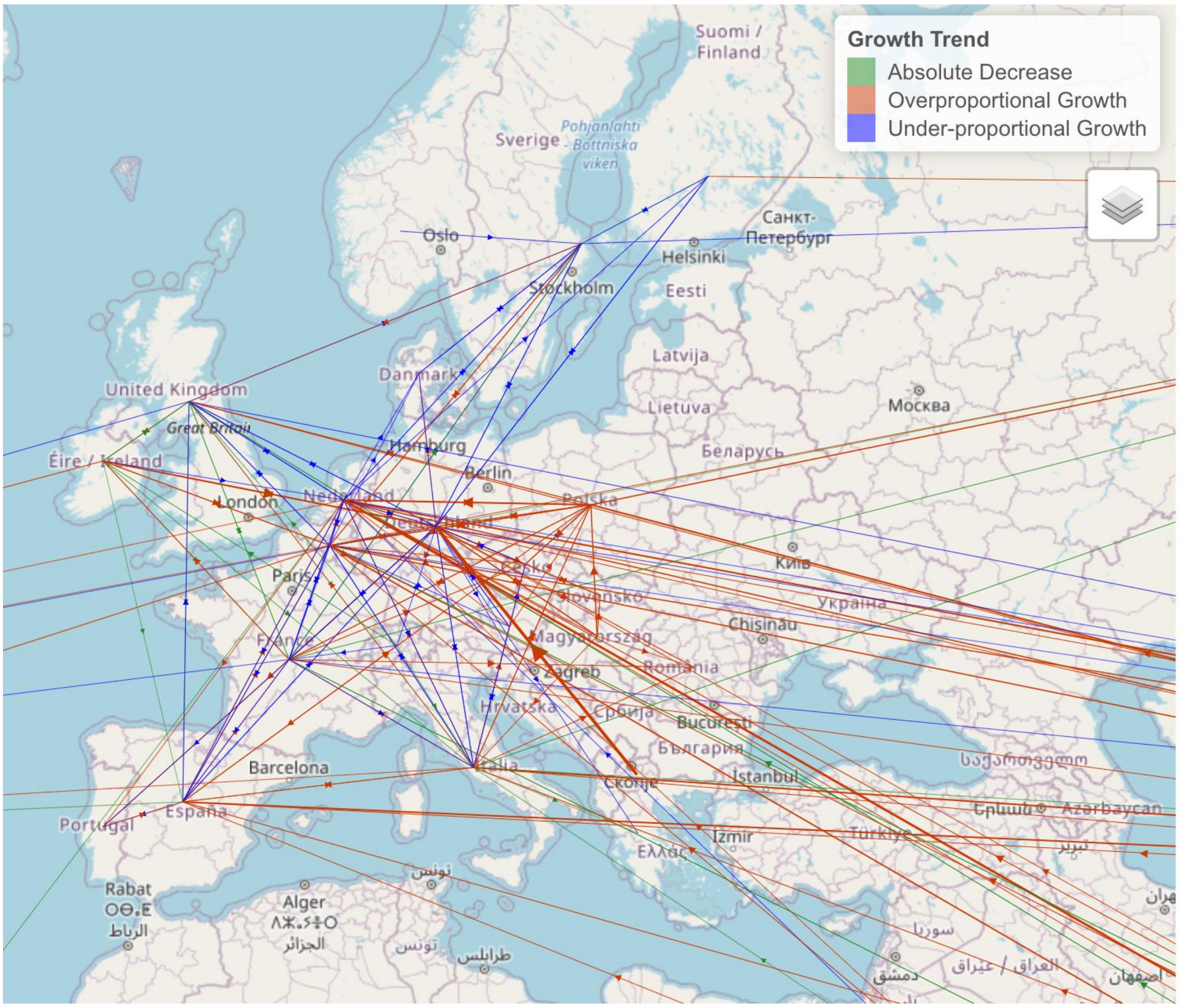

Figure 18: Temporal Trends of Chemical Industry Imports of EU Countries 2010-2018

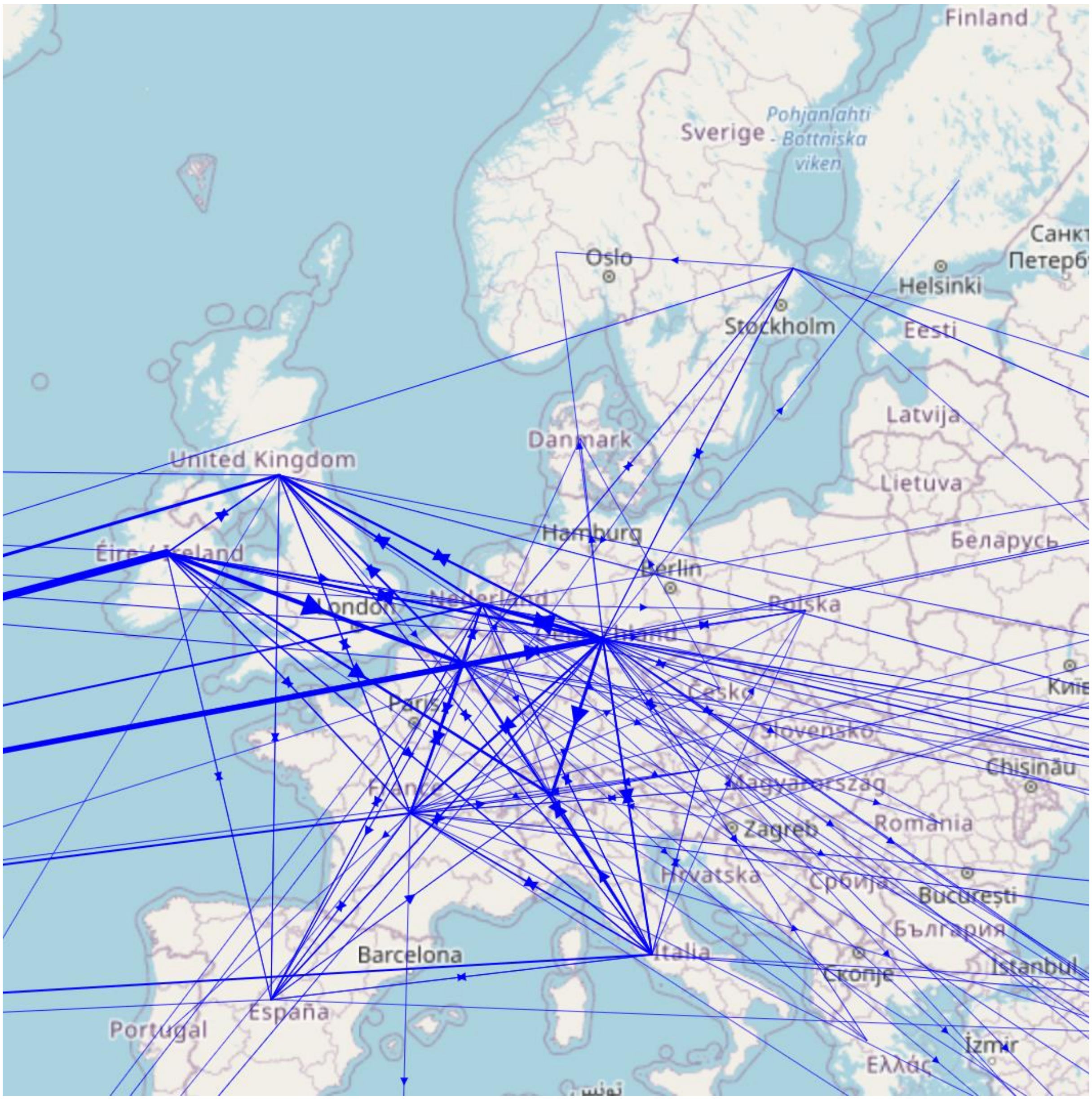

Figure 19: Pharma Industry Exports of EU Countries in 2018

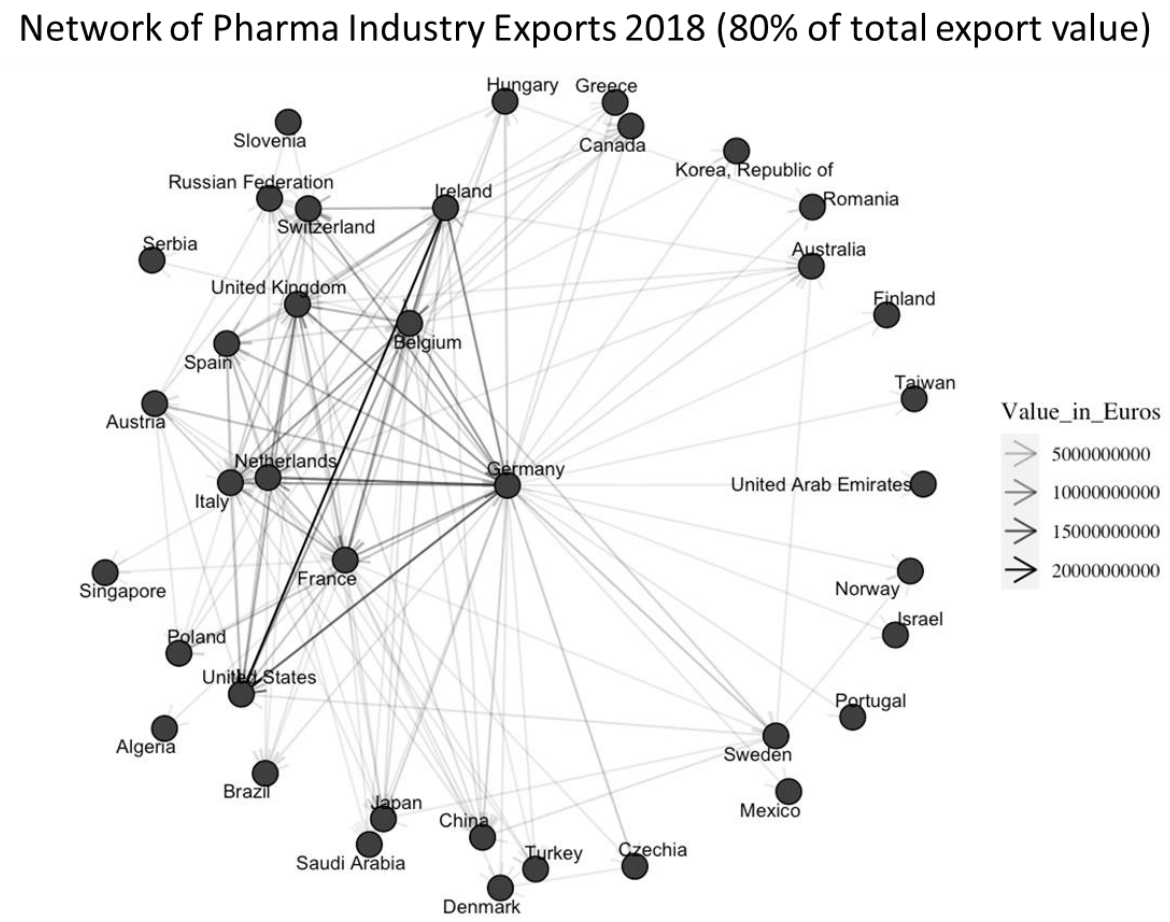

Figure 20: Network of Pharma Industry Exports of EU Countries in 2018

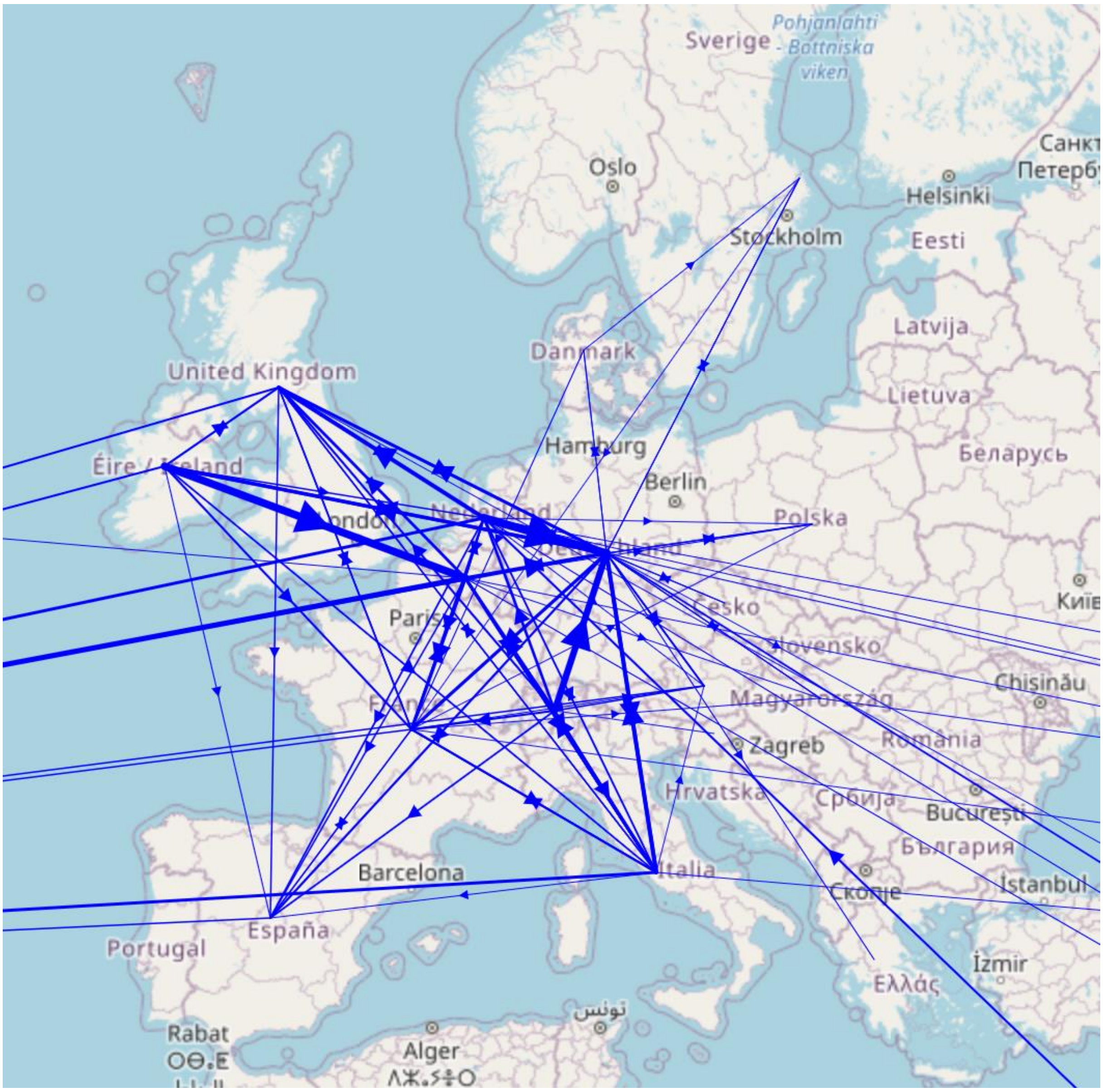

Figure 21: Pharma Industry Imports of EU Countries in 2018

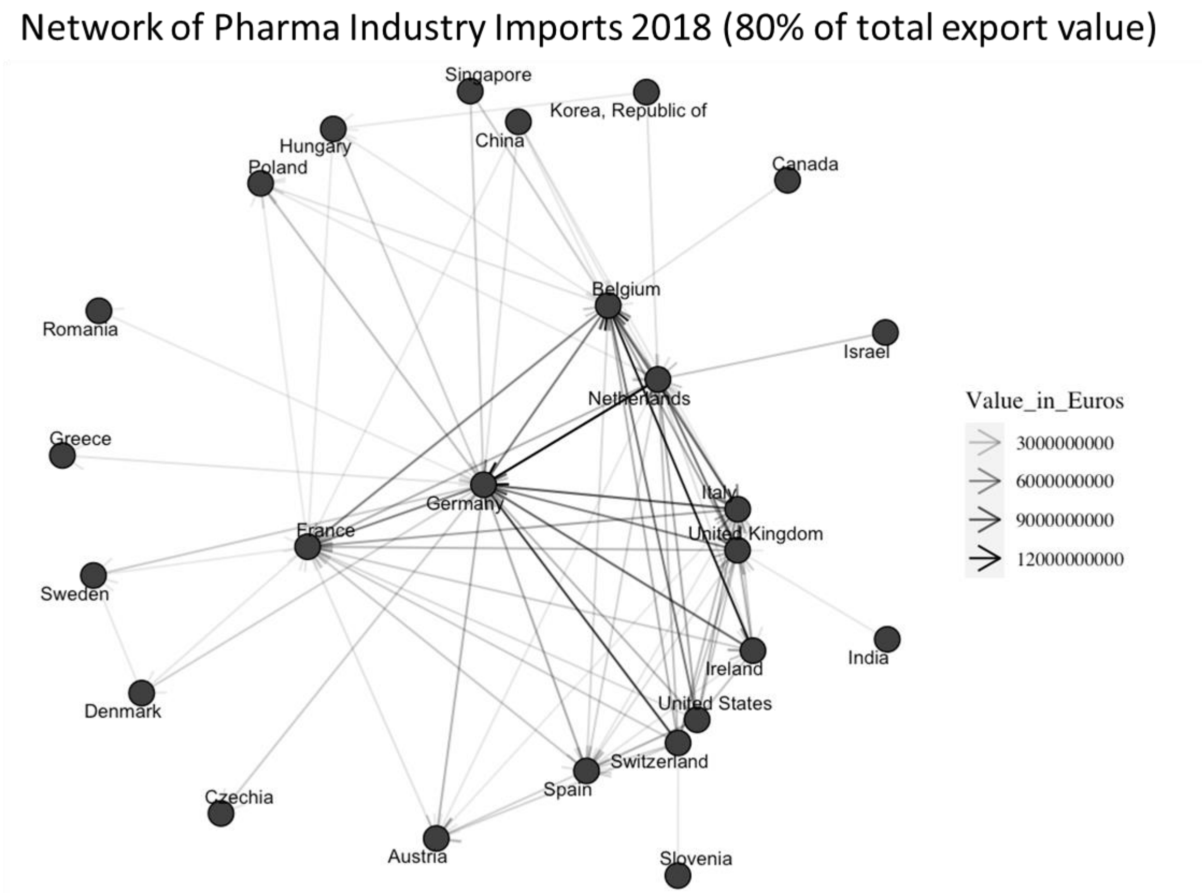

Figure 22: Network of Pharma Industry Imports of EU Countries in 2018

In pharma industries the participation in the network is also limited and diversified. While research and leading-edge pharmaceuticals can be afforded by MNEs only or by highly specialized SMEs engaged in particular areas of research, there are also enterprises which produce standard pharmaceutical products at low costs or engage in packaging etc. Thus, again, there is a simultaneity of value chains, supply chains, and research networks. This is also expressed in the European networks (see Fig. 19 and 21). Import and export of pharmaceuticals, of course, are related with both industrial capabilities and the size of the population of a country. Consequently, concerning imports the big European countries (France, Germany, Italy, and United Kingdom) form the market while also mutually importing and exporting pharmaceuticals. Due to strength in industry, plants of MNEs and research countries such as Switzerland, the Netherlands and Belgium are rather centrally placed (see Fig. 20 and 22; Export: Germany (23.5%), Ireland (16.2%), Belgium (12.8%), Netherlands

(9.2%), France (8.5%), UK (7.7%); Import: Germany (20.6%), Belgium (13.8%), UK (9.9%), Italy (9.5%), France (9.3%), Netherlands (8.4%)). Countries such as Spain and Poland contribute to the network of exports while smaller countries such as the Czech Republic or Hungary are first of all small additional markets which are characterized by their population. When considering the change between 2010 to 2018 there is an over proportional growth of imports to Germany from countries such as Spain and Poland, which are not considered as home of manufacturing and packaging of pharmaceutical products. These processes indicate their increasing contribution to the export network during this period, while this is not the case when it comes to imports (see Fig. 23 and 24). These changes also highlight the growing importance of locations in Southern and Eastern Central Europe when it comes to manufacturing. The network itself is different from other industries mentioned before by the strong positioning of Switzerland, the Netherlands and Belgium. This points to opportunities of countries and regions which are not placed in the countries which are in general the most important ones (France and Germany). In contrast, the growing population of these countries and some others will provide for an increasing demand of pharmaceuticals. Specialized locations in manufacturing and packaging also can take advantage of these developments.

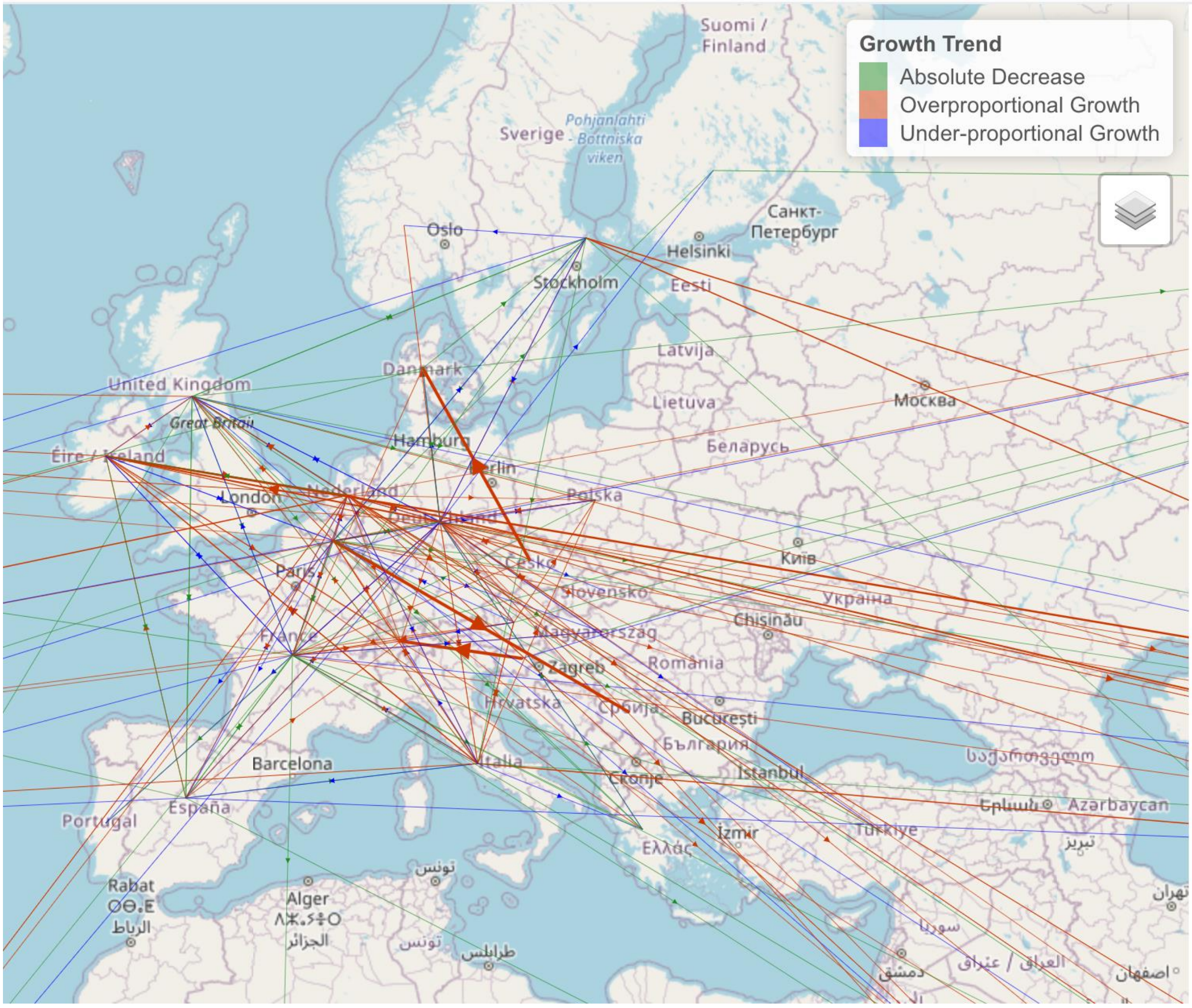

Figure 23: Temporal Trends of Pharma Industry Exports of EU Countries 2010-2018

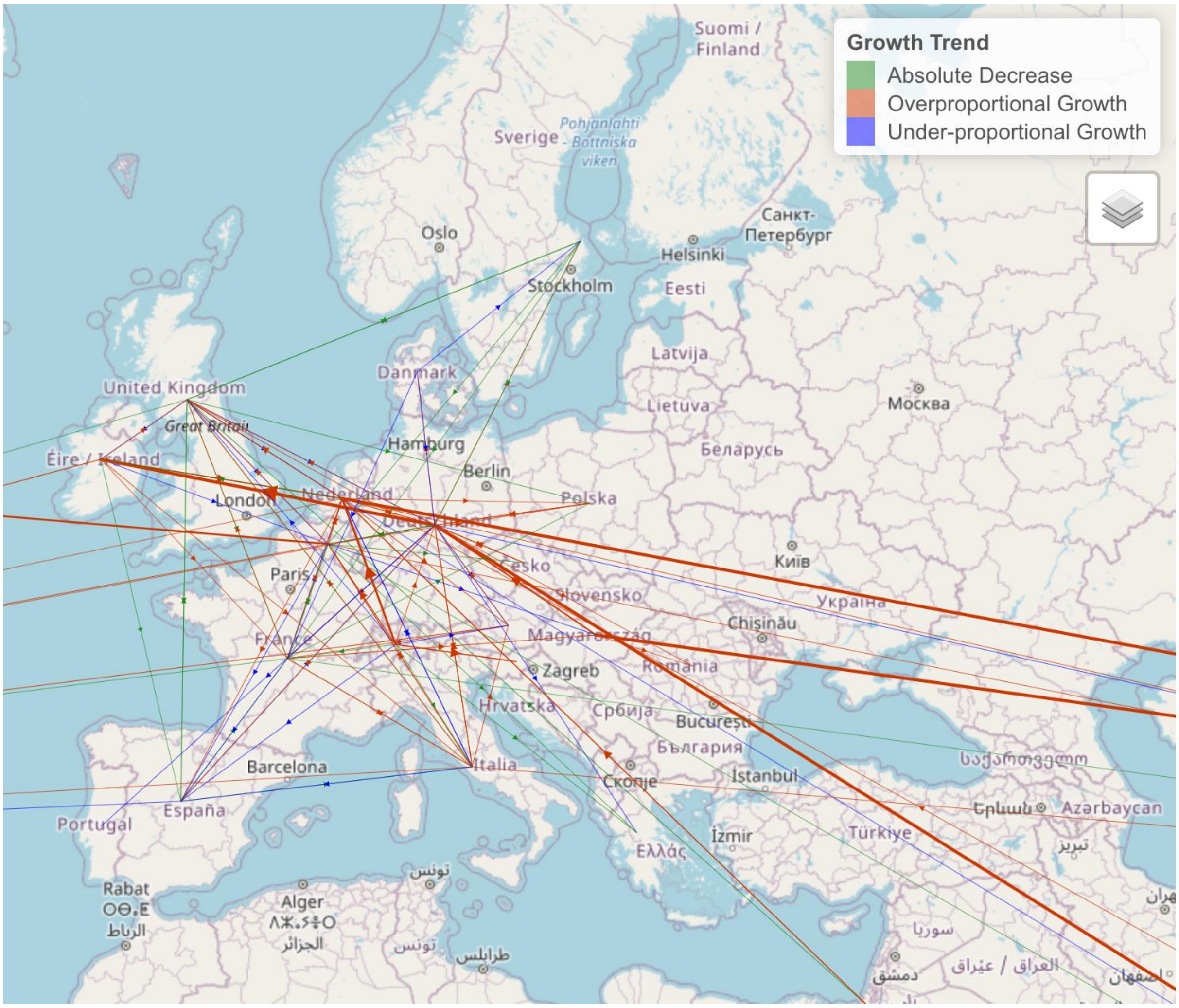

Figure 24: Temporal Trends of Pharma Industry Imports of EU Countries 2010-2018

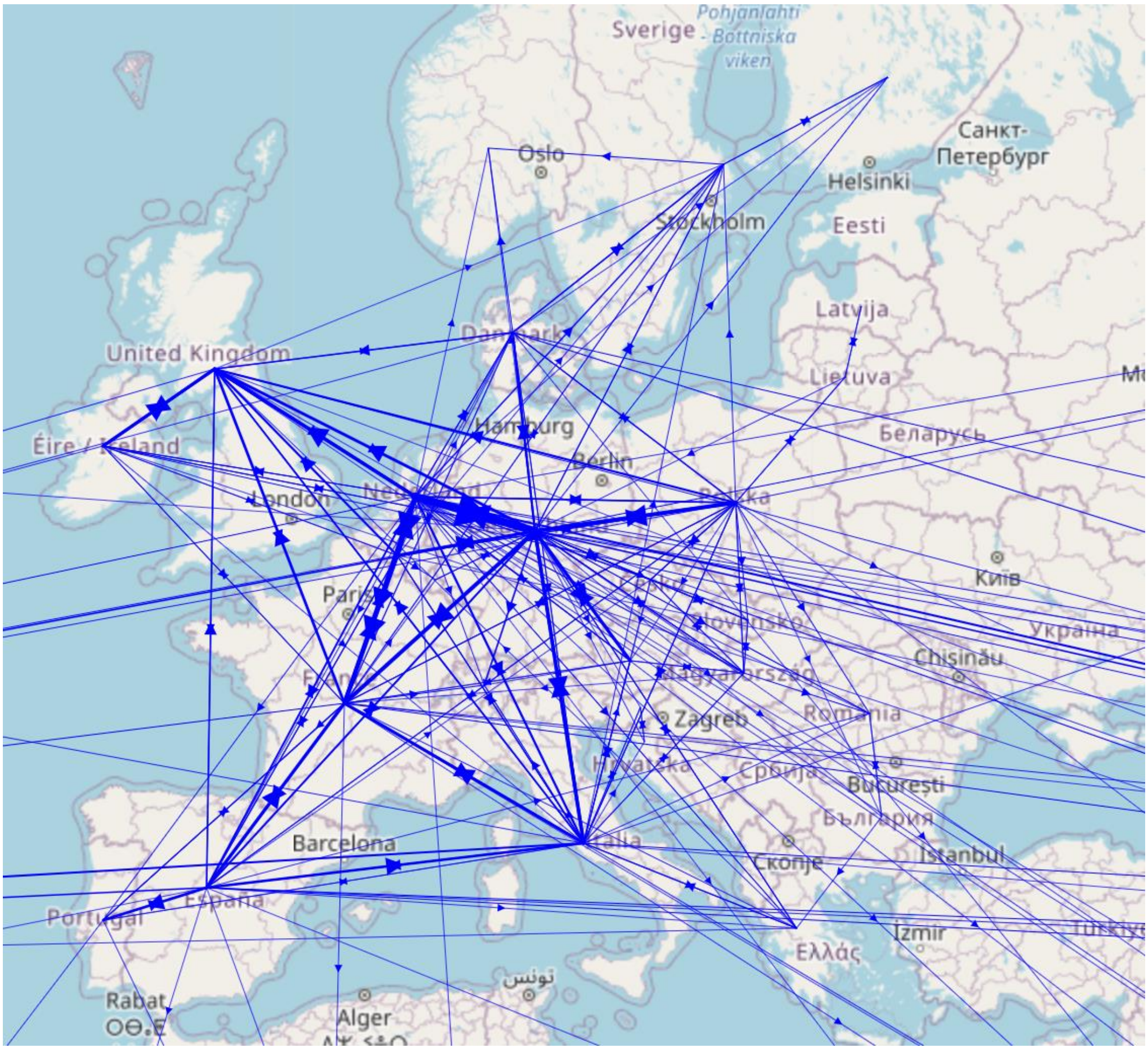

Figure 25: Food Products Industry Exports of EU Countries in 2018

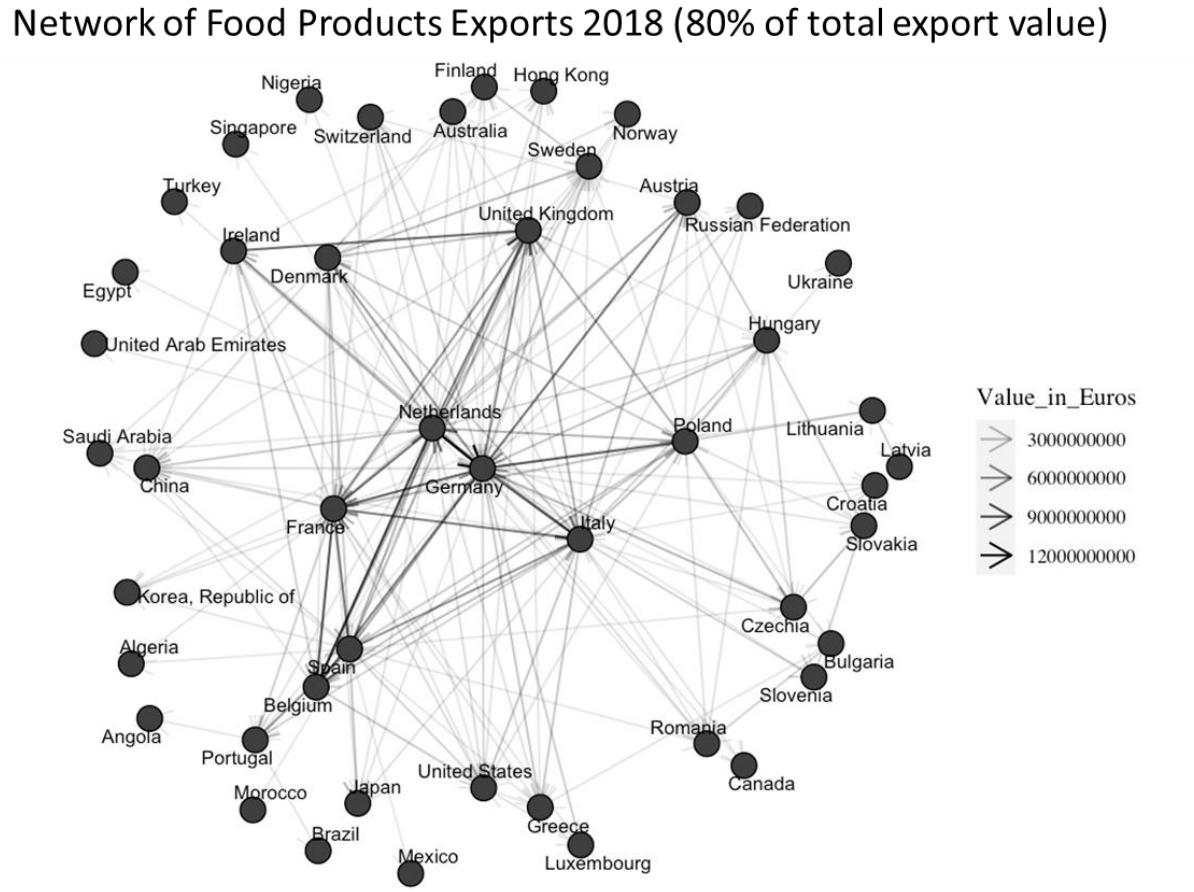

Figure 26: Network of Food Products Industry Exports of EU Countries in 2018

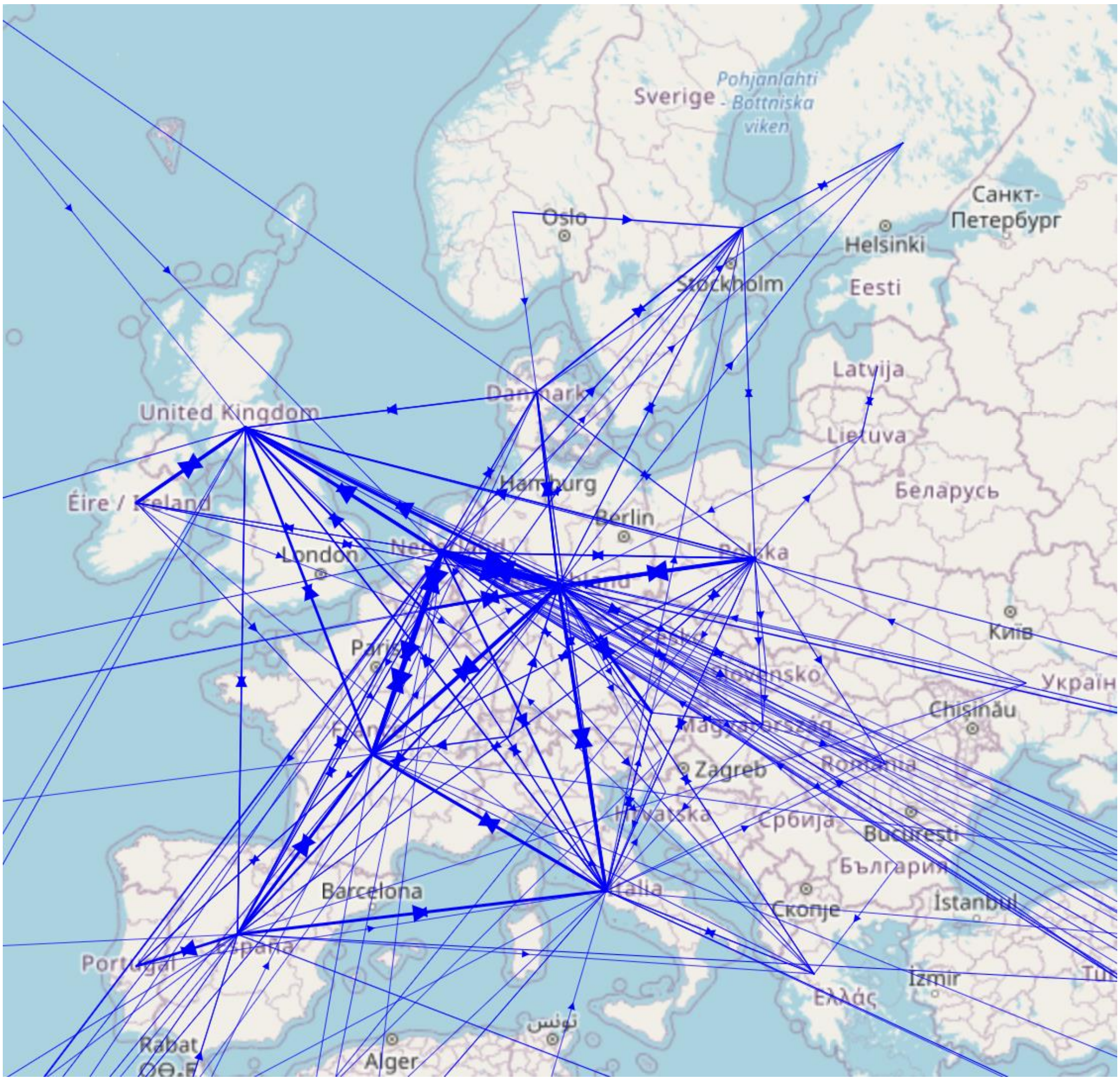

Figure 27: Food Products Industry Imports of EU Countries in 2018

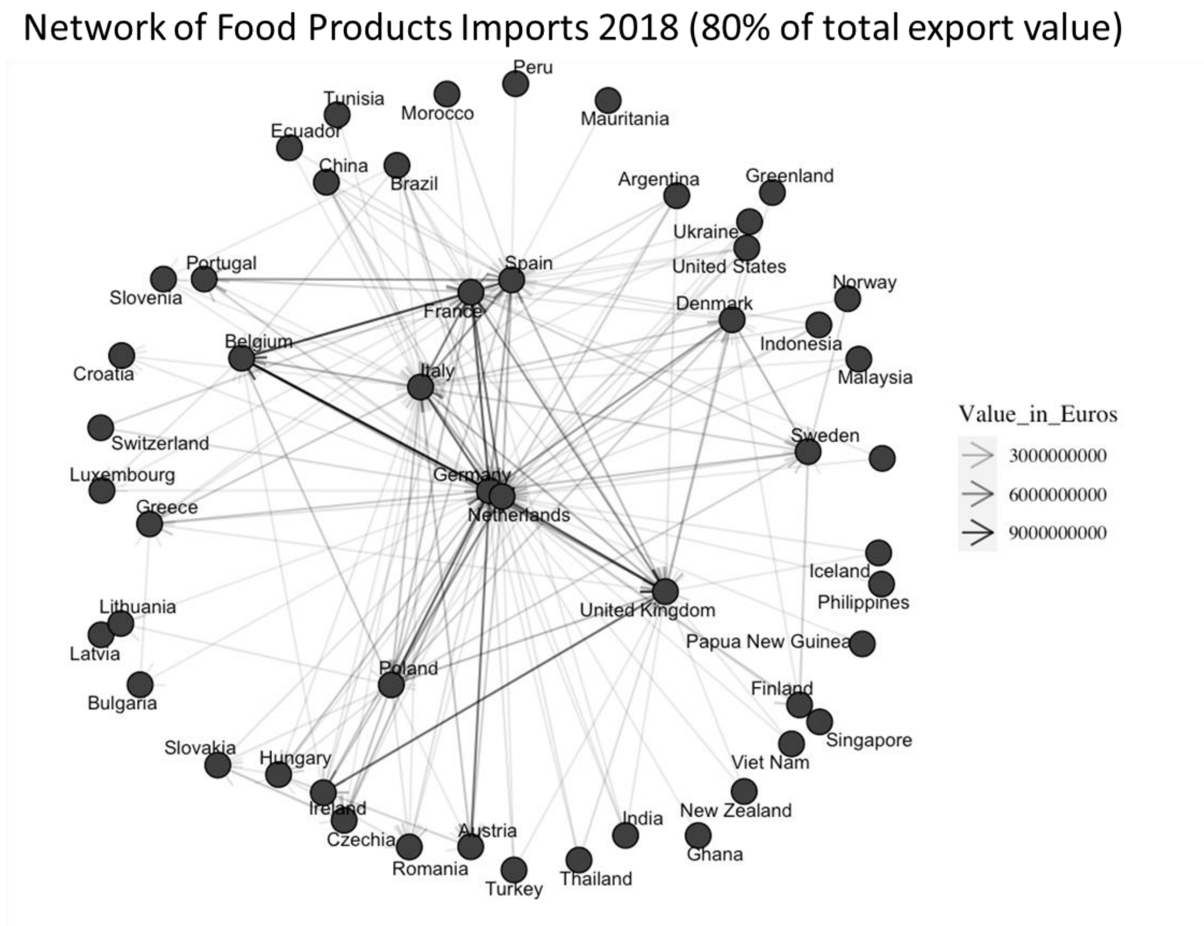

Figure 28: Network of Food Products Industry Imports of EU Countries in 2018

When it comes to economic activities which are less intensively based on industrial competences but can take advantage of the countries geography and its climate the networks clearly change. The network for food products shows that the big European countries because of their population form markets for exports in particular from Southern European countries (see Fig. 25 and 27). Although food in Italy is produced for its large population there are still significant exports of food to other European countries (e.g., to Germany). Spain shows even stronger exports which, in particular, are directed towards France and Germany. The Netherlands also refers to a strong food sector which sells its goods to close markets in these two big markets. The climate of southern Spain is a competitive advantage and allows for growing many different fruits and vegetables as well as a number of special products based on meat. Being close to the big markets is an advantage when it comes to products which need to be consumed rather fast. Thus, Germany also imports food products from Poland which are of course different from those from Southern Europe. The close relationships between countries concerning der imports and exports are expressed in the network which indicates the intensity of trade (see Fig. 26 and 28; Export: Germany (16.8%), Netherlands (16.4%), France (9.5%), Belgium (8.7%), Spain (8.3%), Italy (8.1%); Import: Germany (15.7%), France (11.7%), UK (11.1%), Netherlands (10.8%), Italy (8.6%), Spain (6.8%). Spain and Italy maintained their positions during the period between 2010 and 2018 (see Fig. 29 and 30). Due to the advantage of climate when it comes to production and consistent consumers taste the existing structure of the networks did not change. These products show a much stronger contribution and positioning in the networks than the industries mentioned before. They also pinpoint to potential strength and opportunities outside of Europe's traditional centres.

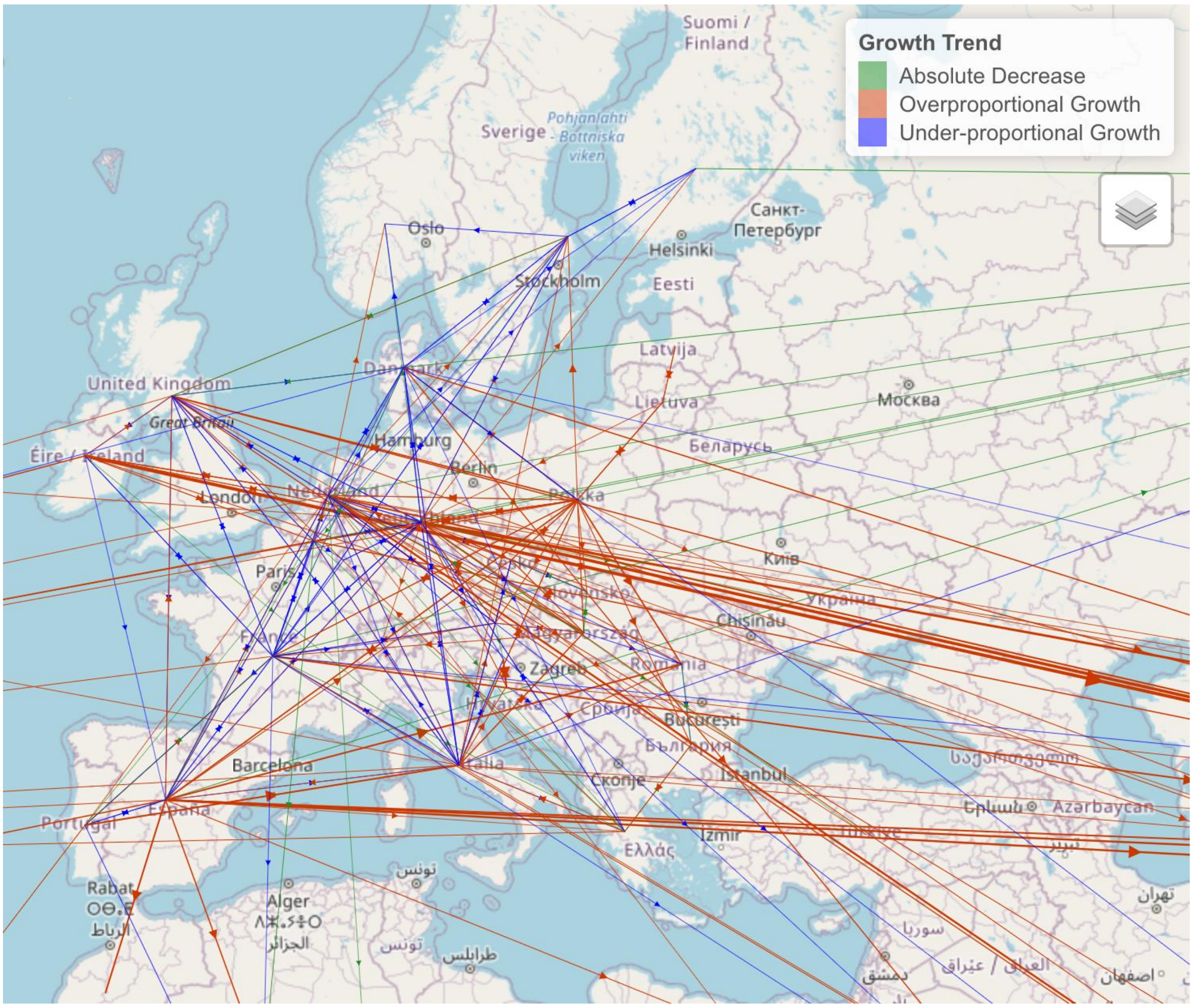

Figure 29: Temporal Trends of Food Products Industry Exports of EU Countries 2010-2018

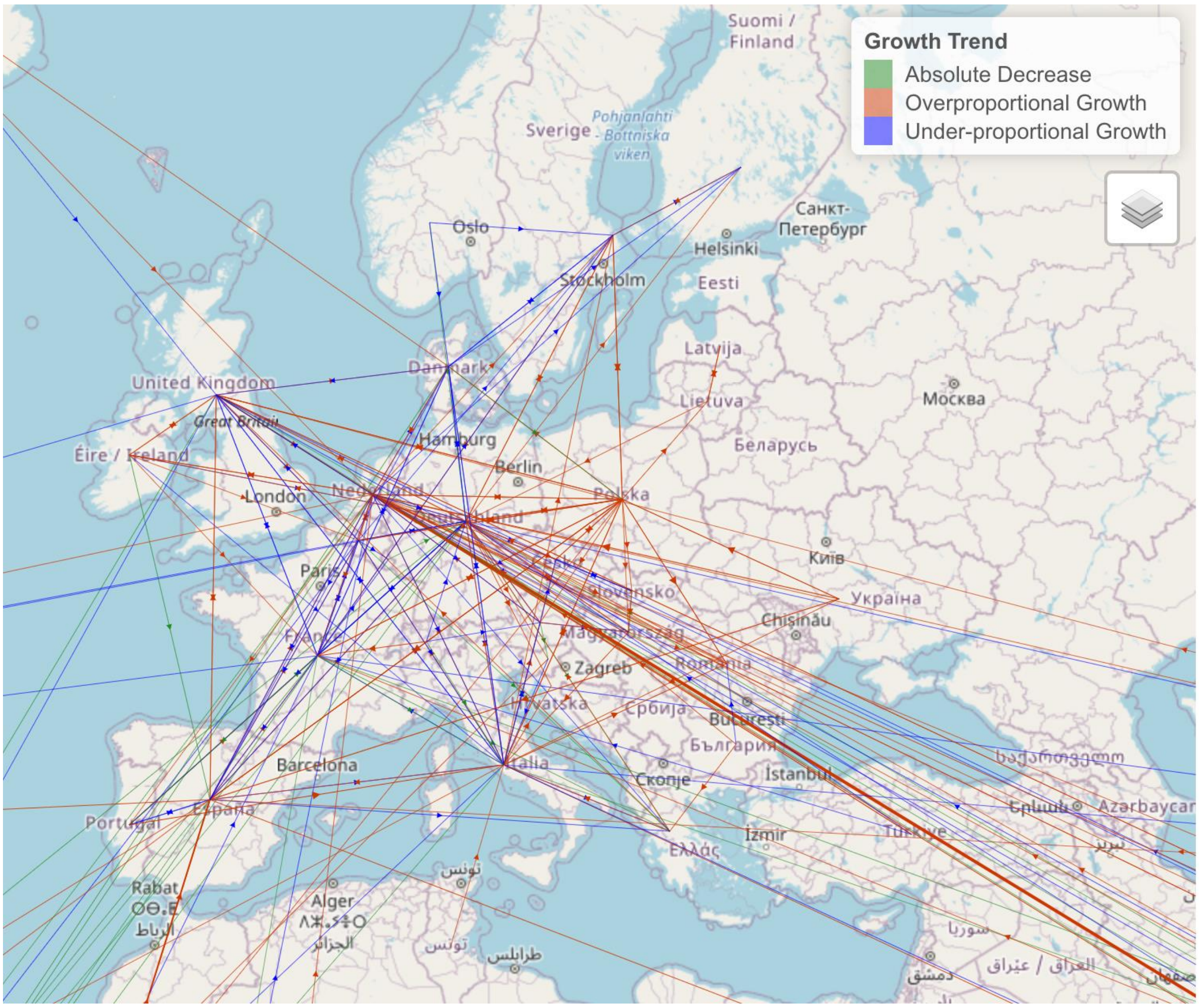

Figure 30: Temporal Trends of Food Products Industry Imports of EU Countries 2010-2018

These examples of industries and networks in Europe express some important opportunities and rationalities. It is important to distinguish between the layers of the networks. Concerning research-based and knowledge-intensive products and collaborations the traditional centres are continuing to lead. Where strong Islands of Innovation are located and in addition mutually strengthened by collaboration, these countries will continue this position for the foreseeable future. Value chains and research networks are built among these locations and will provide benefits based on synergy in countries such as Germany, France, and the Netherlands as well as in Scandinavia and Northern Italy. Also, the United Kingdom will continue being a part of it despite the effects of Brexit. The economic strength of these countries and innovation allows for a Europe which participates in the leading and most attractive developments. While this may be regarded as a problem for development in Europe, of course, it is also a basis for an all-European development and the inclusion of less innovative countries.

Simultaneously, the networks point to particular competences which are the basis for participation of countries which are not part of the innovative network. Production costs and opportunities to manufacture products and parts designed elsewhere exist and provide the basis for the participation in supply chains. Established capabilities in countries like Spain, Poland, or the Czech Republic are the basis for their type of participation in the chains and networks. Different industrial histories and differently skilled labour forces are important when they supply alongside the chains. Nevertheless, the European networks of the different industries also point to the particular competences of these countries which have emerged with the plants established and the supply they provide. While the research networks and the value chains both are oriented towards innovation based on leading edge technologies the countries mentioned and their regions have the potential of modernisation and development associated with the process of manufacturing. It is important to take into account that there are further countries and locations south of the Mediterranean Sea which aim at a participation in these networks based on low production costs and weaker regulatory frameworks.

Since these industries are not equally distributed across countries like Spain nor do clusters and MNEs create similar situations there are regional concentrations of individual industries and opportunities. It is important to identify the specific profiles of the different regions. Clearly, chemical industries refer to innovative opportunities and requirements different from mechanical engineering and obviously agribusiness again is different from both. Thus, regional situations need to be considered when national transformation is discussed. In addition, the requirements of skilled labour and the opportunities to improve value added are forming diversities of innovation. While in some industries it is technological progress which drives innovation concerning the final product or the production process, there are also cases where skilled labour is a basis of innovation or the organization of manufacturing and management. Although there are competitive situations between countries like Spain and South-Eastern Europe when it comes to simple mass-production there are countries like Poland or the Czech Republic which provide skilled blue-collar labour as a comparative advantage on manufacturing more complex parts and components. Compared with those countries, nevertheless, there is a climatic advantage concerning agricultural products which demand for the Mediterranean climate. This indicates both the divergent situations throughout Europe and the regional diversities of innovation based on existing opportunities and potential areas of modernisation.

1.4 Strong regions as drivers of innovation and economic development (Germany)

Germany is a leading exporter of manufactured goods and its manufacturing related share at GDP (23%) in 2016 is only exceeded by Japan and South Korea. Overall, more than 50% of its GDP is generated via exports showing strong integration in international trade and value chains. Key aspects associated with this success are for example the vocational training and applied educational pathways, the institutional framework (transfer institutions, policies, applied science universities) focussed on technology transfer, the SME landscape, and the policy framework focusing on regions to leverage regional competences and implementing local frameworks within the broader policy context benefiting the regional structures. Though overall in a comfortable position, Germany and its states have experienced economic transformation and overcome various structural challenges as well as the economic challenges posed by reunification leading to the development of such a framework.

While cases of successful economic restructuring and past and ongoing adaption to change of West German states like Baden-Wuerttemberg, Bavaria, and North Rhine-Westphalia are interesting and information is provided as reference, this report emphasizes on transformation in East Germany as an example of fundamental shifts and changes of the institutional environment. The report uses the examples of Saxony and Thuringia, as they have the largest manufacturing industries among East German states, to understand the transformation process, which partially was informed by experience from other transformation processes in West Germany. Germany's economic history after the Second World War is characterized by a rebuilding period followed by a period of dynamic growth between the 1950s till the oil crisis in 1973. This growth was driven by high demand, manufacturing (especially automotive and heavy industries) and accompanied by a rapid industrialization of West Germany. The oil crisis marked a departure from this trajectory at least for the Ruhr Area in North Rhine-Westphalia. International cost competition in coal, steel, and metal industries caused a crisis in the steel and coal industry leading to closures and deindustrialization. Together with technological advances reducing the need for labour unemployment rose significantly – policies in response were developed including labour market policies (e.g., early retirement, retraining), phasing out of industries (coal) as well as strategies promoting knowledge-based innovation (e.g., funding of various higher education institutions including applied science universities). While structural change in North Rhine-Westphalia is ongoing today, the lessons learned here were applied in East Germany to reduce unemployment and modernize industries.

Other states in Germany were less affected by the steel crisis- Bavaria, for example, was significantly less involved in the steel and coal industry and was mostly affected by employment losses in textiles and other similar industries affected by reduced labour demand constituting overall only a small fraction of Bavaria's industry. In response to the crisis, Bavaria emphasized technology investments (especially ITC, microelectronics), the competitiveness of its SMEs, and the exchange between R&D institutes and firms to foster technology transfer.

Similarly, Baden-Württemberg emphasized program supporting its vast SME landscape with various policy programs, applied science initiatives, and transfer institutions. For example, among industry concerns of obtaining sufficient skilled labour, Baden-Württemberg established in the early 70s proactively dual study programs (combining academic with vocational training (till 1995 not recognized as academic degree) and founded in 2009 an applied science university focusing on such programs. Technology transfer is a key aspect of SME focused policies. One of the largest actors in technology transfer is the Steinbeis Foundation present with approximately 600 transfer offices in Baden-Württemberg mainly serving the SMEs of the state with consulting, engineering, and other services related to enhancing competences of SMEs. Though not free, state subsidies are enabling SMEs to seek contact with the transfer institutions and have initial conversations with scientist to reduce barriers and familiarize SMEs with science-based cooperation. The idea of transfer institutions has been widely adopted across Germany and was among the institutions transferred to East Germany though the nature of adoption varies. While for example adapted in Thuringia in form of a foundation, Saxony organized the program within its Aufbaubank mostly providing funding for SMEs to work with transfer institutions (e.g., Steinbeis, Fraunhofer). Overall, lessons learned (SME funding, workforce development, public research and applied sciences, technology transfer) from these examples were transferred in the form of institutions to East Germany as later sections show.

Though Germany overall has a high importance in manufacturing industries, states and regions in Germany are diverse and have different structures and conditions. The population in Germany as well as the manufacturing industry is characterized by strong concentration in few select states. Germany's population of 83 million is concentrated in the West German states. In 2019, 84.9% of the population live in the former West German states (including Berlin), and 15.1% live in East German states. Overall, 50.7% of Germany's population are concentrated in North Rhine-Westphalia (21.6%, 17.9 million), Bavaria (15.8%, 13 million), and Baden-Württemberg (13.3%, 11 million). The largest East German state is Saxony (4.9%, 4.1 million). Thuringia has a population of approximately 2.1 million (2.6%). While the West German states in the study experience overall population growth, East German states (excluding Berlin) have overall experienced significant and often continuous population losses since reunification and an aging population. Nonetheless, larger cities in these states are able to gain population.

Manufacturing employment is similarly strongly concentrated. Overall, 7.2 million are employed in manufacturing industries – this compares to 5.9 million in 2008 and shows an increasing trend in manufacturing employment though growth is unevenly distributed with especially Baden-Württemberg and Bavaria capturing growth. In 2018, 20.6% of manufacturing employment is located in Bavaria, 20.2% in Baden-Württemberg, and 19.6% in North Rhine-Westphalia. Saxony has 4.6% of Germany's employees in manufacturing leading the East German states, while Thuringia follows with 2.9%.

Gross value added in manufacturing is similarly highly concentrated in select German states. Approximately 91% of Germany's gross value added of nearly 674 billion Euro in the manufacturing industry in 2018 was generated in the West German States including Berlin – only approximately 9% are generated in the East German states. In 1991 approximately 96% of Germany's gross value added of nearly 380 billion Euro was generated in West German States including Berlin and only 4% in the East German States. The generation of manufacturing GVA is highly localized –overall nearly 72% of Germany's total GVA in manufacturing in 2018 were generated in Baden-Württemberg (23%), Bavaria (21%), North Rhine-Westphalia (18%), and Lower Saxony (10%) – Saxony and Thuringia lead the East German States and Saxony contributes approximately 3% and Thuringia 2% to the total GVA showing differences in GVA per employee between locations in the East and West. Especially North Rhine-Westphalia declined in importance from 25% of national GVA in 1991 to 18% in 2018. Other above-mentioned states increased their share at GVA. The distribution of the GVA shows with its trend that development in East Germany is progressing albeit slow.

R&D expenditures in Germany are similarly concentrated. In 2018 nearly 105 billion were spent on R&D within Germany. Only 12.6% were spent in East Germany including Berlin; though the share of R&D expenses was initially higher (e.g., 14.4% in 1997) the share since 2003 is around 13%. Three German states are responsible for 61.2% of R&D expenditures in 2018: Baden-Württemberg (27.9%), Bavaria (18.8%), and North Rhine-Westphalia (14.5%). While Berlin contributes 4.8%, among the other East German States Saxony (3.4%) and Thuringia (1.4%) lead in R&D expenditures.

Differences emerge observing the source of R&D spending. Based on 2017 R&D expenditure data, in Germany 69.1% of R&D expenses are generated by the private sector. The share is especially high in Baden-Württemberg (83.6%), Bavaria (75.9%) and Hessen (75.6%) – in North Rhine-Westphalia 58.9% of R&D expenditures are generated by the private sector. Except for Bremen (34%) and Saarland (49.2%), the private sector generates in all West German States more than 50% of R&D expenditures. In the East, the private sector contributions are lower – Thuringia (50.2%) and Saxony (43.5%) have the highest shares of private sector R&D expenses at total expenses. This shows structural differences in how businesses innovate – public support is still crucial in Saxony and Thuringia for industrial innovation.

While Germany and its states are experiencing transformation and structural change – especially notable in North Rhine-Westphalia and Thuringia and Saxony among the observed states, overall trends in manufacturing show positive development and crisis resilience. While Germany was affected by the economic crisis, employment numbers and gross value added returned quickly (by 2011) in most states to pre-crisis levels and continued a positive trend. An exception is North Rhine-Westphalia, which has experienced overall only slight growth and lost importance in the manufacturing sector overall in Germany given the dynamic growth in other regions. Overall employment, gross value added, labour productivity, and wages and salaries have overall increased – as well as labour cost (see Table x).

Table 2: Select Macroeconomic Variables (Germany)

Industry	**Variable**	**Unit**	**2008**	**2018**
Manufacturing	Employees	Number	5925949	7244138
Manufacturing	GVA at current prices per person in employment (domestic concept)	EUR	68458	87317
Manufacturing	Labour productivity per person in employment (domestic concept)	2015=100	92.84	105.36
Manufacturing	Gross wages and salaries per employee (domestic concept)	EUR	37736	47515

Manufacturing	Unit labour costs per capita (domestic concept)	2015=100	92.52	100.97
Total	GVA at current prices per person in employment (domestic concept)	EUR	62356	74806
Total	Labour productivity per person in employment (domestic concept)	2015=100	98.85	102.09
Total	Gross wages and salaries per employee (domestic concept)	EUR	28007	35922
Total	Unit labour costs per capita (domestic concept)	2015=100	86.25	105.78

Employment in the manufacturing sector increased by over 22% between 2008 and 2018 and most manufacturing sectors experienced growth as well (see Table x). Few manufacturing sectors are experiencing decline, namely apparel production and the production of print or recorded media. The employment wise largest industry sectors in Germany are Machinery Industry (1.23 million), Vehicle industry (954 thousand), Fabricated metal products (795 thousand), Food products (625 thousand), and Electrical equipment production (494 thousand) – all these sectors experienced more than 20% growth in employment. Though regional distributions of these industries vary, they mostly concentrate in the three West German states of Baden-Württemberg, Bavaria, and North Rhine-Westphalia. Among East German states, Saxony and Thuringia are in leading positions, though absolute and relative size of these industries is significantly smaller than in many West German states:

Baden-Württemberg has the highest share of employees in Machinery Industry representing 29.9% of Germany's employees in the sector. Bavaria (21.6%) and North Rhine-Westphalia (19.2%) follow. Saxony (3.9%) and Thuringia (1.8%) lead within eastern Germany.

Employment in the German Manufacture of motor vehicles, trailers and semi-trailers sector is highly concentrated in Baden-Württemberg (26.9%), Bavaria (24.5%) and North Rhine-Westphalia (10.1%). Lower Saxony with Volkswagen is another major employment centre though values are withheld. 4.7% of the employees in the sector are employed in Saxony and 2.2% in Thuringia.

Employment in the Fabricated metal products is highly concentrated in North Rhine-Westphalia (25.7%), Baden-Württemberg (22.6%), and Bavaria (15.9%). In Saxony 6.2% of the industry are employed in the sector followed by Thuringia (4.6%).

Electrical equipment production is highly concentrated in Bavaria (27.4%), Baden-Württemberg (23.9%), and North Rhine-Westphalia (21.2%). The leading East German states are Saxony (4%) and Thuringia (2.6%).

Bavaria captures the largest share of Food products employment with 20.7% followed by North Rhine-Westphalia (18.9%), Lower Saxony (13.8%), and Baden-Württemberg (12%). In eastern Germany Sachsen-Anhalt captured 3.9% followed by Thuringia (3.6%) and Saxony (3.5%).

Notable is that these sectors, except for Electrical equipment production, which is replaced by Chemical industry, constitute the sectors with the highest investments in tangible good within manufacturing showing not only employment growth but also significant investments and investment growth between 2009 and 2018.

Table 3: Trends in Manufacturing Industries 2008-2018 (Germany)

Industry	**2008**	**2018**	**Change (%)**
Manufacturing Overall	5925949	7244138	22.2
Manufacture of food products	469142	625197	33.3
Manufacture of beverages	62554	70978	13.5
Manufacture of tobacco products	9565	10297	7.7
Manufacture of textiles	72568	74432	2.6
Manufacture of wearing apparel	37882	32811	-13.4
Manufacture of leather and related products	17649	23805	34.9
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	84404	98772	17
Manufacture of paper and paper products	137416	153204	11.5
Printing and reproduction of recorded media	120184	108797	-9.5
Manufacture of coke and refined petroleum products	20478	21628	5.6
Manufacture of chemicals and chemical products	311098	391310	25.8

Manufacture of basic pharmaceutical products and pharmaceutical preparations	117630	136699	16.2
Manufacture of rubber and plastic products	365937	469351	28.3
Manufacture of other non-metallic mineral products	192103	223869	16.5
Manufacture of basic metals	267115	293786	10
Manufacture of fabricated metal products, except machinery and equipment	631028	793222	25.7
Manufacture of computer, electronic and optical products	283448	353753	24.8
Manufacture of electrical equipment	405954	493983	21.7
Manufacture of machinery and equipment n.e.c.	987402	1226059	24.2
Manufacture of motor vehicles, trailers, and semi-trailers	770377	954066	23.8
Manufacture of other transport equipment	113549	153262	35
Manufacture of furniture	111434	115602	3.7
Other manufacturing	137978	190414	38
Repair and installation of machinery and equipment	199054	228841	15

A few key differences and similarities exist among the observed states. While manufacturing employment grew in all states, demographic trends vary. The West German states grew in population, while Saxony and Thuringia overall lost population over the last decades and are characterized by an aging population. This may become for the manufacturing industry in eastern Germany a future problem, as the demand for skilled labour is in some cases difficult to meet and higher wages in other German regions reinforce the problem. While GVA and employment have increased in all states, the increase is in relative terms smallest in North Rhine-Westphalia, which lost overall in importance - while some sectors declined or experienced under proportional growth the largest industrial sector show still significant growth rates in the state indicating a diverse picture of the competitiveness of its industries and structural transformation of the manufacturing sector.

Overall, the section above shows positive trends in manufacturing with increasing employment, wages, gross value added, and productivity. Historical data shows, that East German states lost substantial employment after reunification but over time the industry adapted, and its importance is growing (essentially doubling between 1991 and 2018 measured by gross value added) – though the respective share at the German economy is at least relative to the population distribution still under proportional. Though the picture overall shows growth and development as well as investments in R&D and tangible goods, not all industries and regions benefit equally.

1.5 Spain: a country and its regions under stress of transformation

For several decades, Spain has been searching without success for an economic model to compete with the most advanced economies. The absence of a clear economic model explains the evolution of manufacturing industries in Spain. The first phase of the history of the modern Spanish manufacturing industry began in the 1960s. At that time, Spain was mainly an agricultural country, isolated from international supply chains and with a very fragile and limited base of industrial and crafts firms. Because of these limitations, the Franco government imitated the post-war French economic development model, by supporting economic development on governmental action, geographical concentration, and the growth of large companies. The importance of the role of large corporations in Spanish economic policies has continued over the decades, even with democratic governments, and persists today. The downside of this bias towards large corporations is the fragility of Spanish industrial SMEs. During these early years, favourable regulations attracted some important multinationals such as Renault, Citroen or CPC International, which established production plants in Spain.

After the 1973 oil crisis, Spanish industry underwent its first period of transformation, in which some heavy industry sectors such as steel and shipbuilding began to be abandoned. During this period, an increasing number of large foreign multinationals consolidated its presence in the country, absorbing or replacing local companies.

The establishment of manufacturing companies in Spain is not always explained by the search for a low-cost labour force but is often justified by the multinational's intention to incorporate high value manufacturing, engineering, or innovation skills from Spanish firms. The last decades have seen numerous acquisitions of multinational companies such as the purchase of ISA by Renault, Femsa by Bosch, or Tecosa by Siemens in the 1960s and 1970s, the purchases of Uniplast, Curtex or Urruzola by BASF, of Enasa by Iveco in 1990, and more recently the purchases of Telstar by Azbil, Gamesa by Siemens or Ficosa by Panasonic. All these acquisitions are just some examples of operations in which the main objective of foreign multinationals was to take over the knowledge and advanced capabilities of Spanish firms rather than accessing low cost manufacturing capabilities.

During the post-1973 period, Spanish industries were increasingly integrated into European supply chains, driving industrial growth. This integration in global supply chains utterly benefited from Spain's entry into the European Union in 1986.

These processes of change did not affect Spain homogeneously. For instance, the loss of competitiveness of Spanish heavy industry was particularly felt in the economic activity of northwest Spain, especially in the Basque Country. Moreover, while some industries and regions benefited from the entry in the European Union and the reduced barriers to international trade, some other industries such as the textile industry in Catalonia or the shoe industry in Valencia were struggling with an increasingly fierce international competition, especially from low-cost countries.

With the entry of the 21st century, the manufacturing industry was affected by two contrasting phenomena. In the first place, the challenge of stronger foreign competition, already suffered by a few industries during the previous decade, extended after 2000 to an increasing number of industries. This process was the result of the progressive consolidation of both the enlargement of the European Union towards Eastern Europe and the growing global trade with East Asia. This first phenomenon triggered a progressive reconfiguration of European supply chains, whereby Spanish production began to be progressively replaced by production from Eastern Europe or East Asia.

In second place, Spain saw how the workers from the baby boom generations born in the 1970s and 1980s consolidated in the Spanish labour market. Unemployment rates were at their minimum historical levels during the early 2000s and the wage bill started to grow significantly until 2008. This phenomenon produced a strong push in the internal demand for housing in Spain. In just eight years, between 2000 and 2008, the Spanish construction sector doubled its gross value added. This growth benefited not only the construction industry, but also its whole supply chain, including manufacturing industries such as construction materials, ceramics, furniture, or electronic appliances. In 2008, the size of the manufacturing industry in Spain reached the maximum historical size of 141 billion euro GVA, 36 billion euro more than in 2000. Despite this growth in production volume, employment in manufacturing industries slightly decreased in Spain from 2.9 million jobs in 2000 to 2.6 million jobs in 2008.

The growth of the construction industry was abruptly interrupted by the great recession of 2008-2013. This economic downturn in Spain was more severe than in other countries because it was characterized by the combination of two different forces that contracted the demand. On one hand, the Spanish economy faced the collapse of the domestic demand in the whole supply chain of the construction sector. On the other hand, Spanish firms had to face the slowdown of the external demand due to the global crisis.

The Spanish manufacturing industry managed to circumvent the problem of external demand by decoupling labour productivity and wages. During the period 2008-2019, while the productivity per hour in the manufacturing industries increased by 13%, labour costs per employee decreased by 2%. The decoupling process increased competitiveness, allowing manufacturing exports to rise by 52% over the same period up to 172 billion euro in 2018. The industries in which exports grew at a higher rate during the period 2008-2019 were the Chemical industry, the Motor vehicle industry, the Manufacturing of other transportation equipment, the Wearing apparel industry, and the Food industry.

Despite the good performance of exports, the Spanish manufacturing industry has not been able to offset the problem of weak domestic demand. In fact, between 2008 and 2019 the GDP of the manufacturing industry in Spain fell by 26% to a minimum level of 114 billion euro in 2013. After 2013, the Spanish manufacturing industry recovered in terms of GDP reaching 139 billion euro. Despite this improvement in production volume, manufacturing industries have not been able to recover previous employment levels, destroying nearly 600,000 jobs between 2008 and 2019. Notably, 40% of the job loss was concentrated in suppliers or auxiliary industries in the supply chain of the construction sector.

Table 4: Trends in Manufacturing Industries: Persons employed 2008-2018 (Spain)

Industry	**2008**	**2018**	**Variation 2008-2018**
Food products	337,224	377,697	40,473
Beverages	52,194	56,862	4,668
Textiles	59,355	46,123	-13,232
Apparel	83,876	43,715	-40,161
Leather	42,884	39,441	-3,443

Wood and other products	90,580	54,682	-35,898
Paper	53,777	45,385	-8,392
Printing	91,836	60,452	-31,384
Chemical	94,477	94,135	-342
Pharma	40,140	47,449	7,309
Rubber and plastic	116,055	100,876	-15,179
Non-metallic mineral products	183,735	98,615	-85,120
Metallurgy	75,919	60,757	-15,162
Fabricated metal products	367,256	256,135	-111,121
Information Technology products	41,182	27,800	-13,382
Electrical equipment	84,266	71,760	-12,506
Machinery	130,894	112,814	-18,080
Vehicles	164,064	161,721	-2,343
Aerospace, train and ships	49,762	49,602	-160
Furniture	115,808	61,592	-54,216
Other	45,488	41,991	-3,497

Repair	75,288	95,550	20,262

It is important to point out that the internal devaluation process mentioned above (understood as a reduction in unit labour costs) has not been transferred to a larger reduction of domestic or export industrial prices as compared to the main European competitors. Contrastingly, the internal devaluation produced an increase in the gross operating surplus of manufacturing companies in Spain. Between 2008 and 2019 the gross operating surplus per employee for the Spanish economy increased by 20%.

Table 5: Macroeconomic Variables in Spain, 2008 vs 2019

	2008	2018
GDP	1,109,541	1,244,772
Wages	422,811	440,482
Persons Employed	20,512	20,266
Gross Operating Surplus	477,690	546,449
Goods Exports	193,476	293,867
GDP Manufacturing Industries	140,862	138,899
Wages Manufacturing Industries	63,300	56,175

Persons Employed Manufacturing Industries	2,628	2,029
Gross Operating Surplus Manufacturing Industries	58,638	65,968

The decoupling between wages and labour productivity has not only happened in Spain. Most developed economies have noticed this phenomenon since the early 2000s. One of the main reasons for the decoupling process is Skill Biased Technological Change. The gains in labour productivity observed from the beginning of the XXIs century are explained by the combination of the skills of a small proportion of high-skilled workers and the increasing adoption of information technologies and organizational innovations. However, most of the workforce with lower skills have not contributed to these productivity gains, making the average wages to remain stable. Because of this process, wage inequalities have typically risen. For instance, the difference between workers in the top-3 deciles of wage distribution and the rest of the deciles increased in Spain by 8% between 2009 and 2017.

In Spain, skill biased technological change had no incidence between 2000 and 2008, because of the growth of the construction industry and its supply chain. The industries in the construction supply chain were labour intensive, had low productivity and had low levels of adoption of information technologies and organizational innovations. Nevertheless, after the sudden crisis of 2008, manufacturing industries less labour intensive, more productive and more intensive in information technology and innovation started to drive most of the recovery of the Spanish industry.

The returns to capital investment in Spain increased because of the combination of internal devaluation and the decoupling between labour productivity and wages. For this reason, the period 2008-2019 has seen a strong increase in foreign direct investment in the manufacturing industry. In fact, while foreign direct investment in manufacturing reached a cumulative total value of €34,185 million between 2000-2008, the cumulative total value of foreign direct investment in manufacturing sectors rose to €53,681 million in the period 2008-2019, even despite of the recession. Often, these capital investments did not translate into new productive capacities (greenfield investments) or improved existing productive capacities (brownfield). In fact, the levels of foreign gross investment in tangible goods in the manufacturing industry were below those of 2008 until 2017.

One of the main challenges of modern economic policies is to increase or even maintain employment levels in a future where skill biased technological change will become more intensive. A possible answer to this question would be to sharply increase the proportion of high-skilled workers in the overall labour force by supporting the growth of those higher value manufacturing industries which are high-skills intensive.

Therefore, to compensate for the huge job loss post-2008, the Spanish manufacturing industry needs a strong growth impulse based on a shift towards the production of higher value-added goods and its complementary services. In fact, the combined effect of market globalisation and skill biased technological change will hamper the sustainability over the medium and long term of economic policies based on internal devaluation or low costs.

Currently, the shift towards this new paradigm is not possible because a huge part of the Spanish labour and management in manufacturing industries need to transform their skills and competences in order to create high value goods and services. Moreover, the existing institutions, culture and policy instruments governing innovation systems in Spain have demonstrated over the last decades that they are not ready to support the transformation of these skills and competencies in labour and firms.

Manufacturing firms in Spain have specialized in certain sectors such as the automotive industry and its components, the chemical industry and plastics, and the food industry, pharma industry, and the aerospace industries. All these sectors are facing major challenges for the future that require new competencies. European environmental regulations are imposing the transformation of the automotive industry towards the manufacture of electric vehicles. The chemical industry faces the challenge of a more efficient use of energy and reduced waste generation. The food industry is facing the increasing demand for healthier, more value-added and gourmet products in developed markets and growing competitiveness of low-cost countries from North-Africa in low-value food products. The pharmaceutical industry faces increasing competition from low-cost manufacturers (i.e., India), and new opportunities arising from the digitalization of the industry, the scientific advances in genomics and the integration of food and health industries. The aerospace industry must resolve the challenges arising from lower military spending in many countries, the beginning of the era of private exploitation of space and the evolution towards a more sustainable air transportation industry.

All these changes imply that the Spanish industrial policymakers face the task of promoting an urgent shift towards high-value products. Over the past decades, manufacturing industries in Spain have already undergone some transformation processes. However, the competencies needed for industrial transformations in the past were less uncertain than the current need for competencies, and therefore, the manufacturing industry in Spain is probably facing the most uncertain transformation process in its recent history.

As commented above, the value added of the Spanish manufacturing industry in 2019 was 139 billion euros, still below the 141 billion euros value added of 2008. The number of jobs in this industry barely exceeded two million in 2019. Because of the Great Recession, the Spanish manufacturing industry destroyed 600,000 jobs between 2008 and 2019. This figure represents 30% of the 2.6 million jobs that existed in the sector in 2008.

One of the main effects of the Great Recession of 2008-2013 on the Spanish manufacturing industry is the increasing dependence on foreign investment, foreign markets, and the strategies of foreign multinationals.

The proportion on the total value added of the manufacturing industries in Spain created by foreign companies has increased significantly from 21% in 2008 to 34% in 2018. The average size of the manufacturing foreign companies has also increased in the same period from 232 employees in 2008 to 272 employees in 2018. While in 2008, 378 thousand employees worked in foreign manufacturing companies (15% of total employment in manufacturing industries), in 2018 the number of workers in these firms was 455 thousand (23% of total employment in manufacturing industries).

The manufacturing industries that have attracted the largest proportion of foreign investment during the last decade have been the Chemical industry, the Food industry, Non-metallic mineral products industry (mainly cement industries), Metallurgy (mainly in the manufacture of aluminium), Petroleum and Vehicle components and accessories.

Between 2008 and 2018, the main investor countries were Luxembourg (mainly in the Aluminium sector), the Netherlands (mainly in the Food, Paper and Cement sectors), the United Arab Emirates (mainly in the oil refining sector through the purchase of CEPSA by the Abu Dhabi sovereign wealth fund), Japan (mainly in the Chemical industry), Germany (mainly in the pharmaceutical sector) and France (mainly in the Food and Cement sectors).

It is interesting to notice that the foreign firms are targeting those industries with higher export potential. In 2018, 72% of the gross value added of the Motor vehicle industry was produced by foreign companies. Similarly, the same year the share of foreign production reached 56% in the Manufacture of electrical material and equipment, 54% in the Manufacture of other transport equipment, and 43% in the Chemical industry.

The general description of the manufacturing industries in Spain should take into account of regional diversities. Spain has a heterogeneous distribution of competences and industries, which has led to different processes of industrial specialization in the different regions. This report analyses in detail the specific characteristics of the manufacturing industries in Madrid, Catalonia, Basque Country and Andalusia. The selection of these regions is explained by the fact that population, innovative activities and the manufacturing industry are highly concentrated in these four regions. More than half of the value added (54%) and 50% of the employment in the manufacturing industry, as well as 53% of the population is concentrated in these four regions. Despite the Great Recession, the concentration of population, manufacturing production and employment has not increased over the last 20 years.

Table 6: Selection Criteria Spanish Regions

Region	Variable of Inclusion in the Study	Value	Relevance
Andalusia	Region with the largest population (000 people) in Spain, 2020	8,483	Andalusia has 18% of Spanish Population
Madrid	Region with the largest GDP (million euro) in Spain, 2019	240,129	Madrid has 19% of total GDP in Spain
	Region with the largest employment (000 workers) in Spain, 2019	3,191	Madrid has 18% of total employment in Spain
	Region with the highest apparent labour productivity (GDP per employee in euro) of manufacturing industries in Spain, 2019	79,692	Spanish Average 72,174 euro
Catalonia	Region with the largest Manufacturing GPD (million euro) in Spain, 2019	34,839	Catalonia has 25% of Total Manufacturing GDP in Spain
	Region with the largest manufacturing employment (000 workers) in Spain, 2019	450.4	Catalonia has 23% of Total Manufacturing Employment in Spain
Basque Country	Region with the highest contribution of manufacturing industries to regional GDP in Spain, 2019	19%	Spanish Average: 11%
	Region with the highest contribution of manufacturing employment to regional total employment in Spain, 2019	20%	Spanish Average: 11%
Andalusia+Madrid+Catalonia+Basque Together	Population (000 people) 2020	25,081	53% of Spanish Population
	GDP (million euro) 2019	717,305	58% of Spanish GDP
	GDP Manufacturing industries (million euro) 2019	74,532	54 % of Spanish Manufacturing GPD
	Employment (000 workers)	9,872	56% of Spanish Employment

	Manufacturing Employment (000 workers)	1,003	52% of Spanish Manufacturing Employment

Table 7: Selected Variables Describing Spanish Regions

	Population (000 people) 2020	**GDP (million euro) 2019**	**Employees (000 workers) 2019**	**Manufacturing GDP (million euro) 2019**	**Manufacturing Employees (000 workers) 2019**	**Contribution of Manufacturing to total GDP**	**Manufacturing employment in total employment**	**GDP per Employee in Manufacturing Industries (euro)**
Andalusia	8,482	165,866	2,585.7	11,584	199	7%	8%	58,211
Catalonia	7,655	236,814	3,173.2	34,839	450.4	15%	14%	77,350
Madrid	6,755	240,130	3,190.9	13,667	171.5	6%	5%	79,692
Pais Vasco	2,189	74,496	922.3	14,442	182.2	19%	20%	79,264
Spain	47,351	1,244,772	17,479.7	138,899	1,924.5	11%	11%	72,174

The innovative activity is even more concentrated in these four regions. In 2019, Andalusia, Catalonia, Madrid, and the Basque Country accounted for 71% of total business in-house R&D investment in Spain and for 75% of total public in-house R&D investment. Clearly, Catalonia and Madrid lead the innovative activity in Spain with 52% of the total business in-house R&D expenditure and 60% of the total public in-house R&D expenditure, due to the presence of several of public research infrastructures, the location of the headquarters of the most innovative multinationals and large Spanish companies.

A first common characteristic to these four regions is the ageing of the workforce. In all four regions, the marked aging of the population has increased the number of retired workers by nearly one million between 2008 and 2019. This increase in retired workers has stagnated the active population, even though the regions analysed have experienced a small increase in population.

Catalonia, the Basque Country, and Madrid are, together with Cantabria, the four regions with the highest labour productivity in Spanish manufacturing industries. However, these leading regions in Spain have lower labour productivity than most regions in Belgium, Germany, Austria, Norway, the United Kingdom, Denmark, France, Ireland, Finland, or the Netherlands. Likewise, the productivity of the most productive regions in Spain is between two and three times lower than the productivity of the leading regions in manufacturing productivity in Europe. In terms of manufacturing labour productivity, Catalonia is the 83rd most productive region in the EU, the Basque Country is the 91st, Madrid the 103rd and Andalusia the 137th.

Among the four regions analysed, Andalusia has the lowest manufacturing productivity, the lowest ratio of income-value added and the lowest ratio of wages to value added (49%). Low productivity of Andalusian manufacturing is explained in part by lower size of the firms and weaker economies of scale. Andalusian manufacturing firms have on average 7 employees, compared to 10 employees in Madrid, 13 employees in Catalonia and 18 employees in the Basque Country. The average manufacturing firm in Spain has 9 employees if it is Spanish-owned and 273 employees if it is foreign-owned. The industrial structure of Andalusia also has a strong influence on the low manufacturing productivity of the region, since the vast majority of manufacturing employment in the region is concentrated in low value-added sectors (81% of employment in low value sectors), compared to 62% in Madrid, 48% in Catalonia and 46% in the Basque Country.

In both Madrid and Andalusia, the manufacturing industry represents a small proportion of the economy, with 6% and 7% of GDP respectively, while in Catalonia and the Basque Country, the importance of the sector is greater, with 15% and 19% of GDP respectively. For this reason, the economic policies of Catalonia and the Basque Country have traditionally paid more attention and budget to the development of manufacturing industries compared to Madrid and Andalusia.

Catalonia, the Basque Country, and Madrid have managed to recover production levels prior to the 2008 crisis, unlike Andalusia, which suffered from the lower competitiveness of its industrial structure. However, none of the four regions has managed to recover the pre-crisis level of manufacturing employment of 2008. Catalonia stands out for having had the largest job destruction in absolute terms (140,000 jobs).

Catalonia, Madrid, and Andalusia have a bipolar sectoral structure that combines a few concentrated sectors with a strong presence of large multinational companies, and a large number of highly fragmented manufacturing sectors where the activity of micro-SMEs is very intense. In the highly fragmented sectors of these regions, there is little innovative activity and low levels of competitiveness. The situation in the Basque Country is different, since the average size of firms is higher and the proportion of companies carrying out innovative activities is also higher (28% firms carry out innovative activities in the Basque Country compared to 26% in Catalonia, 23% in Madrid and 19% in Andalusia). The greater innovative activity in the Basque Country benefits from the close relationship between innovation technology centres and companies, which allows companies to carry out innovative activities even if they do not have the internal resources to do so.

These four regions specialize in different industrial sectors. Andalusia specialized in Food, Aerospace, Chemical and Metallurgy industries. Catalonia specialized in Motor Vehicles, Chemical, Food and Pharmaceutical industries. Basque Country specialized in Metallurgy, Metallic Products and Machine and Equipment manufacturing. Madrid specialized in Aerospace, Motor Vehicles, Pharmaceuticals and High Value Services (Consulting, Engineering, Software and Professional Services). The specific characteristics of these industries will be discussed in detail in the next sections, but taking into account that the analysis of the arrangement of innovative transformations in these industries should consider regional diversities in terms of industrial specialization, industrial competences, institutions, and culture.

1.6 East Germany: a case of restructuring, transformation, and new institutional settings

Entering a development which aims at marketable products of higher values added based on increasing innovative content reaches beyond the activity of a single enterprise. Although marketing and sales is related with enterprises, there is R&D required to develop the products, research facilities and engineering to transfer knowledge to enterprises, skilled and educated labour to realise manufacturing and frequently this is based on collaboration among firms of different competences. Access to markets or a position along the supply chains and value chains is important to promote sustainable socio-economic development. While in existing situations of manufacturing and economic activity this already indicates that it relates with a complex arrangement of elements, transformation demands for an almost full reorganization and modernisation of such settings. Since the entire socio-economic system is changing and developing a process needs to be established which helps to overcome current problems but also to prepare systematically for future processes of development and constant modernization.

When the political situation of Europe changed in 1990 many countries and regions located in the former Eastern Bloc faced this challenge. The specificity of the German situation was the unification of the Federal Republic of Germany with the German Democratic Republic and the responsibilities which were laid out in the constitution. The German government had to take care of the socio-economic development in East Germany and had to help in supporting the transformation of the system. While much was realized through the national government the federal structure of the country also meant that new regional authorities had to be established which took over the exclusive responsibilities for certain areas in research, education, and regional development. This situation demanded a transfer of institutions and policies to support enterprises in their attempt to modernize substantially. West German Regional Governments (Länder), in addition, were active in helping the New Länder to introduce departments and policies which were employed in West Germany before and were necessary to carry out the policies in accordance with the federal system. This did include the welfare system, the role of the social partners, but also the areas of research and education.

Although this was a fundamental change in many ways and many institutions had to be established from scratch, certain elements were already to some extent in place. Relationships between research and enterprises existed and a system to train a skilled labour force was already in place. These were differently organized but the fundamental elements of skills and education were available. Many researchers were eager to take advantage of opportunities which did not exist because of the previous political situation, and quite a number of enterprises had the potential for modernisation and the labour force was skilled and ready and able to engage in further training. While some enterprises disappeared due to high and uncompetitive prices after the introduction of the Western currency or because their products did not meet anymore the expectations of the customers, others now could take advantage of the new environment. Firm could, for example, access research that was kept secret before, were allowed to modernize by reorganization of the enterprises, had access to new markets and partners for forming new networks with other enterprises in the region, or could access new technologies which were not available before. Simultaneously, there were public policies on continuing education of the work force on both manufacturing as in business administration which helped to cope with the new system. The fundamental changes of the entire systems in economy, industry, administration, and society, of course, were widely balanced through a welfare system which did avoid the worst possible effects and by a migration of approximately three million people to West Germany, particularly to Bavaria, Baden-Württemberg, and North Rhine-Westphalia and, in addition, many found jobs along the former inner German border in regions which were West Germany before. Those who left were mostly highly skilled and well-educated workers and had a longer lasting impact on the recovery of a number of rural regions. Younger age cohorts left and among them in some regions 30 to 50% of young well-trained women.

The transfer of institutions and funding helped tackling the difficult societal problems while it was a much more difficult task to arrange the transfer of institutions for a sustainable and innovative socio-economic development. Here, the Länder of Saxony and Thuringia are of particular interest. They formed the industrial centres of former East Germany and had a long tradition in mechanical engineering, precision engineering, optical industries, industrial ceramics and chemical industries, medical instruments, measurement instruments and apparatus building. Although the products were either not state of the art or due to prices no longer marketable there were competences in these areas ready to modernise. The introduction of the system of *Applied Science Universities* (Fachhochschulen) helped because it was addressed to bring research competences and higher education to less central regions and to interlink such competences with innovation-oriented enterprises of the regions. Thus, 27 Applied Science Universities were founded in Thuringia and Saxony, all East Germany now has 90 (only 49 excluding Berlin) of these institutions of higher education. The orientation varies and often it is oriented in the specific industrial competences of regions and their enterprises or meant to add additional competences which may help for further competences and innovation.

Table 8: Universities and Applied Science Universities in East Germany

	Universities	Students	Applied Science Universities	Students
Berlin	13	128031	41	61200
Brandenburg	6	35445	10	12682
Western Pomerania	3	23022	7	14134

Saxony-Anhalt	2	33901	5	18259
Thuringia	4	32309	9	41065*
Saxony	7	75767	18	26752
Total	35	328475	90	174092
				* Includes 24841 Students in Private University with focus on remote teaching

While the Applied Science Universities clearly have a regional focus, in addition, there are traditional universities which are regarded to build linkages with the international scientific community. The Technical University of Dresden in particular did benefit from a decision to strengthen their competences in information and communication technologies and to focus on related engineering departments. Because of this orientation there are international collaborations which help participating in leading-edge development and made their contribution recognised within the academic community. Spin of enterprises as well as additional research institutions supported federally or by the State of Saxony are complementing the Technical University. Similarly, the Technical University of Cottbus was established in Brandenburg having a strong focus on robotics which was established in close collaboration with the department at the Technical University of Berlin. Also, the University of Magdeburg engaged in several departments of high technological importance. It is important to see that the success of the technical University of Dresden is built upon expertise of both the university and the surrounding industries which did exist already before 1990 providing an appropriate basis for modernization on an established level of competence. Frequently, such universities were complemented by top-research carried out at institutes of the Max-Planck-Society for the Advancement of Science and the Fraunhofer Society. Further particularly strong research competences were located in East Germany by the Leibnitz Foundation which also helped to develop a wide area of research.

These different activities helped to revitalize and modernise the research basis of East Germany which brought state of the art knowledge into these regions and allowed to exploit these for the benefit of the regions. Furthermore, the federal system of Germany allows for establishing foundations oriented in innovation which are funded by the individual state (Land). These are meant to support the infrastructure and projects which have the potential to become technologically relevant and economically attractive. Following the example of West German Länder the newly established Länder in East Germany started their own foundations to focus on the particular opportunities of their state (Land). The foundations were ready to complement the activities in relationship with the institutions of research and higher education. The federal system allows for activities of the Länder which are very close to their opportunities and highly specific situations. These institutions help to transfer knowledge to the region and from research and education to enterprises of the region.

The specific need for support is also characterized by innovative policies. Although the federal government is not supposed to engage in regional policies as the Länder are tasked with such polices, instruments were invented to initiate additional research and technology-based development. Since the situation of the East German Länder was characterized – and still is – by the small size of the enterprises the *Federal Ministry of Research and Technology (BMBF)* launched a program which is addressed to less central regions for activating their potentials. The programme provides support to clusters with the *potential of innovative growth (Wachstumskerne*) and allows bottom-up initiatives to form consortia to develop a common platform of technology. The findings can be exploited by the enterprises individually according to their products and competences or jointly by using the platform as a basis for products to be manufactured jointly. This did help the small and medium-sized enterprises to gain technological competence, as a consortium to get attention from larger enterprises or customers worldwide and to modernize their current products by the access to research and development they could not afford on their own. Furthermore, this policy instrument allowed them to continue or bring competence to rather peripheral regions and to continue making their techno-industrial competences effective for development in the region.

Table 9: Foundations in East Germany: The Example of Thuringia

State	Name	Activities
Thuringia	State-wide	
	Stiftung für Technologie, Innovation und Forschung Thüringen (STIFT) (Erfurt)	supports businesses, universities, and research institutions in innovative and competence building activities
	University Specific	
	Ernst-Abbe-Stiftung (Jena)	provide science and innovation support foremost to the University of Jena but supports also select research across Thuringia and has a specific focus on education in the area of optics
	FBF-Stiftung für Wissenschaft und Kunst (Schmalkalden)	supports local R&D/university
	Stiftung Wissenschaft und Technik Ilmenau (Ilmenau)	supports local R&D/university

Bildungs- und Technologiezentrum zu Eisenberg-Stiftung (Eisenberg)	supports local R&D/university
Technology Specific	
Stiftung NanoTechnologie (Jena)	support for research related to nanotechnology
Klimaschutzstiftung Jena-Thüringen (Jena)	supports research related to renewable energy and environmental sustainability

Table 10: Wachstumskerne (Growth Poles) East Germany

State	Wachstumskerne / Growth Poles
Berlin	8
Brandenburg	4
Western Pomerania	9
Saxony-Anhalt	10
Thuringia	15
Saxony	26

Figure 31: Growth Poles in East Germany

(Source: BMBF - Innovative regionale Wachstumskerne)

It is important to see that institutions successfully can be transferred to a region. The case of East Germany highlights the difficult adjustment when such institutions transferred and when employing such institutions in general to make sure these match the highly divergent situations. Consequently, such institution-building and the introduction of new policies can be realized in a successful way when the existing situations are considered. Besides the case of East Germany, the restructuring of the Ruhr Area is an impressive example. As a region characterized by mining and steel mills it was changed by establishing higher education. While there was no university or Applied Science University during the 1960s and 1970s there were massive policies towards restructuring and transformation. Today there are around 20 Universities and 70 Applied Science Universities. Spin-offs from university research and start-up enterprises have mushroomed and helped the region in the attempts to change the industrial structure.

What can be learned from the East German example is that transformation demands for a mix of policies in different areas. There is the need for capable welfare policies which help to reduce problems associated with unemployment. Instruments of short-time work in relation with training or re-education. This also helps to provide well skilled labour for a newly emerging industrial structure and contributes to appropriately skilled workforces of the enterprises. National and regional governments need to search for appropriate solutions while knowing about the diversities of opportunities and innovation. Situations at individual locations may vary significantly and policies need to be adjusted accordingly. It is important that upgrading of skills and re-education keep in mind potential areas of employment after industrial structures are changed or enterprises have modernised their strategies and products. The transformation takes time and demands for short-term activities and solutions which also need to contribute to the aim of a modern and sustainable industrial structure. Successful transformation refers to situations where policymaking considered opportunities of existing industrial structure, workforce, and research capabilities to establish in a suitable way.

Chapter 2

2.1 MNEs and SMEs in Germany and its states

Germany has a variety of large MNEs and large corporations of international importance and with control functions in international supply and value chains. Companies in the area of automotive include for example Volkswagen, Daimler, BMW but also large automotive suppliers like Bosch and the Schaeffler Group but also other broad technology oriented corporations like Siemens. In the area of chemicals and pharmaceuticals, Bayer, BASF, Merck, and Boehringer Ingelheim are for example located in Germany. While these corporations are important, Germany's industry is overall comprised by SMEs and in 2019 54.4% of GVA and 63.7% of employment in Germany is generated by SMEs. In 2018, especially small and medium sized corporations exceed the European average in employment and gross value generation (see table)

Table 11: Employment and Gross Value Added by Company Size Classes in 2018 (Germany)

	Number of Persons Employed			GVA		
Size	Number	Share Germany	Share EU	GVA in billion	Share Germany	Share EU
Micro (0-9)	5,795,011	19.3%	29.7%	276.5	15.5%	20.8%
Small (10-49)	7,208,212	24.0%	20.1%	334.4	18.8%	17.6%

Medium (50-249)	6,096,584	20.3%	16.8%	357.7	20.1%	18.0%
Large (250+)	10,884,283	36.3%	33.4%	812.7	45.6%	43.6%

Source: adapted from SBA Facts 2019 – Germany

A distinct characteristic of SMEs in Germany is that they are, compared to SMEs in other EU countries, stronger involved in extra EU export activities and import documenting the international reach of their business activities and integration in international business. Overall, 16.9% of German SMEs export outside the EU compared to 9.8% of EU SMEs. Similarly, 16.5% of German SMEs import goods from extra-EU locations compared to the EU average of 11.63%. The export orientation may be an indicator of the international competitiveness of the SME sector in Germany.

A study of R&D in Germany and the role of SMEs in manufacturing and manufacturing related services shows that SMEs (10-249 employees) were responsible for 16.3% of innovation related expenditures of German corporations in 2013 – 40% of those innovation expenses of SMEs were generated by only 4% of SMEs. Corporations between 250-999 employees contributed 13.7% to innovation related expenditures. While the share of R&D of SMEs appears to be small it should be considered that few large corporations have significant R&D budgets. Volkswagen alone had an R&D budget of 13.1 billion compared to the 5.2 billion R&D expenses of German SMEs in 2013.

Manufacturing is overall dominated by SMEs in Germany though in some industries large corporations have considerable influence. While in NRW the manufacturing industry is overall characterized by SMEs, e.g., in 2018, only 10% of companies were larger than 250 employees some sectors have a considerable share of large corporations. These coal and petroleum (47%), Vehicle industry (31%), Metallurgy (25%), and Manufacture of pharmaceuticals (20%). Other vehicles, electrical equipment, and Chemical industry have with 18% also relatively high shares of large corporations.

Large corporations are more common in West German states and though SMEs are dominant overall, company sizes are substantially smaller in East Germany. Overall larger companies are present in the West though variation exist among industries. For example, in the key industry Machinery Industry the average firm size in Bavaria and Baden-Württemberg is approximately 62 employees, in North Rhine-Westphalia the average size is around 41, while it is 36 in Saxony and 34 in Thuringia. The Fabricated metal products shows a more balanced picture (~26 employees), though firms are especially small in Saxony (22). While Thuringia has among the observed states the largest average size of food products firms (36), Saxony has with 17 the lowest.

The industrial composition of the five regions varies (see table 12 displaying the 5 most influential industries based on employment numbers, detailed information on the states industries and exports/imports can be found in Appendix 4) indicating different competences within regions. Saxony and Thuringia's largest industries are for example fabricated metal products, while in the West German states Machinery Industry leads in employment numbers. While Manufacture of machinery and manufacture of fabricated metal, as well as Manufacture of motor vehicles, trailers and semi-trailers and food products are present in most states, some states have other competences. Thuringia has a special competence in the rubber and plastic industry, while Saxony has a comparatively large workforce in Manufacture of computer, electronic and optical products. North Rhine-Westphalia has a large workforce in the chemical industry and the basic metal industry. While salaries per employee are mostly above the state average in those sectors, the food products industry, represented in most states among the largest sectors, is an exception – on the other hand salaries in the motor vehicle industry are high constituting an important element for the regional economies.

Measured by exports other competences of the regions are highlighted showcasing which products are competitive in an international market environment. In Bavaria (16.4%), Baden-Württemberg (14.3%), and Saxony (30.5%) “Motor cars and motor caravans” are the main export product, while in Thuringia automotive parts are the most important export product. Differences in the diversity of exports emerge. Finished cars are exported globally, while parts are mostly traded within the EU. Parts are mostly aligned with supply networks of large manufactures and have distinct geographies within their EU trade patterns – Bavaria’s main export destinations are for example Austria (10.5%), Poland (8.23%), and the UK, while Saxony is sending a substantial share of its part exports to Spain (16.2%) and the UK 9.56%). Thuringia exports the majority of produced parts to Hungary (22%), Spain (19.4%), and Finland (11.8%). Understanding the relationship of the automotive industry in Spain with Thuringia and Saxony, given their high share of exports to Spain, may provide useful insights in the distribution of innovation and value added in the automotive industry and Spain’s position within.

In most states major export goods accumulate substantial shares of overall exports (e.g., automotive in Saxony with 41.6%) - NRW deviates from this pattern and has a more diverse mix with the largest section being pharmaceuticals with a 5.2% share at exports.

Table 12: Largest manufacturing industries by Employment in Select States

Rank	Bavaria	Baden-Württemberg	NRW	Saxony	Thuringia

1	Machinery Industry	Machinery Industry	Machinery Industry	Fabricated metal products	Fabricated metal products
2	Vehicle industry	Vehicle industry	Fabricated metal products	Machinery Industry	Rubber and plastic industry
3	Electrical equipment production	Fabricated metal products	Metallurgy	Vehicle industry	Food products
4	Food products	Electrical equipment production	Food products	Manufacture of computer, electronic and optical products	Machinery Industry
5	Fabricated metal products	Rubber and plastic industry	Chemical industry	Food products	Vehicle industry

2.2 MNEs and SMEs: Clusters and Chains in Spain

Multinationals, large Spanish-owned corporations, industries, clusters, and SMEs are the core of the industrial system in Spain.

The first element of the Spanish industrial system are Multinationals (MNEs). MNEs have increased their presence in Spain over the last decade, despite the new competition from low cost locations in Eastern European and Asian countries. The presence of MNEs has not homogeneously increased across different industries. Moreover, the increasing presence of MNEs has not implied a growth in employment strong enough to outweigh the loss of employment in Spanish owned firms. Therefore, the goals and strategies of the MNEs and their Spanish subsidiaries need to be studied carefully.

The second element of the Spanish industrial system are the industries. Industrial analysis should take into account that technological change is modifying industrial boundaries. Firms may profit from existing competences to reduce entry barriers into new industries. Namely, firms may pivot on an existing competence to build a new valuable competence in a new market. For instance, food firms such Nestlé are entering the health industry, car components manufacturers such as Gestamp are successfully competing in energy industries, or chemical firms such as BASF are competing in the software industry through its subsidiary BASF Digital Solutions located in Madrid. Therefore, industrial analysis and policies should use a broader concept of industry more based on competences than on products.

The third core element are SMEs. SMEs are a heterogeneous group of firms ranging from start-ups to centenarian's family firms. Therefore, SMEs need to be understood not as a single entity but as an integrated part of a larger value chain where the value of the SMEs competences and strategies would fluctuate according to the path of change in the value chain. This complexity means that traditional economic policies designed to support SMEs in

Spain with a “one size fits all” approach cannot be successful, and need to be transformed into more value chain specific initiatives.

SMEs and large corporations will participate in clusters in order to get access to the existing knowledge flows within and across value chains. Similarly to what happened with SMEs policies, clusters across Spain are quite diverse in structure, governance and goals. Therefore, general “cluster” policies that do not recognize these diversities will fail in supporting cluster consolidation and growth.

This section will study how these dimensions of the Spanish industrial system apply to the main Spanish manufacturing sectors in the four regions considered: Food, Vehicles, Chemical, Pharma and Machinery.

Food industry is the largest industry in Spain. In Andalusia and Catalonia, the Food Industry is the main industry in terms of employment (26% and 19% of total manufacturing employment respectively) and turnover. In Madrid, the Food Industry is the leading industry by employment (11% of total manufacturing employment), but the third industry in terms of turnover. The Food industry in the Basque Country is an exception in terms of economic relevance, since it represents only 6% of total manufacturing employment in the region. Catalonian Food sector is highly internationalized compared to other Spanish regions with 7.4 billion euro in exports in 2019, mainly directed to France and to a lesser extent to Italy and Germany. The exporting performance of the Food industry in Catalonia is supported by transformed and high value products. Catalonian production is concentrated around the processing of meat products, with an important production pole in Girona. Catalonian Food industry has on average, a higher proportion of high-skilled workers, higher R&D levels and labour productivity than the rest of Spanish regions. However, Food firms in Catalonia are still smaller than the leading competitors in the EU markets and lack the access to the funds needed to start an innovation-driven transformation. For instance, Germany, the United

Kingdom or France have a venture capital sector significantly more active in investing in Food manufacturing companies as compared to Spain and Catalonia in particular.

The Food Andalusian sector is more concentrated in low value products where olive oil is the main transformed products. While olive oil production is concentrated in Jaén and Córdoba provinces, olive oil exports, mainly to Italian and Portuguese markets, are driven by large companies located in Seville, such as the Portuguese group Sovena or the Spanish owned Grupo Ybarra-Migasa or Acesur. The rest of the export activity of the Food industry is explained by the tractor effect of the strong agro-industrial cluster in Almeria. However, most of the exports of this cluster are related to low value products such as raw vegetable products or fruits.

The Spanish aerospace sector is mainly present in Madrid (5,200 million euros of revenue in 2019) and Andalusia (2,600 million euros of revenue in 2019) due to the Airbus plants in both regions of Airbus. Practically all of the sector's production is destined outside Spain (Aerospace exports were 4,000 million euros in Madrid and 2,200 million euros in Andalusia). The products of the Madrid and Andalusian aerospace industry were mainly exported to countries with other Airbus factories, such as France, Germany, and the United Kingdom. Imports of this industry came mainly from the United States. The Andalusian aerospace supply chain also produces components for the Madrid plants.

Airbus plants in Madrid are responsible for the design, engineering, and manufacture of components for all Airbus aircraft. In addition to components for the A330 and A320, the plants manufacture components for the A350 and A380 long-range aircraft. The Cadiz plant in Andalusia is more focused on the production of A380, A330, A320 and A350 components that will be fully assembled at the Madrid plant.

Airbus' decision to cease production of the A380 program and the expected slower recovery of intercontinental flights that will affect A350 orders pose significant challenges to aerospace production in Madrid and Andalusia. The Madrid and Andalusia plants are also focused on military aircraft. For example, the Madrid plants are also home to the Eurofighter assembly and the A330 MRTT conversion centre, where refuelling systems and military avionics are installed on Airbus A330 aircraft in their conversion to the Multi Role Tanker Transport version. The Seville plants (San Pablo and Tablada) are the epicentre of Airbus' military transport business, with final assembly lines for the A400M four-engine turboprop aircraft and the twin-engine C295 and CN235 transports. Andalusia is also home to the Airbus International Training Center and the Airbus Military Aircraft Delivery Center. Airbus has two major engineering centres in Madrid, one focused on aircraft and helicopter components and the other on satellite development and space mission engineering. These Madrid centres perform work for most European space programs (Ariane commercial launch vehicles), the Copernicus Earth observation platforms and the Galileo satellite navigation constellation. Madrid is also the prime contractor for satellites such as PAZ and Ingenio (the Spanish Earth observation satellites), and for the European Space Agency's CHaracterising ExOPlanet Satellite spacecraft.

Most of Spain's regions participate to a greater or lesser extent in the value chain of the Vehicle sector. Catalonia is the region of Spain with the largest presence of the sector with a turnover of €18 billion and exports of €10.2 billion in 2019. In Madrid, the sector has the highest turnover in the region with €5.6 billion and €2.7 billion in exports. In the Basque Country, the sector is much more export oriented and less dependent on the domestic market, as in 2019 it had a turnover of €6 billion and €5.4 billion in exports. In contrast, the Catalan sector is the one that is most dependent on the evolution of the Spanish demand and is more affected by the decisions on economic, environmental and innovation policy taken by the Spanish government. In all three regions there is the tractor effect of large multinationals in the sector. Catalonia is home to the Volkswagen Group's factory for the production of cars under the SEAT, Audi and Cupra brands. The main automotive industry plants in the Madrid region are the Stellantis group for cars, the American firm John-Deere for tractor components and the Italian group CNH Industrial for trucks. The Stellantis plant is the group's smallest assembly plant in Spain and is focused on the final stages of production of the Citroen C4 model. Interestingly, the Stellantis plant in Madrid began a transition to electric car production in 2017 in order to be ready to produce the electric version of the third-generation Citroen C4. However, demand for these cars remains weak, and the plant's productivity capacity, number of shifts or employment have not increased significantly. Low demand also explains why battery components for cars produced in Madrid are imported from China and assembled at the plant the group has in Vigo, Galicia.

The CNH Industrial group's plant in Madrid specializes in heavy trucks and produces the X-Way, S-Way, Trekker and Stralis models for European markets. It is currently one of the group's most efficient plants and exports 90% of the production. John-Deere used to produce tractors in Spain, but after 1992 the Madrid plant has specialized in the production of components for the plants the firm has in Germany and the United States.

Catalonia benefits from the tractor effect of the SEAT plant and its ecosystem. SEAT is the second largest car manufacturer in Spain. The plant in Catalonia has not started to develop manufacturing competencies linked to electric cars yet, lagging behind some other plants of the Volkswagen group outside Spain. Moreover, some of the design effort from SEAT and Cupra does not have a strong effect on local employment, since the Volkswagen group has decided to exploit economies of scale by grouping in a single plant the production of different cars that share the same platform. For this reason, the WV groups produces outside Spain cars designed in Catalonia such as the SEAT Mii electric, which is produced in Slovakia in the same plant of Skoda Citigo and Volkswagen E-Up, the SEAT Ateca, which is being produced in the same plant as the Skoda Karoq in Czechia, the SEAT Tarraco, which is being produced in the same plant where the Volkswagen Tiguan Allspace is assembled in Wolfsburg in Germany, and the SEAT Alhambra, which is being produced in same plant as the Volkswagen Sharan in Portugal. The first electric car designed by SEAT, the Cupra Born model is going to be produced in the Zwickau (Germany) plant of Volkswagen group, highly specialized in producing electric cars. The Basque Country is home to the factory of the Mercedes-Benz group where vans Vito, Viano and ClassV, including some hybrid electric versions. However, the plant of Mercedes-Benz in the Basque Country would need a complete reconfiguration of processes and layout in order to adapt to fully electric vans.

Madrid has some plants of large suppliers of car components such as Bosch, Gestamp, Saargummi or Faurecia which export car components to France and Portugal following Stellantis Group supply chains. Catalonia and the Basque Country are also home to numerous suppliers of this supply chain, not only for Mercedes-Benz or Volkswagen, but for other manufacturers located in Spain, such as Renault and Ford. The characteristics of the products manufactured and the strategies of the parent companies have a very clear influence on the different export destinations. Thus, while the Madrid sector exports mainly to France and Italy, the Catalan automotive sector is oriented towards Germany, the United Kingdom and France, while Basque exports are mainly directed to Germany. The sector is not as relevant in Andalusia as in the other three regions, with the important exception of Renault's gearbox factory for combustion, hybrid, and electric vehicles located in Seville.

The Spanish chemical sector has two very important activity poles in Catalonia and Andalusia. These poles have benefited from the presence of oil refineries and an adequate port infrastructure, and in the specific case of Andalusia, also from the access to raw materials in the Andalusian mines. For example, CEPSA's two refining plants also create strong externalities to the chemical industry, such as Cepsa's plant in San Roque, which is the second largest phenol production plant in the world.

The chemical industry is the second largest industrial sector in Catalonia with a turnover of 18.5 billion euros and 37,000 employees, accounting for almost half of the employment in the sector in Spain. The region's chemical industry has recovered very quickly (in less than two years) from the great recession of 2008. Although chemical manufacturing historically began in Barcelona, it is increasingly concentrated in Tarragona. Exports of the sector in Catalonia reached 11.1 billion euros in 2019, experiencing a growth of almost 50% compared to 2008. These exports go mainly to France, Italy and to a lesser extent Germany. Although the cluster has plants of several multinationals such as BASF, Covestro, Dow Chemicals, Elix Polymers, Sekisui Specialty Chemicals or Messer, the activities of Spanish SMEs are particularly relevant. Although companies in this cluster invest heavily in R&D, Spanish chemical industry tends to produce more incremental innovations. The industry is highly dependent on rising electricity costs in Spain and faces the future challenge of stricter environmental regulations regarding its production processes and the recycling and reuse of products.

In Andalusia, the chemical cluster is concentrated in Huelva. The sector's turnover in the region amounted to 6 billion euros, making it the second largest industry in Andalusia in terms of revenue. While coke and oil exports have shown strong volatility in the last decade, exports of chemical products in Andalusia have not stopped growing even during the Covid-19 crisis. Basic chemicals such as phenol and high purity copper cathodes are some of the main products exported from this Andalusian chemical cluster.

The manufacture of plastic raw materials is the main line of business in the Spanish chemical industry with €11 billion in 2019, ahead of organic chemistry with €9 billion and perfumes and cosmetics with €5 million. Due to the importance of plastics, a large plastics manufacturing industry linked to the chemical industry has developed in Catalonia and Andalusia. This sector in turn serves the supply chain of the construction, food, and automotive sectors, which are among the most important sectors in the economies of these two regions. This interconnection between supply chains leads to snowball phenomena when any change affects any of these sectors. For example, the stagnation of the construction sector, the reconfiguration of vehicle design brought about by electrification and the increasingly demanding regulations on product packaging are three challenges that threaten not only the plastics sector, but also the whole Spanish chemical sector.

The pharmaceutical industry is concentrated in Madrid and, above all, Catalonia. In 2019, the production of the pharmaceutical industry was 6.6 billion euro in Catalonia and 4.5 billion euro in Madrid. Pharmaceutical products produced in Madrid were sold mainly in Germany, United Kingdom, France, and Italy, while those produced in Catalonia were mainly sold to Germany, France, and Italy. Most of the imports of pharmaceutical products came from the United States, Germany, and France. There are differences between Madrid and Catalonia pharmaceutical industries. In Madrid, the plants of large multinationals such as Merck, Insud Farma, Teva, Pfizer, Astellas or GSK are responsible for most of the production, despite some of the main Spanish owned producers have plants in Madrid such as Normon, Rovi, Servier, Indas, Pharmamar or Synerlab. In the pharmaceutical sector, Madrid counts on 23 production plants both from Spanish firms (Faes Farma, Normon, Rovi, Prim, etc.) and multinationals (GSK, Pfizer, Abbott, Lilly, among others). While some of these Spanish firms and multinationals have R&D centres in Madrid such as Rovi, Lilly or GSK, compared to other regions in Europe, the activity of the pharmaceutical industry in Madrid is increasingly focused on contract development and manufacturing, and less on the development of new pharmaceutical products. Additionally, the innovative activities of pharmaceutical firms in Madrid are more focused on applied pharmaceutical research (the region had the largest number of patients in clinical trials in Spain with almost 34,000 patients in more than 600 trials).

In Catalonia there are plants from large multinationals as well, such as Novartis, Sandoz, or Sanofi, but there is the presence of a larger number of Spanish owned manufacturers such as Grifols, Bioiberica, Ferrer, Reig Jofre or Esteve. Because of these Spanish firms, the Catalonian pharmaceutical industry is more focused on product innovation even if product innovation activities are diminishing over the last decade.

In the Basque Country, the main industries revolve around the machine tool sector. Manufacture of metal products, except machinery and equipment is the main sector in the region with 7.2 billion euros revenue and 43,200 employees in 2019. The Manufacture of machinery and equipment also stands out with 4.5 billion euros revenue and 20,100 employees. Historically, the sector has also had a strong Metallurgy industry; manufacture of iron, steel, and ferroalloy products with 6.5 billion euro and 17,000 employees. In general, in these three industries there is a high presence of microenterprises. However, the Manufacture of machinery and equipment has a greater number of medium-sized companies and the Metallurgy, manufacture of iron, steel and ferroalloy products sector has some companies of considerable size such as Mittal-Arcelor, Sidenor, Gsb, Tubacex, and Tubos Reunidos.

Many Basque firms of these three industries are embedded in the supply chains of automotive, aerospace, train, or ship-building industries. Nevertheless, as we will discuss below, the Basque government is trying to diversify the industrial structure of the region by entering into biotech, renewable energies, and health ecosystems. The firms in the region have been early adopters of Industry 4.0 technologies in Spain, especially the Basque suppliers in the aerospace industry supply chain. However, the adoption process has been interrupted by the severe impact of Covid-19 crisis in the aerospace industry. Moreover, the adoption of additive manufacturing processes in the region is following an approach with little cross-fertilization between firms in the aerospace supply chain and other early adopters of additive manufacturing in the automotive, energy and construction industries. Additionally, the adoption of additive manufacturing in Basque firms is suffering from the lack of standards on Additive Manufacturing, which in part is due to this lack of inter-industrial cooperation, and the lack of skilled workers that may use Additive Manufacturing machines.

Within the Manufacture of machinery and equipment and Metallurgy and Metallurgy sectors, the Basque Country is the main exporting region in Spain with 3.2 billion Euro and 3.1 billion Euro respectively. The main export destinations of the Manufacture of machinery and equipment industry were France and Germany, while the main export destinations of basic metals were France and the United Kingdom. However, while exports of machinery and equipment have increased 23% between 2008 and 2019, exports of metallurgy products fell in the same period by 27% due to strong competition from Asian countries and overcapacity in the sector. The Manufacture of metallurgy; manufacture of iron, steel and ferroalloy products is also a relevant industry in Andalusia with 5.9 billion euros. However, compared to Basque Country, Andalusia is specialized in the exports of precious metals and lower value products.

2.3 Germany: Skills, R&D, and policy instruments

Training and continuous training

The German labour market overall is characterized by skilled labour which completed vocational training (apprenticeship). These apprenticeships, which usually take 3 years and contain 70% workplace-based education and 30% theoretical schooling, provide employees with professional competences through in-company training based on binding requirements guaranteeing a uniform national standard – social partners together with the BIBB create and update in cooperation the core content of vocational training programs. Though this is a challenge for SMEs as they are often not able to cover the broad training requirements in-house, SMEs either cooperate with each other or engage with larger corporations to cover parts of the mandated curriculum. Among the 25–64-year-old population in 2018, 57.5% completed vocational training (vast majority) or obtained upper secondary degrees. Among the age group of 25–34-year-olds 47.2% have obtained vocational training and can be considered skilled labour and 7.5% have obtained an upper secondary education degree in Germany. The share of tertiary education grew among the 25–64-year-old population from 21.3% in 2000 to 29.1% in 2018. Notably, the share of vocational training among the population is not affected by this increase. Rather the share of unskilled labour in Germany declined from 18.7% in 2000 to 13.4% in 2018. This trend shows that the unskilled labourer continues to disappear in Germany indicating the strong demand for skills. The strong focus on vocational training provides businesses in Germany with a specialized workforce able to adapt to changing demands due to their broad education. In the manufacturing sector this workforce may be a necessity to innovate production processes and manufacture complex products. It should be noted that the vocational training in the GDR – with differences in curricula, technology, etc. - was similar to the West German system, and a skilled labour force was present after reunification though skills had to be updated.

Recently, spearheaded by Baden-Württemberg with the creation of an applied science university specialized in dual study programs, dual study programs are increasingly popularized to reinforce the link between vocational training and academic studies and support the development of specialized labour and technology transfer and innovation. STEM subjects constitute between 32% (NRW) to 38% (Thuringia) of the newly signed dual study contracts in 2017 – these programs are especially popular in Bavaria and Baden-Württemberg, overall, the most innovative states in manufacturing, compared to the overall population distribution. Thuringia is a leader among East German states while dual study programs are less popular in Saxony.

In the higher education sector, the vast number of students visit traditional universities, but the applied science universities provide a more application-oriented training. Overall, student numbers increased fast after the establishment of these institutions. In 2019/2020, nearly 75000 students were enrolled in Thuringia. 32300 students studied at universities in Thuringia – among those, 4370 were involved in Math or natural sciences subjects, 7570 studied engineering related subjects, and 2300 studied medicine or other health related subjects. Over 41000 students studied at universities of applied sciences – nearly 9400 studied engineering related subjects while nearly 3000 studied medicine or other health related subjects; 250 studied math or natural sciences related subjects. This compares to overall 17000 students in Thuringia in 1992.

In 2019/2020, nearly 107000 students were enrolled in Saxony. 76000 students studied at universities in Saxony – among those, 10100 were involved in Math or Math or natural sciences subjects, 23000 studied engineering related subjects, and 7500 studied medicine or other health related subjects. Around 27000 students studied at universities of applied sciences – nearly 14500 studied engineering related subjects while nearly 500 studied medicine or other health related subjects; 1300 studied math or natural sciences related subjects.

The employment of scientists and engineers is another indicator for skills within manufacturing. In absolute numbers, the West German states are ahead. Especially Baden-Württemberg and Bavaria attract a high share (over 28% in 2018) of the within the state employed scientists and engineers into the manufacturing sector contributing to the competitiveness of their industries. In the other observed states approximately 18% of scientists and engineers are employed in the manufacturing industry.

Continuous training is an important aspect involving social partners and corporations. Overall, German corporations spent in 2017 11.2 billion on continuous training or 0.3% of the GDP. In 2010, 60% of small corporations emphasized in their continuous training on improving technical skills and job core competences of their employees. In contrast, larger corporations tended to provide training related to general competences (IT training, language training, etc.). Especially the manufacturing sector has invested in career advancement of its employees – 20% of businesses had at least one person taking part in a career promotion training driven by corporations with high digitalization affinity. The role of unions is apparent in continuous vocational training – employees of businesses with a by social partners established continuous vocational training agreement spend in the manufacturing industry on average 7.6 hour on training in 2015. In contrast, employees in manufacturing businesses without such agreement take part on average in 2.2 hours of training.

R&D Landscape: Knowledge Transfer

In 2018 nearly 105 billion were spent on R&D within Germany but these expenditures are highly localized. Three German states are responsible for 61.2% of R&D expenditures in 2018: Baden-Württemberg (27.9%), Bavaria (18.8%), and North Rhine-Westphalia (14.5%). Only 12.6% were spent in East Germany including Berlin – while the share of East German R&D expenses was initially higher with 14.4% in 1997 the share since 2003 fluctuates around 13%. While Berlin's R&D expenditures amount to 4.8% of overall expenditures, among the other East German States Saxony (3.4%) and Thuringia (1.4%) are leading in R&D expenditures – measured in relation to the state GDP R&D expenditures amount to 2.21% of state GDP in

Thuringia and 2.81% in Saxony. While this exceeds NRW's GDP share (2.11%) of R&D, Bavaria (3.15%) and Baden-Württemberg (5.3%) are well ahead in relative and absolute terms.

Based on 2017 R&D expenditure data, in Germany 69.1% of R&D expenditures are generated by the private sector. The share is especially high in Baden-Württemberg (83.6%), Bavaria (75.9%) and Hessen (75.6%) – in North Rhine-Westphalia 58.9% of R&D expenditures are generated by the private sector. Except for Bremen (34%) and Saarland (49.2%), the private sector generates in all West German States more than 50% of R&D expenditures. In the East, the private sector contributions are lower – Thuringia (50.2%) and Saxony (43.5%) have the highest shares of private sector R&D expenses at total expenses.

The R&D landscape in Germany is comprised by universities, applied science universities, and research institutes. Notable are here the applied science universities which were founded since 1969 to address a shortage of skilled labour and provide skilled and specialized workers by focusing on applications in teaching. Later in the 1980s the mission was expanded by emphasizing applied research. The application focus makes the universities of applied science an important factor in technology transfer. After reunification, the applied science university system was transferred to the East German states leading to their creation and designation in the early 1990s. States like NRW pursued a science based industrial transformation after the traditional coal and metal related industries started to experience pressure. Overall, over 70 applied science universities were founded in the state to provide qualified labour and promote technology transfer to complement existing skills and increase the competitiveness of remaining businesses. A similar strategy was pursued in Saxony and Thuringia. For example, 5 universities of applied sciences were designated in Saxony and nine in Thuringia.

Research institutes complement the higher education sector. While overall the majority of research institutions is in West German states, R&D policies focussed on the establishment of complementary research institutes in East Germany to support the development and resilience of existing industrial structures. The population wise largest state in Germany – NRW - has 14 Fraunhofer Institutes, 12 Max Planck Institutes, 10 Leibniz Association institutes, and three Helmholtz centres supplemented by 29 state funded research institutes. Saxony, with only 23% of NRWs population has six Max Planck Society Institutes which received in 2008 € 34.9 m in regional support, 14 Fraunhofer Institutes (€ 3.8 m regional support), 2 Helmholtz Centres, and ten Leibniz Association Institutes (seven institutes received € 61.4 million in regional support in 2008) are located in Saxony. Additionally, three German Centres of Health research and various state government funded institutes (7) are present. Currently the BMBF is conducting a competition to create two additional Helmholtz institutes in the Lausitz area, a former coal mining region, to support economic structures in the region. The goal is the formation of research centres with complementary links to existing regional competences. Both centres will receive up to 170 million Euro annually in funding. Similarly, Thuringia, approximately half the size of Saxony, has five Fraunhofer institutes, three institutes of the Max Planck Society, one institute of the Helmholtz Association, five Leibniz Association institutes and a variety of state funded research institutes (e.g., 9 research institutes at the Beutenberg Campus Jena e.V., 8 industry-oriented regional research institutes). These numbers in combination with the variety of transfer institutions show the strong emphasis on technology transfer to modernize and foster the competitiveness of industries in East Germany.

The innovation and research landscape is further supported by various foundations providing funding or services for research and technology transfer. The Steinbeis Foundation in Baden-Württemberg as transfer agent was introduced earlier. In Thuringia, a similar approach is pursued. The Stiftung für Technologie, Innovation und Forschung Thüringen (STIFT) (Erfurt) supports businesses, universities, and research institutions in innovative and competence building activities. Special emphasis is given to technology-based start-ups and networking between actors. Support takes the form of subsidies, loans, and guarantees as well as the creation of university chairs. The Ernst-Abbe-Stiftung (Jena) provide science and innovation support foremost to the University of Jena but supports also select research across

Thuringia and has a specific focus on education and training in optics aligned with the local industrial cluster.

The Steinbeis Foundation is present with approximately 600 transfer offices in Baden-Württemberg mainly serving the SMEs of the state with consulting, engineering, and other services related to enhancing competences of SMEs. Though not free, state subsidies are enabling SMEs to seek contact with the transfer institutions and have initial conversations with experts about potential innovation pathways – these experts are in many cases persons with relations to R&D and higher education institutions.

The initial cooperation between a Steinbeis consultant and a company is free for the company to reduce barriers and familiarize SMEs with science-based cooperation and is subsidized for several days in which the consultant aims to understand the applied needs and the situation of the company and provides initial recommendations. Within the Steinbeis framework companies can seek help in finding cooperation partners – these cooperations can be supported by the Steinbeis foundation with mentoring/coaching to help in overcoming challenges; this can be also subsidized by state funds. As an additional service the Steinbeis foundation provides for example consulting services how companies and cooperations can receive EU subsidies and provides support in creating applications for competitive programs. This activity of the Steinbeis foundation is subsidized by Baden-Wuerttemberg. Main characteristics of the interaction between Steinbeis and SMEs seems to be the focus on cooperative exchange and the support/mentoring of R&D cooperations.

Several university locations have foundations supporting research (e.g., FBF-Stiftung für Wissenschaft und Kunst (Schmalkalden), Stiftung Wissenschaft und Technik Ilmenau (Ilmenau), The Bildungs- und Technologiezentrum zu Eisenberg-Stiftung (Eisenberg)). Other foundations provide topical support for research areas. Examples are the Stiftung NanoTechnologie (Jena) providing support for research related to nanotechnology while the Klimaschutzstiftung Jena-Thüringen (Jena) supports research related to renewable energy and environmental sustainability.

In contrast, foundations in Saxony are more topical and geographically limited than the foundations supporting technology transfer between R&D institutions and businesses in Thuringia and for example Baden-Württemberg. While, for example, in Leipzig, the "Leipziger Stiftung für Innovation und Technologietransfer" (Leipzig Foundation for Innovation and Technology Transfer) focuses on the transfer of basic research and applied research to businesses and society similar to the STIFT/Steinbeis foundations in the Leipzig area, no state-wide foundation could be identified pursuing a similar mission. A variety of topical foundations provide support for sustainability research, medical research, nanotechnology, and other fields. Functions as being conducted by the Steinbeis or STIFT in Thuringia seem to be performed partially by the SAB (Sächsische Aufbaubank) in Saxony - a development bank. While the SAB connects companies with consulting, engineering, and other services related to enhancing competences of SMEs, it also supports local SMEs in other ways. For example, the SAB supports SMEs in hiring qualified transfer assistants with industry experience and high academic qualifications providing funding for up to 48 months and up to 50% of the salary (up to 60000 Euro) embedding transfer competences directly within SMEs.

While other factors contribute, manufacturing data shows an increase in gross value added in the East German states of Saxony and Thuringia likely associated with the large-scale investments in R&D and higher education. While GVA and employment has increased, the share of private investments in R&D expenditures is compared to industrial centres in West Germany still low – this may be an expression of the by small corporations dominated manufacturing sector in both states as small corporations rarely have the funds to pursue R&D projects on their own. It should be also noted that the investment cost was high and the generation of benefits of the implementation of these institutions has not been instantaneous but rather a decade long process requiring patience and continuous investment. East German GVA in manufacturing, mostly driven by Saxony and Thuringia, has increased from 4% in 1991 to 9% in 2018.

Policy Measures

The German States are embedded in European and national funding frameworks – given the importance of SMEs for the German economy in size and innovative potential, a strong focus is put on fostering the innovativeness of SMEs by supporting R&D and linking SMEs with higher education and research institutions.

Examples of federal SME centric policy programs are the ZIM and InnoRegio programs. The ZIM (Zentrales Innovationsprogramm, Central innovation Program), for example is designed to support the innovativeness of SMEs. Businesses and their development pursuits are supported with non-repayable subsidies. While individual companies are supported, the program emphasizes especially the cooperation between corporations and R&D institutions and the formation of networks including the establishment of international linkages. The latter part aims to contribute to the internationalization of SMEs but also connecting companies with for the innovation process necessary competences. The program pays between 50 to 120% of the pre-tax salaries of the in the innovation project involved employees (up to 120000 Euro per employee) reducing the risk of innovation – rates vary by regional conditions and type of project (cooperation, single project) with structurally weaker regions (e.g., former coal regions, East Germany) and cooperative projects receiving higher subsidy rates. The program supports SMEs and middle-sized companies under 500 employees. Corporations up to 1000 employees can benefit if the cooperate with at least one SME in their innovation project. Additionally, the program finances pre innovation studies and provides support in the commercialization of R&D projects.

The in 1999 started and 2006 ended InnoRegio program is another example. The idea of the program to build on existing regional competences an innovation strategy for regions to especially support competitiveness and innovativeness of SMEs and create sustainable innovation networks in East Germany and keeping competences in structurally weak regions.

These networks can be built upon specific regional competences, which can also exist in structurally weaker regions aside of the larger population centres. Building networks among regional partners is one of the main goals to allow the exchange and transfer of ideas and competences to develop new products. The program was designed as a competition in which regions had to develop strategic concepts and a jury selected overall 23 network proposals staring to fund 1100 projects since 2001. Evaluations showed that involved companies increased employment by 11% and the businesses involved in exports (~75%) increased exports by 73% from 2000 to 2004.

Overall, the larger policy concepts and technology fields invested into are similar among German states within their own state programs. Main funding sources, especially for East Germany are the European ERDF and ESF programs though capital endowments vary (see table) and focus technologies differ slightly. The Regional Innovation Smart Specialisation Strategy (RIS3) focusses generally on industrial production and systems (material design, plant-design, nanotechnology), information and communication technologies (mobility and logistics, microelectronics, ITC), renewable energy (e.g., PV), as well as health innovation (e.g., biotech, m-health). Additionally, the strategies identify – if not covered in the aforementioned areas, basic technologies with larger impacts across multiple sectors (e.g., new materials, laser technology, micro-systems technology, mechatronics). Additionally, the strategies emphasize SMEs and R&D focussing on technology transfer and innovation by encouraging the formation of clusters and/or networks. Exemplarily current policy programs in Saxony and Thuringia are described and additional information for other states can be found in Appendix 5.

Saxony

The subsidy structure and emphasis in Saxony has shifted since the 1990s. While initially support was targeted towards public research and the establishment of transfer institutions, the current emphasis of public subsidies is the formation of networks and clusters enabling the private sector to build cooperative relations with other businesses and R&D institutions.

Saxony receives funding from various EU programs. During the funding period 2014-2020 Saxony receives 2.1 billion Euro from the European Regional Development Fund (ERDF/EFRE), and 663 million Euro from the European Social Fund (ESF). Main priorities of the ERDF funding in Saxony are strengthening research, development, and innovation in Saxony (933 million Euro), increase the competitiveness of SMEs (288 million Euro), subsidize the reduction of CO2 emission in all economic areas (418 million Euro), integrated and sustainable city development (192 million Euro), and promote environmental risk prevention (209 million Euro). ESF priorities relate to promoting employment and education (adoption to technological change), increase quality of education, competence building, and lifelong learning, social inclusion, and poverty reduction.

Innovation related EFRE Measures are focussed on strengthening R&D and innovation and the competitiveness of SMEs. The program “Forschungsinfrastruktur und Forschungsprojekte” (research infrastructure and research projects) supports building improvements at universities and the purchase of devices, funds application oriented R&D projects, supports building information infrastructure and access (libraries), and supports pre-founding research of start-ups (incubator projects/ transfer). Within the program “InET”, application oriented innovative energy technology research related to efficiency increases, energy generation etc. can receive funding. The program “Technologiefoerderung” (technology support) is focused on promoting the exchange between science and businesses offering three measures: funding for research cooperation between businesses and research institutions as well as individual R&D projects of individual businesses; promoting technology transfer by offering especially SMEs funding for obtaining external technology as well as funding technology integration and external consulting services; support for SMEs to use external R&D services to develop new or improved products/processes/services.

Overall, the emphasis of R&D and transfer support is directed towards a set of key technologies. These include microelectronics, ITC, nanotechnology, material design, advanced production technologies, and PV- and biotech. Another sector of special relevance for Saxony’s subsidy frameworks are innovative approaches and technologies in the health care sector especially related to e-health, and ambient assisted living.

SMEs are eligible for additional support measures. These include the provision of venture capital for start-ups in high tech sectors; support for SMEs for the introduction of new products or design (for example, external knowledge intensive business services); support digitalization; market expansion/ international exposure; financing for expansion/upgrading; support high speed internet adoption/access.

Thuringia

Thuringia receives funding from various EU programs. In the funding period 2007-2013, Thuringia received 1,477 billion Euro from the European Regional Development Fund (ERDF/EFRE) and 629 million Euro from the European Social Fund (ESF). Overall, 367 R&D projects received ERDF funding while 149 cooperative projects, cluster, and networks received funding. 805 start-ups received funding; 160 companies relocated to Thuringia subsidized by funding – overall 7800 jobs were created. Additionally, 53km of new state streets were newly build and 16km were upgraded. Under the ESF program 257 million were spent on social inclusion measures, 238 million were spent on improving access to education and increasing the quality of education, while 95 million Euro were spent on lifelong learning programs and promoting entrepreneurial thinking. Seven hundred thousand people benefitted from ESF funding. Additional 14 million were allocated to transnational projects.

During the funding period 2014-2020 Thuringia receives 1.17 billion Euro from the European Regional Development Fund (ERDF/EFRE), and 499 million Euro from the European Social Fund (ESF). Main priorities of the ERDF funding in Thuringia are strengthening research, development, and innovation in Thuringia, increase the competitiveness of SMEs, subsidize the reduction of CO2 emission in all economic areas, integrated and sustainable city development, and promote environmental risk management and flood protection. ESF priorities relate to promoting employment and mobility, education, competence building, and lifelong learning, social inclusion, and poverty reduction.

Thuringia's innovation policy is guided by the RIS3 (regional innovation strategy for smart specialization) strategy concept. Its implementation is organized by the Thuringian Cluster Management Company comprised of scientific and economic stakeholders, which aims to foster cooperation between economic, social, and other partners and the education system and develop ways to improve the region al innovation strategy. Within Thuringia's RIS 3 strategy “four fields of specialization are emphasized: (i) industrial production and systems, (ii) sustainable and intelligent mobility and logistics, (iii) healthy life and health economy, (iv) sustainable energy and utilization of resources. Additionally, the strategy identifies the cross-cutting field of information and communication technologies, creative industries and services.” Thuringia’s Innovation Policies build upon these fields and support innovation, networking, and knowledge transfer distributing European funds. 333 million Euro of Thuringia’s EDRF funds are allocated to promote R&D and innovation in the 2014-2020 funding period. Of those, 161.7 Million are assigned to the Program (Richtlinie zur Förderung von Forschung, Technologie und Innovation (FTI-Richtlinie)) which supports three aspects: 1) support of R&D projects. Cooperation between businesses and research institutions is supported. Single companies are eligible for funding if they are SMEs. 2) Innovation vouchers. The preparation of R&D cooperation, feasibility studies for R&D projects, model projects are eligible for funding. Furthermore, creative economy services and the protection of intellectual property can receive funding. Funding is available for process and organizational innovation implementation. 3) Infrastructure support. This includes support for R&D infrastructure like the creation of innovation centres. Within this knowledge-based start-ups can receive free rent in application/innovation centres.

The research support program (Förderung der Forschung) subsidizes research in Thuringia associated with the specializations developed in the RIS3. It provides funding for research projects and research infrastructure which includes expenses for R&D personnel, investments in devices, and external services.

The program to promote R&D intensity in Thuringia (Förderung der Forschungs- und Entwicklungsintensität in Thüringer Unternehmen und Forschungseinrichtungen (FuE-Personal-Richtlinie)) provides funding for SMEs to fund students (up to doctoral level) at Thuringia’s higher education institutions and hire them afterwards as R&D personnel. Research institutions can receive funding for establishing research groups and research. This program is sponsored by the ESF.

Additionally, Thuringia is investing in an initiative expanding and strengthening existing research infrastructure and attracting talented researchers (ProExzellenz). From 2008-2011 110 million were spent on 27 projects. In the period 2012-2019, 20 million were invested. The initiative ProDigital (2020-2024) is promoting digitalization in academia to drive innovation and cooperation among higher education institutions and R&D facilities – the program is funded with 10 million.

The policy programs in both states in conjunction with the national program show the strong orientation towards SMEs. Policies are designed to form cooperation among SMEs and link them with R&D institutions to foster technology transfer as well as cross sectoral exchange with other corporations. Notably is the focus on building on existing capabilities while supporting development and research of cross-sectional technologies providing SMEs with access to new technologies.

Table 13: European Funding in funding period 2014-2020

	Bavaria	Baden-Württemberg	NRW	Saxony	Thuringia
ERDF	495 million	246.6 million	2.42 billion Euro (50% from the EU)	2.1 billion	1.17 billion
ESF	298 million	260 million	627 million	663 million	499 million

2.4 Skills and education matching and the transformation of industries

Innovation is a human-centred process that relies on the fit between business opportunities, institutional framework, organizational routines and skills. In this section, we focus on skills and how educational policies promote the development and updating of skills. The contrast between institutional rigidity of educational systems and the speed of technological change typically produces a mismatching between education supply and skills demand in all modern economies. The goal of this section is to understand the nature and extent of this mismatch in Spain.

Spain has the second largest population of bachelor's degree (1.2 million) and doctoral degree students (71.5 thousand) students in the EU. Spain has also the largest ratio of bachelor students per capita in the EU (25 students per 1000 habitants) and the second largest ratio of doctoral students per capita (1.5 students per 1000 habitants).

Despite this large number of students, the Spanish educational system has traditionally failed in transforming high levels of educational attainment into competencies that are valuable to the labour market. Consequently, the unemployment rate for workers with tertiary education levels is, together with Greece, the highest in the EU (9.4% at the end of 2020).

Regarding the four regions in our analysis, Andalusia has the third largest unemployment rate of tertiary education students in Spain (12.4%). The unemployment rate of tertiary education students is 7.7% in Madrid, 6.1% in Catalonia, and 5.3% in the Basque Country, which is the lowest in Spain, but it is still above the average rate in the EU.

A second impact of the education-skill mismatch in Spain is that workers with tertiary education tend to be employed low skills positions. For this reason, the proportion of workers with tertiary education who are overqualified for their employment is 23% in Spain. The over qualification of workers with tertiary education has an impact on worker of different educational levels in Spain. For instance, recent data for Catalonia shows that Information Technology students in vocational training have higher unemployment rates because the job positions that require vocational training skills are being done by overqualified bachelor graduates. The large supply of Bachelor graduates in Spain is displacing workers with secondary educational levels to lower skill jobs and in turn worker with secondary educational levels are expelling from the job market those workers with low educational levels.

A third impact of the oversized tertiary education demand in Spain is the lack of financial resource to cope with it. The Spanish education budget per tertiary education student is one of the lowest in the EU (5,540 €), significantly below the average of the EU (8,705 €). Therefore, public higher education institutions, which are the main player in public R&D in Spain with more than 75% of R&D public personnel, are oversized and underfunded compared to the vast majority of EU countries. Oversize and underfunding explains only in part why higher education institutions in Spain lack the resources needed to transform education into valuable skills. A second important reason for this problem is curriculum rigidity. In Spain the process to adapt higher education programs to technological change is very slow because of rigid and extremely bureaucratic systems of program quality accreditation and strong cultural resistance against change by higher education professors and institutions.

Regarding higher education institutions in our regions of interest, Madrid is the region with the largest number of universities in Spain: 15 universities with 32 technical or polytechnic schools and 98 non-technical schools. Catalonia has 12 universities with 23 technical or polytechnic colleges and 124 non-technical schools, Andalusia 11 universities with 27 technical or polytechnic colleges, 118 non-technical schools and the Basque Country has 3 universities with 5 technical or higher polytechnic schools and 33 non-technical schools.

These four regions have a large population of university students. For instance, Madrid is the region in Europe with the third largest population of university students after Ile de France and London. Madrid has 308,000 university students, 49,000 of which were master's degree students. Andalusia has 245,000 university students (26,000 Master's students), Catalonia has 281,000 university students (48,000 Master's students) and the Basque Country has 59,000 university students (5,000 Master's students). Altogether, these regions have almost one million university students. However, despite this large number of students, Spanish universities offer relatively few vacancies available in technical disciplines (Engineering, Architecture and Science) as compared to other disciplines. Therefore, even if the unemployment rate tends to be lower for graduates in technical disciplines, the proportion of students in these fields has not increased over the last decade above 25% of total students. Madrid had in 2019 73,000 students of technical disciplines (12,000 Master's degree students), Andalusia 64,000 students (7,000 Master's), Catalonia 70,000 students (12,000 Masters) and the Basque Country 17,000 students (2,000 Master's).

Madrid and Catalonia attract scientists and engineers from many regions of Spain. In 2019, Madrid had 325,000 scientists and engineers and Catalonia 286,000. However, this skilled labour often works in industries and occupations where their skills are not used to produce innovation. For instance, only 84,600 scientists and engineers in Madrid were employed in high technology sectors (High-technology manufacturing and knowledge intensive services). Moreover, in Madrid, 26,100 scientists and engineers work in manufacturing industries, but only 5,600 in high-tech manufacturing firms. Andalusia had also a large base of 199,000 scientist and engineers, but only 10% of them worked in high-tech manufacturing or knowledge intensive services. The Basque Country had 80,000 scientists and engineers, which is a relatively small number that contrasts with the relatively high innovative intensity of the region.

Traditionally, Vocational Training has not been very popular among the Spanish students, who prefer pursuing instead a bachelor's degree. Spain had just 413,000 students of

Higher Vocational Training during the academic year 2018-2019. Only a small proportion of higher vocational training students, 12%, studied in knowledge fields directly related to manufacturing processes. Almost 50% of the students in manufacturing fields enrolled in electricity and electronics, while the number of students studying mechanical production is slightly below 10,000.

At the regional level, Madrid had just 4,000 VET students enrolled in VET programs linked to manufacturing competences and Andalusia just 6,000. These are quite low numbers. In both regions, among the disciplines linked to manufacturing competences Electronics and Electricity programs are the most popular (50% of total students in manufacturing fields). Because of the oversupply of tertiary education workers and the relatively small local manufacturing industry, employment rates of VET students were not especially high in these two regions, 65% in Madrid and 55% in Andalusia, one of the lowest in Spain. Catalonia had 9,000 students in vocational training programs linked to manufacturing industry occupations and the Basque Country 8,000. This higher demand of this type of courses reflects the higher economic relevance of manufacturing sectors in these regions. Moreover, the VET specialization by disciplines also reproduces the productive specialization of these regions, since Catalan students followed mainly in courses in Electronics and Electricity (35%) and Chemistry (25%), while Basque students preferred Mechanical Production (45%) and Electricity and Electronics (30%). Employment rates for VET graduates were 70% in both regions, the highest in Spain. However, these employment rates are still below the employment rates of bachelor students. For this reason, many students prefer to study bachelor's degrees instead of a vocational training degree.

Industrial firms in Spain have often criticized the contents of Vocational Training, arguing that the public educational system focuses on competencies that are outdated and disconnected from the real needs of the firms. Recent education policies in Spain considered that dual vocational training programs could eventually solve this problem. Moreover, some large corporations such as Volkswagen with its Volkswagen Academy in Navarra, Seat in

Catalonia, Tubacex in the Basque Country, or Renault in Castilla-León have designed their own VET programs. Another initiative aimed at promoting dual VET programs in Spain is the Alliance for Dual Vocational Training, a public-private initiative led by the Bertelsmann Foundation, and that currently counts on more than 500 firms in Spain interested in dual vocational training.

Despite these efforts, the number of students in dual programs is still low. In 2018, only 16,400 students enrolled in dual VET programs in Spain. Moreover, only 4,400 of these students followed dual programs in fields related to manufacturing industries. Therefore, dual training is still anecdotal in most Spanish regions. In VET programs linked to manufacturing fields, Madrid and the Basque Country had a 7% of the students following dual VET programs, Catalonia 6%, and Andalusia just 3%.

There are regional differences in the content specialization of dual programs depending on the structure of the local manufacturing industries. For instance, while dual programs in the Basque Country were more oriented to Mechanical production, in Catalonia they were more focused on Chemical production, Mechatronics, and Electronics and Electricity. In some regions such as the Basque Country, Madrid, Cantabria or Extremadura, students in dual VET are significantly older than the rest of the VET students. This fact suggests the existence of a selection bias, where firms prefer to select experienced workers for their dual training programs. While this bias could help older workers to readapt their professional careers, it could also reduce the employability of younger workers looking for their job.

Continuous education is gaining more importance in public policies for adapting skills to technological change. One of the main institutions supporting continuous education in Spain is Fundae, a public foundation that subsidies training costs of the firms. In 2019, Fundae subsidized more than 12 million training hours for almost 900,000 workers in industrial sectors. Most of the Fundae training in industrial sectors focused on generic skills such as languages, safety regulations, and administrative tasks. There are differences between regions in terms of specific industrial skills developed through the Fundae funds scheme. On one hand, Madrid and Andalusia over the last eight years devoted relatively more training hours to Aerospace sectors than Catalonia and Basque Country. Similarly, Andalusia devoted more training hours to Food manufacturing than the rest of the regions. On the other hand, the Basque country devoted more training to metallic constructions, mechanical operations, mechanical production, and polymer transformation. Catalonian firms devoted a significant amount of training hours to electrical and electromechanical occupations. Overall, the structure of Fundae training initiatives matches the industrial structure of the region. The generally weak innovative strategies in Spain explain why firms using this instrument tend to demand training which is more focused on consolidating existing and simple competences than on developing new and more complex competences. This approach is more based on a conservative and tactical focus on skills updating, than on a strategic approach where continuous training is one of the main tools for boosting innovative change in Spanish firms. Nor do the Trade Unions, when involved in the design of continuous education in medium and large enterprises, follow a strategic approach to boost innovative change in Spanish firms.

Table 14: Vocational Training in Spain

	Madrid	Andalusia	Catalonia	Basque Country
Students in Vocational Training related to Manufacturing	4,000	6,000	9,000	8,000

Proportion of students by main Manufacturing Fields of Study	Electronics and Electricity (50%)	Electronics and Electricity (50%)	Electronics and Electricity (35%) Chemistry (25%)	Mechanical Production (45%) Electronics and Electricity (30%)
Proportion of Students of Manufacturing Fields in Dual Programs	7%	3%	6%	7%
Employment Rate (After four years of graduation)	65%	55%	70%	70%

Innovative efforts: MNEs, SMEs and the upgrade of products and value chains

Innovation processes are uncertain and risky tasks that require a significant amount of financial resources. This section analyses what are the financial resources devoted to innovation by Spanish industries with a special focus on SMEs and foreign MNEs.

In 2019, Spain spent 15.5 billion euros in R&D (1.25% of the Spanish GDP). The innovative effort is highly concentrated in the four regions of interest of this report. In 2019, Andalusia, Catalonia, Madrid, and the Basque Country accounted for 71% of total business in-house R&D investment in Spain and for 75% of total public in-house R&D investment.

Clearly, Catalonia and Madrid lead the innovative effort in Spain with 52% of the total business in-house R&D expenditure and 60% of the total public in-house R&D expenditure. The high amount of business and public R&D resources in these two regions is explained by the presence in these regions of the most important public research infrastructures, the location of the headquarters of the most innovative multinationals and large Spanish companies. More precisely, the region with the largest R&D internal expenses was Madrid with 4.1 billion Euro in (1.7% of GDP), followed by Catalonia with 3.6 billion euros (1.5% of GDP), the Basque Country with 1.5 billion Euros (2% of GDP) and Andalusia with 1.5 billion Euros (0.9 % of GDP).

Spanish firms nearly spent 9 billion Euro on internal R&D (0.7% of the Spanish GDP). The Basque Country with 1.1 billion euros is the region where firms invested a higher proportion in R&D (1.5% of regional GDP and 73% of the total regional R&D investment). In Madrid and Catalonia, firms´ R&D intensity is much lower, with 2.4 billion euro in Madrid (1% of regional GDP and 59% of the total regional R&D investment) and 2.2 billion euro in Catalonia (0.9% of regional GDP and 61% of the total regional R&D). Firms in Andalusia had a low R&D investment, with 0.6 billion euro (just a 0.3% of regional GDP and 40% of the total regional R&D).

Traditional analyses of the Spanish Innovation System underscore the absence of a sufficient number of small and especially medium-sized players with innovative competences as a major weakness of the innovation system. This comes from problems of capability, which also block absorptive capacity for externally generated knowledge. Without employees possessing at least basic technological and R&D process knowledge it is very unlikely that such companies can make effective use of R&D and innovation support schemes either at national or European level.

Although the weakness of the innovative competencies of Spanish SMEs is true, on occasions excessive political attention has been paid to this problem, to some extent hiding or minimizing the problem of the also weak innovative capacity of large companies in Spain.

In fact, in 2019 the total internal R&D spending of SMEs in Spain (4,100 million euro) was not significantly lower than the total internal R&D spending of large corporations (4,700 million euro). This is not the result of the good performance of Spanish SMEs, but of the low levels of R&D of large corporations in Spain. In fact, the average R&D spending per employee of firms with more than 250 employees in Spain (1,179 euro per employee) is significantly below the average R&D spending per employee of large firms in Germany (5,191 euro per employee), France (3,236 euro per employee) and Italy (3,147 euro per employee). One could thing that this is a problem of access to external funds. However this is not the case, since large companies in Spain are among those in Europe that devote the least amount (79%) of their own funds to R&D. In other words, the development of innovative capabilities has not so far been among the competitive priorities of large companies in Spain. Furthermore, among large corporations in the industry and construction sectors, foreign companies have a greater weight in R&D spending in Spain (40%) as compared to countries such as Germany (24%), Italy (22%) and France (35%).

Contrastingly, Spanish SMEs have an R&D spending per employee in (458 euro per employee) which is even higher than the R&D spending of German SMEs (312 euro per employee), not much lower than the R&D spending of Italian SMEs (513 euro per employee), even if it is much lower than the R&D spending of French SMEs (1,178 euro per employee). Therefore, the commitment of Spanish SMEs towards innovation is similar to their European counterparts.

In the manufacturing industry, the average R&D spending per employee is much higher than in the rest of the Spanish economy, with 3,616 Euro R&D spending for manufacturing firms with more than 250 employees and 1,029 Euro R&D spending for manufacturing SMEs.

In manufacturing, there are also larger differences between SMEs and large corporations in terms of total internal R&D spending. During 2019, total R&D spending for manufacturing SMEs was 1,325 million Euro, and 2,743 million Euro for large firms.

The industries that account for the largest share of R&D expenditure in Spain are Pharmaceuticals (19% of total R&D Spending in manufacturing), Aerospace (13% of total R&D Spending in manufacturing), Motor Vehicles (12% of total R&D Spending in manufacturing), Chemicals (8% of total R&D Spending in manufacturing), Food Industry (7% of total R&D Spending in manufacturing) and Other Machinery and equipment (7% of total R&D Spending in manufacturing).

There are differences between industries depending on the role of SMEs in R&D investment. In some industries, the majority of R&D investment is made by SMEs, such as Machinery and equipment (75%), Computer, electronic and optical products (74%), Manufacture of fabricated metal products (68%), Chemical products (64%) and Food Industries (54%).

The machine-tool ecosystem in the Basque Country leads the innovative capabilities of Machinery and equipment and the Manufacture of fabricated metal products. The innovative capabilities of SMEs in the sector of Computer, electronic and optical products are concentrated in Catalonia and to a lesser extent in Madrid. Catalonian and Valencian SMEs lead innovation in the Chemical industry, while Catalonian SMEs have strong innovative capabilities in Food industries.

The role of SMEs in the total R&D investment is very modest in the case of the Aerospace sector (3%), Pharmaceuticals (10%) and Motor vehicles (11%). When innovative capabilities are concentrated in large firms, they tend to be also geographically concentrated. For instance, the innovative capabilities of the Aerospace manufacturers such as Airbus and large suppliers such as Aciturri, Aernnova, and ITP are concentrated in Madrid, the Basque Country and to a much lesser extent in Andalusia. To solve this lack of innovative capabilities of the firms, the Andalusian government developed the Aerospace Strategy 2021-2027. However, this Andalusian strategy prioritizes innovative capabilities more related to manufacturing and process automation than to product design and innovation.

The innovative capabilities in the pharmaceuticals industry are more concentrated in Catalonia and Madrid. However, while large Spanish firms in Catalonia such as Almirall, Ferrer, Esteve or Grifols are more focused in their product development, large Spanish firms in Madrid are more oriented towards Contract Manufacturing business models, and therefore their innovative strategies are more focused on process innovation.

In some sectors, a large part of the R&D effort is made by foreign companies, as is the case of the motor vehicle sector (88% of total R&D in the sector), Other transport equipment (67%), Manufacture of electrical equipment (61%) or Manufacture of basic metals (55%). However, in some sectors with high R&D investment, Spanish owned companies lead R&D investment. R&D spending of Spanish owned firms is 81% of the total R&D investment in the Food Industry, 80% in the Manufacture of Computer, electronic and optical products, 79% in Machinery and equipment, 78% in Pharmaceuticals and 63% in Chemical industries.

Finally, some of the industries with higher export growth over the last decade (Motor Vehicles, Manufacture of Electrical equipment, Manufacture of Basic metals) are those where large multinationals have stronger innovation capabilities, such as Volkswagen, Ford, Stellantis Group in the automotive industry, Acerinox, Arcelor Mittal or Atlantic Copper in the Manufacture of basic metals, and BSH, Schneider Electric or Exide in the Electrical equipment industry.

The innovative activity of Spanish owned SMEs is the main driver of exports growth in industries such as Chemicals or Machinery and equipment. In the Chemicals industry, there is a significant proportion of Spanish firms that are innovators, however they are more innovation followers than pioneers. In this industry, the investment in basic research that would lead to more radical innovation is very low (11 million Euro in 2019). Two facts explain this low investment. On one hand, SMEs lack the resources and competencies needed to carry out basic research. On the other hand, some of the public basic research centres that could complement SMEs competences, such as the Instituto Catalán de Investigación Química (ICIQ) in Catalonia or the IMDEA Materiales in Madrid, have research lines not always convergent with the local industry and tend to favour research projects with large corporations such as Repsol, Esteve or Henkel.

Spain produces a low number of patents. In 2019, Spain applied for 1,873 European Patents. Bioscience is the most important field of technology of these patents with 270 patents in Pharmaceuticals and Biotechnology and 128 patents in medical technology. Spain has at least 5% of the total European patent applications only in Pharmaceuticals, Analysis of biological materials and Thermal processes and apparatus. The region with the largest number of European patents applications is Catalonia with 645 patents due to its specialization in biosciences research. Madrid has 362 applications, the Basque Country 194 applications and Andalusia just 89 applications. Madrid was the region in Spain with the highest number of European Patents applications in the field of industrial transformation and Industry 4.0 in the period 2011-2016, with nearly 50 applications. However, these numbers are far from European leaders such as Ile de France or Bavaria, both with more than 300 patent applications in the same time period. The rest of the regions produced a very limited number of Industry 4.0 patent applications with Catalonia with 30 applications, the Basque Country had 15 applications and Andalusia had just 5 applications in six years.

In general, the sectors with the greatest relevance of SMEs R&D have also a greater relevance of Spanish companies in innovation processes. On the contrary, in sectors with high investment in R&D by large manufacturing companies, foreign companies are the main players in innovation processes. The two important exceptions to this rule are the pharmaceutical sector and, to a lesser extent, the Food industry, in which the innovative activity of large Spanish companies is especially relevant.

The innovative preponderance of foreign multinationals poses some challenges for the transformation of the Spanish manufacturing industry. For example, due to the weak innovative capabilities of Spanish-owned firms, initiatives to promote the transition to electric vehicle manufacturing or green hydrogen highly depend on the innovative competencies of foreign companies that participate in these projects.

When investigating the Spanish situation, it turns out very clearly that there are important capabilities based on the established industrial structures and advantages based on the climate. Simultaneously, the demand for transformation indicates a change towards modernised structures and institutions. Since the industrial situation is dominated by large MNEs and SMEs which usually are suppliers there are established situations which provide the basis for such processes. MNEs are engaged in Spain according to their own business strategies and profits to be realised. Leading edge R&D and highly complex components or products, in general, are designed or manufactured elsewhere. MNEs will engage in Spain into such additional activities when it is beneficial for both their business in general and to increase the return on investment they already have in Spain. Consequently, the arrangements at locations need to be changed and modernised that it will suit also for future MNE strategies. Strengthening the conditions of modern manufacturing by support to investments or infrastructure helps to continue industrial competences at the location. Building modern capabilities in engineering and management to make the location more attractive for higher values added. Advancing the products also demands for different and higher skills and education.

Dealing with MNEs refers to capabilities of national governments. In addition, regional governments can complement based on their expertise from being close to the locations. Also, to make such situations complete for innovation additional capabilities in engineering, design, skills, and education will be administered must appropriately through regional or local governments. This clearly refer to improved skills and education and puts the labour force into a central position to realise sustainable transformation. These need to be established at the location and to be closely interlinked with the strategy of modernisation that has a long-term perspective and short-term action that also helps with a longer time scale. While key industries and key enterprises may change and modernise their business models towards higher values added there is also a growing demand for industry related services. Such structures do not exist as it will become necessary because the structural demand does not exist. Providing for such small but highly capable business there needs to be appropriate education and start-ups in engineering, consulting, lawyers, banking, realty etc. Such change demands specific education and competences which meet the individual regions demand.

The diversity of such processes of change is obvious when clusters of SMEs are taken into account. Firms which are used to supply MNEs have competences which are exploited according to this relationship. But there may be potential for synergy when collaborating and merging such competences. This phenomenon is widespread in clusters throughout Europe when the importance of knowledge increases and new products are created. The stronger the individual competences the more engineering is required, and the more such a body of knowledge is built the more opportunities to apply this in different fields are emerging. Since SMEs have limited capabilities concerning personnel and budgets to be spent there is the idea of collaboration to take advantage of such potential synergy. SMEs which rather exclusively are suppliers to MNEs or large firms may have the potential and competences to manufacture but they show clear deficits in R&D. These situations are different from those of MNEs, and they can characterize regions vs. those where there are large firms, but they are also different from another because the SMEs which cluster are suppliers for different products, are referring to different industries and have different competences and potential.

Consequently, the general demand for support in building bodies of knowledge which may suit such clusters are highly divergent when it comes to additional competences required in individual regions. The incomplete innovative arrangements demand for highly divergent complementation to allow for newly developed products and higher values added. Business related services as well as the aims of institutions vary according to the demand of different clusters. Clearly, suppliers and industries such as automobiles, mechanical engineering, chemicals, pharmaceuticals, or food processing have very different opportunities and demand for specific skills, education, and support in R&D. Thus, building institutions may have similar patterns of organisations addressing the diversities of innovation but the subjects, of course, are fundamentally different. Institutions which are close to the individual clusters can provide for appropriate competences and help to organise collaboration among SMEs of the region or even with companies or institutes outside of the region but complementing the regional potentials. Overcoming incomplete innovative arrangements needs to consider constant change over time and building complementary competences which provide the basis for ongoing innovation and transformation which will continue even after modernising the current situations at the locations.

2.5 German Case studies

In the following case studies in Saxony and Thuringia are introduced showcasing the interaction and completion of various aspects of innovative arrangements. The examples introduce economic clusters but also small scale projects from the Growth Pole program linking SMEs with missing competences and promoting innovation in less central places.

Saxony

Saxony's manufacturing industry is dominated by corporations with less than 250 employees. The size structure of companies within Saxony in manufacturing is strongly oriented towards smaller enterprises. Considering only enterprises with more than 20 employees, only 6.5% of businesses have 250 or more employees. 55.8% of enterprises have between 20 and 49 employees and 21.6% have between 50-99 employees.

According to Berger et al. (2019) Sachsen, 35% of Saxony's businesses introduced innovations in 2017. 25.9% of all businesses introduced product innovations, while 21.5% introduced process innovations. Overall, 41.9% of all businesses in Saxony were engaged in innovation activities.

Among innovative companies, 27.8% were involved in innovation cooperations with partners. 68% of these cooperations involved universities and applied science universities, 46% involved customers, while 40% cooperated with state funded research institutions. The majority of cooperations (83%) involved local partners while 67% involved partners in other German states. Only 18% of cooperations involved European partners.

Overall, 19.8% (2900) of all businesses in Saxony have cooperated in 7800 projects with higher education institutions between 2015-2017. The majority of these businesses (55%) have received public support for these cooperations (Berger et al. 2019). For example, 41% received support from the Central Innovation Program (ZIM), 38.4% received funding from ministry of education and research, while 16.1% used programs made available by the state. The majority of these programs emphasizes innovativeness and competitiveness of SMEs associated with higher funding amounts and shares especially for East German firms. The programs support complement the SME dominated firm landscape, as small firms may otherwise have not the means to get involved in innovation with uncertain outcome.

According to an innovation study in Saxony R&D expenses in 2015 were concentrated in large corporations (69.8%), but SMEs are responsible for 30.2% of R&D expenses in Saxony. Relative to turnover, large corporations in Saxony invested 2.8% of their turnover in R&D in 2017. Medium sized corporations (50-249 employees) invest 2.1%, while small corporations (10-49 employees) invest 2.9% of turnover in R&D.

Saxony's economy contains several clusters. Saxony's automotive industry is comprised by five car and engine factories of VW, BMW, and Porsche as well as 780 local suppliers and service providers employing overall 80% of the 95000 thousand employees in the industry. The innovativeness of the cluster is complemented by more than 50 R&D institutions in universities and other R&D institutions within the state focussing for example on electro mobility, autonomous driving, and new materials. The higher education institutions among these additionally provide a highly skilled localized labour pool. Beside of the R&D infrastructure the state invested 130 million in around 40 projects in a cooperative project with Bavaria the adoption of Hybrid busses for public transport and the provision of charging stations for electric vehicles.

Another example relates to the semiconductor industry. Silicon Saxony is considered as Europe's largest microelectronics cluster and has over 350 members and displayed as a highly innovative cluster and contains a mix of companies along the value chain. Companies are specialized in sensor technology and electronics (micro-, nano-, organic), tactile internet, and 5G technology. Though the cluster organization has approximately 350 members overall around 2400 companies are involved in the ICT value chain in Saxony representing 64000 employees.

The cluster was formally created in 2000 with 20 member entities. Initial development goals related to linking large corporations (AMD, Infineon) with SMEs in the regions as potential customers and suppliers. The state government supported the cluster by investing over 1.5 billion in attracting large corporations and public R&D labs. The cluster platform serves as a communication and cooperation platform among its members encouraging cooperative partnerships, to promote knowledge transfer, organizing frequent exchange among its members, and offering specialized training and consulting services (funding).

The cluster can draw on four universities, 5 applied science universities and several research institutes (9 Fraunhofer, 3 Leibniz, 1 Helmholtz, 2 Max Planck) providing skilled labour and R&D in microelectronics and ICT technologies. The cluster has due to its specialization in ICT technologies ties to software development firms involved in Industry 4.0, energy efficient production, and mobility relying on sensors etc.

Both examples show how large corporations can become an anchor for regional SMEs. Here investments in education and R&D with a strong focus on the capabilities of SMEs, internationalization, alignment between applied R&D and firms, and workforce development, led to the emergence of a sustainable and innovative cluster, which especially in the case of Silicon Saxony, may have grown beyond its reliance on large corporations. It should be noted that the formation of such structures required substantial investments in education and R&D as well as state subsidies to attract large corporations. This example shows how large corporations can be leveraged to build thriving clusters of SMEs though it should be noted that while initially especially in Silicon Saxony ties between SMEs and large corporations were sought, the SMEs are broader oriented due to internal capabilities and access to R&D and are overall not in absolute dependence of local large corporations.

Though these clusters employ large numbers, they are mostly centred around larger cities. Beyond these hotspots of activity, many SMEs with specialized skills can be found in less central places. The growth pole (Wachstumskerne) program mentioned in chapter 1.6 provided these SMEs with the means to pursue innovation and build connections with other firms and R&D institutions. While many are located in larger cities, examples of competences in less central locations exist. The "highSTICK" growth pole and it's follow up "highSTICK plus" in Plauen are such an example. The goal of the project is to translate regional competencies in embroidery to the design of new materials in construction, vehicle technology, and medical equipment combining the properties of textiles and metals/plastics of textiles. New products designed rely on embroidery competences to position sensors, circuitry, or area heaters on other materials (e.g., concrete, rotor blades). The follow up growth pole "highSTICK plus" focusses on entering growth markets by creating specialized composite materials for specialized use cases in growth industries (e.g., renewable energies, light weight construction…).

The growth pole is comprised of five companies specialized in embroidery, four companies engaged in mechanical engineering, a company specialized in electronics, two companies involved in textile refinement, and 5 companies producing associated pre products. Nine R&D/ higher education institutions support the development. While most of the firms are from the region the project has also intraregional collaborators from Thuringia and Berlin. These stakeholders connected and formulated a strategy (bottom-up) and received from the growth pole program top-down funding to implement the strategy. Overall the program participants pursued seven applied R&D projects for specific use cases (e.g., placement of sensors on materials) and a cross sectional R&D project studying 3-D structure refinement of textiles and other materials to alter material properties increasing suitability for embroidery. This was supported by an education project in cooperation with a local applied science university and a local labour education organization to create formalized education programs ensuring the supply of highly skilled labour. Here cooperative networking and competence exchange across industrial sectors combined with R&D support from public institutions has not only led to the development of new products/product innovation but also ensured that competencies remain in the region. Overall the project received approximately 3.1 million in public funding and within the first project period (“highSTICK” (2007-2010)) approximately 60 new jobs were created and the turnover of involved firms increased by 10%.

Thuringia

Thuringia’s manufacturing industry is dominated by corporations with less than 250 employees. While Thuringia had in 2008 1770 manufacturing companies only 110 had more than 250 employees (6.2%). In 2018, Thuringia had 1698 manufacturing companies with 158 companies over 250 employees (9.3%). The majority of the large companies are concentrated in the Rubber and plastic industry (20), Fabricated metal products (25), Machinery Industry (16), and automotive (19). The share of large corporations at total companies is especially in the pharmaceuticals (21.4%) and Machinery Industry (21.3%) sector high.

Some of the largest companies solely based in Thuringia (based on the 100 largest companies in Middle Germany as released by the State Bank of Saxony, Saxony-Anhalt, and Thuringia) are Jenoptik (4033 employees, optics), a variety of automotive companies (Opel (1800), Bosch (1800), Borbet (930)), producers of medical equipment (Carl Zeiss Meditec (1303), TRUMPF (530)), NIDEC (1080, pumps and compressors), and Carl Zeiss Jena GmbH (1300, technology). While large corporations are overall rare, they have important functions for the local economy. Bosch for example, producing power train solutions for various car makers, trains approximately 160 apprentices in its plant of which 93 are employed at Bosch and the rest at local partner companies.

A notable cluster has emerged around Jena and Ilmenau building upon historic competences in the optics industry. After reunification, the employees of the optics industry were encouraged to pursue entrepreneurial activities leading to a multitude of spin-offs and the creation of highly specialized SMEs forming an innovative ecosystem capturing and having competences in many elements of the optics value chain. The OptoNet cluster was formally created in 1999 and contains approximately 100 companies including several large corporations (e.g., Jenoptik, Carl Zeiss Microscopy GmbH, ADVA Optical Networking SE, Schott). An internal survey shows that 55% of companies within the cluster consider themselves to be leading companies in the market with 36% stating that they are the technological leaders in their market niche.

The OptoNet cluster interacts and benefits from the local R&D landscape and is connected to 12 public and private research institutes and university departments specializing in optics and associated materials design and has close interactions with industries facilitating its products/competences (biotechnology, measurement device and medical technology industries) and is complemented by a Green Photonics cluster lead by Fraunhofer. Additionally, several ITC research institutes facilitating products of the OptoNet cluster are in the region and the region has ties to the neighbouring Silicon Saxony Cluster as well as European and international optics clusters (e.g., Optics Valley in Paris, Hamamatsu Technopolis (Japan) and Ontario Centres of Excellence (Canada)).

A variety of Bachelor, Master and PhD programs supplies the cluster with skilled labour and the close collaboration between higher education institutions and the cluster has led to the development of a highly skilled workforce and internationally renowned study programs. Additionally, vocational training programs in the region specialize in the photonics field while the large corporations within the cluster have collaborated to create an education and qualification centre (Jena Education Centre) to continuously qualify their current workforce and develop the skills of their future workforce. The cluster further provides R&D support and innovation support to its members via its own consulting company.

Though the cluster contains many world leading companies, the cluster is not able to absorb the number of graduates produced each year. Together with higher pay in other German regions, highly skilled labour is moving away. Other problems relate to the availability of skilled workers with vocational training necessary for the production process as such positions are not attractive for the students trained in the cluster.

While the cluster is in regard to its innovativeness and competitiveness a success story it should be noted that currently approximately 15000 people are employed within the cluster – the state-owned company employed over 30000 before the company became private again in the 1990s. The cluster has experienced a strong transformation in regard to its employment size and is overall relying on innovation, R&D, and building a highly qualified workforce. The cluster showcases the importance of the interdependencies between education programs, workforce development, innovation, and competitiveness. R&D and education institutions are aligned with the applied needs of businesses supported by additional institutions providing basic research and translation (e.g., Fraunhofer, Max Planck).

In absence of large corporations, competences are present also in smaller places in Thuringia. Examples for these places are presented in regional growth poles which link industrial competences with each other and R&D institutions to generate innovation by providing businesses with knowledge necessary for innovation. Thuringia received funding for 15 regional growth poles between 2001 and 2016. While some projects related to optics have been funded in Jena, competences are also present in more remote places. Examples are the growth poles “fanimat nano” in Hermsdorf and “ALCERU HIGHTECH” in Rudolstadt.

The growth pole “fanimat nano” is comprised by 8 SMEs located in Hermsdorf and proximity and five R&D institutions in Hermsdorf and Jena. The involved companies have competences in the production of ceramic components in electronics, optoelectronics, and medical technology and are cooperating with research institutions to develop nanotechnology-based coating and material concepts to build together higher quality integrated products.

While the involved companies have specific competences, the individual companies did not have the materials design knowledge to build these integrated products and aimed to acquire knowledge related to material development, forming, and surface structure control using a cooperative approach to transfer knowledge from R&D institutions into their firms. The companies aimed to expand their market position in existing market niches but planned to expand into other markets including biotechnology and aerospace.

The “ALCERU HIGHTECH” growth pole consists of 6 SMEs with competences in chemicals, textiles, and materials design and 3 research institutions. Goal of the project was to develop new cellulosic based materials and develop a more sustainable process for creating cellulosic materials. The project serves as basis for the involved companies to explore new uses and enter new markets with their competencies in cellulosic materials by developing piezo ceramic materials and developing competencies in shaping them. Here the exchange of competences and infusion of knowledge from R&D institutes created a situation in which the combination of competences created new cellulosic based products.

The growth poles in Thuringia and Saxony show how policy can support SMEs in gaining access to capabilities they internally lack, whether these are research capabilities/funds as in the case of fanimat nano or via cross sectoral exchange (“ALCERU HIGHTECH”, “highSTICK”). All growth poles common is the reliance on public R&D institutions and applied research. While the measures are rather small in scale, they showcase that innovative potential exists even in remote regions and can lead to the creation of new products and market niches if companies are enabled to access competences they lack. The cases furthermore show, that regional exchange among firms, especially cross-sectoral exchange, has the potential to create innovation relying on existing regional competences. These measures may support the retaining of manufacturing competences in regions while transformation is ongoing.

The clusters show how large corporations can be leveraged into building a base of innovative SMEs if SMEs can be supplied with sufficiently skilled labour and competences from R&D institutions with an applied focus in research but also education. Overall, the cases show different industries and different scales. Common among all cases, whether larger clusters or small growth poles, is the role of institutions on their formation and success - though it should be noted that how such a framework works and should be designed is place dependent and requires the knowledge of local stakeholders to successfully connect the parts. Establishing an institutional infrastructure, in conjunction with creating complementary access to qualified labour, that is able to conduct applied research, foster exchange between companies and R&D/education institutions as well as other companies within a sector and across sectors allows to build on existing competences and develop new competences. While large corporations were and are important stakeholders in clusters, the cases also show that capability building SME oriented policies can over time contribute to building a sustainable business environment able to innovate and create internal capabilities in SMEs allowing them to diversify regarding their customers.

2.6 Incomplete Innovative Arrangements in Spain

Two of the main characteristics that describe the Spanish Innovation system as a whole are the lack of resources and the inadequate structure and governance.

The public R&D system has adopted over the last decade, especially in Madrid and Catalonia, a dual system combining few and well financed high achieving public research institutes operating under private contractual law and many, small, fragmented, and underfinanced research groups in the universities or the CSIC. This model has been considered by the EU as a 'creaming-off' of talent from the system, as researchers sought a working environment that matched leading international standards. Moreover, these elite institutes are no exception to one of the main problems of the Spanish innovation system which is the coexistence of two innovation systems, the public research innovation system and the business sector innovation system, which seldom interact with each other.

During the 1990s and early 2000s, the Spanish government attempted to adopt, partially and biasedly, some of the characteristics of the American system of researchers' career and tenure track to the context of public research institutions combined to some of the characteristics of the German accreditation system. The incentives defined in the public research system (University Teaching Staff Accreditation System, Six-year research periods productivity measurement, staff promotion models in the CSIC, selection criteria for national and regional research grants, etc.) placed an excessive emphasis on scientific publication as compared to innovation. All these incentives and their corresponding regulations have created a culture of very narrow and limited view of the concept of scientific contribution, which is only based on research publications rankings and citations. As a result of this biased and limited policy, Spain triples Germany and France while almost doubles Italy, Sweden, and the Netherlands in scientific articles published in indexed journals per million euros invested in R&D. Similarly, Spain almost doubles Germany, France, the Netherlands, Sweden, and Italy in articles published in high impact journals (according to Nature Index) per million euros invested in R&D. In contrast, the number of European patent applications per million euros invested in R&D is half that of Italy, Sweden, or France and one third that of Germany or the Netherlands. The combination of a high ratio of scientific publications in reputed journals and a low ratio of patents to R&D investment is a characteristic that Spain has in common with other innovation followers in Europe such as Bulgaria, Greece, Romania, or Poland. As commented above, this prevailing culture of emphasis on scientific publication was established first in the 1990s in Spain through a series of regulations that sought to increase the levels of scientific productivity and the level of openness of the Spanish scientific community to the outside world. While this policy made sense in the Spanish research context of the 1990s, it had the downside of creating a dominant culture that rewards more the effort of public scientists to publish in scientific journals than the effort to produce real innovations.

This scientific culture means that there are little incentives and few resources on the part of the scientific community to interact with the productive sector, creating a strong gap between both worlds. The institutionalization of this gap through policies and regulations has created a dual system where public research and industrial innovation systems are badly connected. For example, Spain, together with Bulgaria and Romania, is the EU country with the lowest proportion of companies that cooperate with public research institutions. In France and Sweden, the proportion of companies that cooperate with research institutions is almost ten times higher than in Spain, in Italy four times higher and in Portugal, it is twice as high.

Reconverting the current dominant culture of scientific publication in the scientific community into a culture of innovation is possibly one of the main challenges facing the Spanish innovation system. There have been some weak and not very successful attempts in this direction, such as the productivity incentive for research transfer activities (Sexenio de Transferencia), innovative public procurement or the implementation of innovation vouchers. However, these initiatives have failed for three main reasons: ill-defined bureaucratic processes that have impeded their proper implementation, cognitive distance because of low technological research levels of the outputs of the public innovation system, and strong cultural resistance in the public research ecosystem, that have shown how challenging is to change the current institutional framework. Without deeply reconfiguring and resetting the existing institutions such as ANECA, CSIC, FECYT or Sexenios system, initiatives aimed at modifying the innovation system such as the Science Law of 2011.

The governance of the Spanish innovation system is characterized by a strong contradiction. On the one hand, there is an attempt to establish a national innovation policy. This policy shares with economic policy a tendency towards the centralization of policy design and stronger support to large companies than to SMEs. In this sense, the role of central state research entities such as CDTI or CSIC in the design of innovation policy is noticeable.

On the other hand, the Spanish autonomous system gives the regions the power to define their own innovation policies. However, there is little coordination with other regions and even sometimes with national policies. Likewise, most of the financing of these regional innovation policies is highly dependent on European funds, such as the Social Funds for employment. This dependence means that often, regional innovation policies not supported by European funds cannot be fully implemented and remain a mere political promise.

The current regional battle for electric batteries plants is an example of the regional lack of coordination of innovation policies. Currently there is a competition between different potential projects to bring some of the productive activities of the electric battery manufacturing supply chain to Spain. There are five different projects, three of them consider mainly the capabilities or the needs of just one region, such as the projects in Catalonia promoted by SEAT, the Valencian Battery Alliance and the Galician project promoted by the Zona Franca of Vigo. The Battchain project involves partners from other regions, but the main participants come from the Basque Country and Navarra (See the Annex for details).

Spanish political institutions at the national and regional level tend to promote public initiatives focused on one region, without considering the possible complementarity of resources from other regions. This pattern is still present in most of the industry transformation projects such as the development of giga factories, green hydrogen projects, projects for the adoption of artificial intelligence or the adoption of additive manufacturing.

The Andalusian Aerospace Strategy, the Madrid and Catalonia Regional Plans for Scientific Research and Technological Innovation, The Basque Green Hydrogen Corridor, the Basque Research and Technology Alliance are examples of such regionally closed strategies that do not pay much attention to the complementary resources of other Spanish regions. There are programs and institutions at the national and regional levels that help firms and research institutions to establish international cooperation programs, however there are not institutions or programs that promote interregional cooperation in innovation.

Another important characteristic of many of these public projects is that the recipients of public funds are mostly large companies, especially in national programs. In 2019, firms with more than 250 employees obtained 80% of the firms' external funds for R&D coming from national institutions. As mentioned above, R&D investment by large firms in Spain is comparatively much lower than in other EU countries. Moreover, the proportion of large manufacturing firms that cooperate with other firms in innovative activities in Spain is 32%, which is the lowest among developed EU economies. The combination of low internal innovative effort and low cooperation means that these projects of large firms have usually produced low knowledge externalities on Spanish SMEs and therefore have had a very low impact on the transformation of the Spanish manufacturing industries as a whole.

Another frequent characteristic of the publicly funded R&D projects of Spanish firms is that they often support more of Spain´s engineering skills, which are highly developed in Spain, than manufacturing skills. This fact means that Spanish initiatives require much longer learning curves and development times than initiatives in other European countries when it comes to developing manufacturing competencies.

Additionally, many of the Spanish initiatives take over much later than in other countries. When this occurs, Spain starts building competences without having a base of pre-existing competences when foreign firms have had time to build these competences. Therefore, it is very difficult to compete with foreign incumbents unless it is through radical or disruptive innovations, which are usually out of range for the innovative capabilities of large Spanish companies.

Spanish firms typically start investing in a specific new technology much later than foreign firms. This problem has been observed for years across many industrial environments from artificial intelligence, new materials to green hydrogen. For example, in the case of battery development, European and especially Asian competitors are years ahead in terms of learning curves. The world-leading producer, the Chinese firm Ganfeng Lithium, was created in 2000, the American firm Livent (a spin-off of FMC company) has been in the sector since 1985 and the Japanese Sanyo marketed the first battery for electric cars in 2010.

Moreover, the focus on large companies of Spanish firms typically neglects the innovative competencies of SMEs that could have complemented large firm competencies. For instance, almost none of the public programs that support the development of an electric vehicle supply chain in Spain have considered any initiative to use the existing expertise and competencies of SMEs that have been innovation leaders in intersecting knowledge fields. The knowledge of pioneers such as the Catalan Wallbox, producer of electric car charging stations, the Andalusian company Premo, supplier of inductive components (transformers, filters and coils) for the power converters of the American manufacturer Tesla, or the Asturian firm Astilleros Gondan, one of the main innovators in marine electric mobility, would have been useful to better define these projects.

From a strategic point of view, the innovation strategy of the Madrid region has developed over the last six years upon its RIS3 specialization strategy. This strategy has been rather confusing, with too many objectives of a very disparate nature. In the case of the manufacturing sector, the RIS3 strategy has paid attention to industrial technologies and applied robotics in two specific manufacturing sectors such as the transportation industry, with special attention to the aerospace industry, and the pharmaceutical industry. The Madrid government chose these sectors in order to build industrial growth upon the possible tractor effect of large companies with manufacturing or R&D units in the region, such as Airbus, Telefónica, Repsol, GSK, Lilly or Rovi. However, Madrid´s RIS3 plan had a small budget, with 48 million euros for business innovation projects over the period 2015-2020 and an average yearly spending of 8 million euros (0.003% of Madrid's annual GDP). One third of this budget was devoted to encouraging large corporations in the Madrid region to create a network of open innovation hubs that would ultimately create an innovation ecosystem called MadrIDTech. However, just three of these hubs have been created (Madridflightonchip, led by the engineering firm SENER with the aim of building satellites; Temacon led by Airbus Operations for the digitalization of materials handling in aerospace; Citizenlab led by the consulting firm Grant Thornton to optimize public infrastructures management through big data). At the time of the development of this report, the RIS3 plan was being revised, due to existing doubts on its efficiency.

One of the pillars of the RIS3 strategy was the Regional Plan for Scientific and Technological Research (PRICIT). This plan allocated to universities and public research centres of the region 420 million euros in the period 2016-2020. Nearly half of the PRICIT budget finally was devoted to support the research activities of Imdea Institutes. A problem related to the implementation of these initiatives is that the Madrid Region did not have an institution that coordinated the implementation of the different plans, as responsibilities were distributed among different regional ministries. In principle, the Madri+d Foundation was intended to orchestrate the ecosystem, however in recent years it was more focused on quality assurance of university degrees and institutions than on promoting an innovative ecosystem in Madrid.

The region's innovation development strategy is cross-industry in nature, with few measures specifically designed for the modernization of a specific sector or industry.

Andalusia

The industrial policy in Andalusia in recent years was based on the Industrialization Strategy Andalusia 2014-2020, the Innovation Strategy Andalusia (RIS3) 2014-2020 and the Andalusian Plan for Research, Development and Innovation (PAIDI) 2020. Although the objectives defined in these plans have been coordinated in the design phase, its execution has been very fragmented and uncoordinated and has not achieved the expected results. Moreover, one of the historical problems of Andalusia is that innovation policies have often lacked enough public and business resources. For example, the Andalusia Innovation Strategy Plan (RIS3) 2014-2020 had practically no funding of its own and a large part of the 2.6 billion budget depended on European funds. Likewise, the financial execution of the Plan's public funds was at the end of 2018 at 25% of the planned level. The governance of these plans also fails to take advantage of the potential of the IDEA Agency to achieve effective coordination between the different initiatives in the region. Within the scope of promoting Industry 4.0, Andalusia proposed an incentive program for the digital transformation of SMEs for 37 million euros, although with a maximum subsidy of 75,000 euros, and focused more on the promotion of e-commerce than on industrial transformation. Process innovation in the scope of Industry 4.0 was supported by an R&D&I incentive program endowed with 84 million euros. One of the problems with the first formulation of Andalusia's smart specialization strategy was that it tried to cover too many areas and sectors. To try to correct this problem, the regional government is in the process of designing a vertical and more focused sectoral strategy such as the aerospace sector plan for the 2021-2027.

Catalonia

Catalonia's innovation strategy is structured around the Smart Catalonia strategies, a plan focused on the development of Catalonia as a digital industry hub, the RIS3CAT 2015-

2020 specialization strategy, the National Plan for Research and Innovation (PNRI) 2008-2020. Public funding was mainly supported by 2,000 million euros of contribution from European funds for the period 2014-2020. Catalonian institutions both at the regional and local level have been traditionally very active in promoting innovative activities. Thanks to this political orientation, Catalonia is the Spanish region with the highest investment in R&D and the strongest innovation culture. However, this political interest for innovation has also produced a very fragmented innovation system with numerous local and regional initiatives and strategies which are not always coordinated. Therefore, one the challenges of the Catalonian innovation system is to increase the social capital of the actors and institutions.

The implementation of dual vocational training in Catalonia reflects this need to establish a socially dense institutional framework as a prior step to establishing initiatives to transform skills. In fact, the implementation of dual VET faced two major challenges. The first challenge was that the regional government attempted to implement a dual VET model in which governance was strongly centralized in the regional government, with little involvement of other agents of the Catalan economy. The second challenge was that, as stated in the document Estratègia Catalana de Formació I Qualificació Professional (2020-2030), Catalan VET centres have traditionally carried out few joint innovation projects with local firms. The lack of continuous interaction between the VET centres and the employers prevents a shared vision of both needs of the labour market and the actual capabilities of the educational centres. At the extreme, mutual ignorance often resulted in an atmosphere of mutual distrust, which does not facilitate the adoption of dual models. For example, VET professors often consider dual VET to be a too narrow educational model in which students develop too firm specific competencies that in the long term will hinder their labour mobility to other firms. To overcome these challenges, the Comisión Rectora del Sistema FPCAT and the Consell de Formació i Qualificació Professionals de Catalunya were created in 2019 as the coordinating body for the Catalan vocational training system that includes the government, trade unions and Catalan companies. However, coordination through this body is carried out at a high level of strategy design and analysis of the system. This coordination has not been transferred to the more concrete levels of strategy implementation, not allowing the creation of an institutional framework for a more concrete dialogue between specific VET centres and firms when it comes to proposing specific projects for the development of competencies in the field of VET in Catalonia. In principle, sectoral councils will be created to create this closer coordination, but their purpose, functions and nature were yet to be defined at the moment of preparing this report.

Basque Country

The region's innovation strategy has revolved around the Euskadi 2020 Science Technology and Innovation Plan 2014-2020, endowed with nearly 3,000 million euros of public funds. This plan has highly focused on the region's main export sectors such as energy and the whole supply chain of the manufacture of transport elements and their components. In addition to these sectors, the plan was committed to the development of the bioscience sector, an area in which the region did not have starting distinctive competencies and resources and which has not been able to develop during the years of the plan's implementation. The lack of strong pharmaceutical or chemical firms, except for Faes Farma, makes the development of competences in bioscience difficult. Likewise, the plan failed neither to create cross-sector innovation nor to develop large-scale, long-term projects. The recent plan Euskadi Next 2021-2026 tries to solve both problems by supporting large cross-sector initiatives such as the Hydrogen Green Corridor or the BattChain project.

Moreover, in the Basque Country there is a contrast between the role of university research centres and the role of technological centres outside the university system. Non-university centres in the Basque country monopolize a large part of the research that used to be carried out by universities, and which. The regional innovation policy clearly favoured the non-university research model and excluded most of the research groups in Basque universities from the focus of strategic innovation policies. Likewise, the economic resources allocated to non-university centres have gone only to areas that promote technological development and innovation, and not to other areas linked to social development, such as social sciences or humanities. This has created a widening gap, firstly, between universities and organizations belonging to the Basque Science, Technology and Innovation Network, and, secondly, between research fields and disciplines. This exclusion explains why the Basque country is experiencing serious problems trying to develop a knowledge base on biotechnology fields, after decades of weak support for the biomedical research carried out by Basque universities.

That is to say, non-university technological centres are still monopolizing all the focus of Basque public policies aimed at research in recent years. For example, the recent initiative of the Basque Research and Technology Alliance does not include Basque universities as main players. For years, the logic of the Basque innovation system was that public funds would subsidize the costs incurred by a company in utilizing the innovative capabilities of technology centres. This model created stable relationships and partnerships between technology centres and Basque companies.

In terms of financing, there is a great asymmetry between the different agents working in the Basque science and technology system. Technological centres and CICs receive most of the funding. This asymmetry also reflects in the different roles of the public institutions and in the fact that the Department of Industry of the Basque Government clearly has a more prevalent role in innovation policy making than the Department of Education.

The existing competences and capabilities provide a basis for further innovative transformation which is based on modernisation of products and production. The search for synergy can built on these structures and needs support to fund the new products, skills and R&D. It is important to notice, that some regions do have established institutions in research and continuing education, but they lack the synergy in relation with existing industrial competences and enterprises. Government programmes on new technologies and innovation demand for new structures and capabilities. Consequently, such policies demand for large budgets and are frequently related with the foundation of new institutes. Also, the lead times until socio-economic effects can be noticed take time. Given the limited budgets available and the research structures of regions which shall be transformed it demands for policies which make most efficient use of the budgets. The diversities of situations require a design of policies which is different from traditional support of industries and economic development. Consequently, the widespread diversities of regional industrial profiles and related specific opportunities form situations which show already existing capabilities. This allows for a smart budgeting because there is demand for additional funding which can complement these situations and initiate endogenous potential of ideas.

Such policies which can complement incomplete innovative arrangements take advantage of private investments and established institutions. Lessons learned from programmes (Growth Poles and InnoRegio) which are employed in Germany to strengthen East German situations can help to design policies to raise and make effective unknown or hidden competences and potentials. In addition to synergy across enterprises and industries there can be synergy of public initiatives and institution building together with private activities and unused potentials of enterprises and labour force. On the side of policies there are opportunities to match the effects of national and regional policies at locations and clusters which were not considered so far. The closer administrations are to the problems of regions and locations the more they will know about the situations and the needs. It will work only, when public policies of different levels of government focus on individual opportunities and enable innovation and help for providing a capable labour force of increasing competences. Also, public policies can match and build local or regional arrangements which show new potential based on vitalising synergy of regional economies, industries and societies.

Policies which help vitalising initiatives of SME-clusters can take advantage of what is already available and what is designed as a project. The offer of funding will make enterprises creative and will intensify the search for complementing competences and capabilities to collaborate across regions. This will be associated with a change in orientation and culture. In the light of receiving additional funding and further areas of economic activity enterprises will be creative in developing innovative ideas and finding competences which complement the own activities when gaining new opportunities. This also implies a change how labour is considered. A skilled labour force provides opportunities for products of higher values as this will be associated with such innovation. Insofar, labour is to be regarded as important and as human capital it is enabling enterprises to realise such strategies and to enable for improvement. The higher values realized would provide for higher profits and incomes while making the situations sustainable.

Since there is demand for more knowledge to be added when upgrading the products or engaging in new products additional competences based on research and engineering are required. This complements with the idea that enterprises may collaborate and form networks while opening for new products and markets. This reaches out much further than to supply funding, because it includes the building of institutions that are ready to provide knowledge required to match the deficits of enterprises and clusters. This will change the situation of many SMEs which, so far, are used to supply according to orders of MNEs. Thus, collaboration with institutions in research and design would be fairly new as this implies joint creation of ideas and processes of development versus expecting final solutions from R&D. This is a major change of both orientations and attitudes because SMEs need to be clear of their aims and how to manufacture the new products or to realise the new processes.

The highly diverse regional situations of industries and clusters also indicate divergent demand for skilled and university educated labour, and capabilities to complement enterprises. Consequently, the general change in culture is different according to the divergent opportunities at individual locations. The organization of supply chains and the number of parts as well as their size is of key influence on the wide range of possible engagement in product innovation. The more opportunities to supply parts exist, the higher is the potential for individual innovation. Thus, some regions or locations may offer more potential for their clusters than others and some may link closer to processes characterized by large plants of MNEs. There are different potentials for innovation based on cultural change and there is different demand for such cultural change according to the way supply chains are organized in different industries. The dimension of cultural change and reorientation may be characterised because of the varieties indicated by individual situations but clearly there is demand for enabling such development. Building capable institutions oriented in funding R&D, skills, education and collaboration can introduce such process of short-term effects and long-term sustainability.

Chapter 3 - Conclusions

Countries like Spain are challenged by a difficult situation. The period of industrialisation based on the cheap labour and as locations for manufacturing is about to find an end. Labour is available elsewhere much cheaper than in Spain and regulations are often weaker. When there is time for investment into new plant and machines, clearly, there is a competition from countries south of the Mediterranean Sea. Simultaneously, Spain is not prepared to enter industrial strategies based on high tech or high competences. In these areas, countries such as Germany, France, the Netherlands or Scandinavia are much stronger and continue to develop their comparative advantage. Also, some countries from eastern central Europe (e.g., Poland and the Czech Republic) can refer to a well skilled blue-collar labour force. Consequently, Spain needs to define strategies which are based on existing capabilities (e.g., participation in European networks and supply chains), comparative advantages (e.g., climate suits for quality food and hydrogen energy) and growing values added.

Such opportunities as well as the profits which are generated are of strong interests of MNEs which take Spanish locations into account when planning their business. Consequently, the attraction of Spain is related to production costs and regulations. In manufacturing industries, because of the strong facilities in R&D in their home countries (e.g., France, Germany, US, Korea, Japan) there is little orientation in establishing such departments in Spain which would contribute to country's strength in innovation. In addition, SMEs are in general suppliers of MNE-plants in Spain, but their orientation is rather limited in making their products innovative and adding higher values. Thus, both SMEs and large corporations in Spain are depending highly on MNEs, but they are also clearly related with locations within the country. The lacking orientation in innovation and product advancement provides little opportunities to enter new markets or to strengthen their export by providing products for different demands and customers. Nevertheless, while MNEs are taking decisions according to their global interests, in contrast, due to the limited international scope these SMEs are potential partners to contribute to the development of the regions where they are based.

Consequently, the Spanish situation is confronted with a process of transformation which is not to be expected to be pushed by foreign based MNEs. Opportunities of change need to be initiated and to identify possible multiplier for modernisation. Thus, clusters of SMEs which are engaged in manufacturing provide a basis for innovation by manufacturing. New machines and equipment and an upgrade of products could help to diversify the products and the markets. A collaboration of different SMEs could merge knowledge and experience in manufacturing, but the need of R&D would still continue. This makes policies of institution building strategically important. The example of East Germany indicates that a transfer of institutions can be realised to a situation where these did not exist before. Public institutions should support technical advancement of products, training on the job and regional or trans-regional networks to generate synergy based on existing and modernised competences. Regional institutions in teaching applied sciences as well as institutions which support the collaboration between the SME-cluster and applied research can help to engage in new products and markets, which would reduce the dependencies on MNEs. Since regions are different there are divergences of innovation and such institutions need both to be oriented in regional industrial structures and to complement these competences. Consequently, the building of innovative institutions can help to apply new machines, new equipment, to modernise organisation and to establish new and effective networks. Engineering and organisational sciences can help to apply such knowledge at firms of the clusters or to provide the basis for newly emerging networks.

It might be more difficult and demand for more political initiative to make MNEs interested in their locations in Spain to engage in higher values added and thus to organise for improving skills of the workforce. Some German enterprises which are engaged with industrial plants have already engaged in this area or did provide training of workers in Germany. That would help to upgrade both the manufacturing processes and the quality along the Spanish supply chain. It may also match with the diversified institution building alongside with the clusters. While this demands national policies there is also a demand for governmental collaboration when incomplete innovative arrangements are to be identified and shall be completed. National programmes can provide support and regional governments can contribute their knowledge about existing capabilities and the demand for complementing competences. It is important to note that existing competences need not to be established expensively. Instead, a smart budgeting can take advantage of these opportunities and focus on funding the synergy building among the contributors. Thus, the identification of innovators among the SMEs and of the clusters is an important contribution to make such innovative synergy emerge.

When considering the demand for transformation and Spain's limited opportunities of innovation which are related with modern manufacturing it is important to be aware of current changes. Although this may include less attractive situations for the workers it can help securing jobs. Industrial capabilities can be continued by transforming into locations of modern industries which provide for innovation by manufacturing. New tendencies associated with Industry 4.0 and digitization will have a major impact on manufacturing, skills, organization of labour and management. Given the experience alongside with already existing industries and plants this may also provide for opportunities to continue industrial development at these locations despite the fact of limited availability of highly skilled blue-collar labour. The application of smart factories and the introduction of new machinery may help to continue industrial manufacturing and jobs at the plants which exist. This can help to continue employment, but it does not yet provide chances towards an improvement of workers competences for products of higher values added. This demands for a longer and comprehensive strategy on industrial policy which gives particular attention to skills and education in relation with research and development as a basis for higher values added. Given the situation of diversities of innovation according to industries and regional settings the regional governments need to contribute actively to provide institutions appropriate to the situation.

Diversities of innovation and the identification of incomplete innovative arrangements also allow for rethinking modernization of regions which are usually not a focus of discussion. There are also potentials for processes of modernization and higher values added, which are not associated with the existing concentration at a few metropolises. This is clearly the case with the clusters mentioned, but it can also be related to agricultural products and food processing industries. Since tastes in food and beverages have become highly internationalized differently treated vegetables, fish and meat finds consumers across Europe. Such products demand for treatment, packaging and preparation for transportation. Consequently, this allows for higher values added, improvement of the products and preparation and can match with the demand for ecologically sound food and agriculture. When associated with ecologically sound agriculture there can also be positive effects on the water regime, conservation of the quality of soil and agro-tourism. Economic activity can be realised in such regions which provide appropriate climate and food. Such situations are not widespread across Europe and are related to a few regions only. The established situation may be incomplete with regard to some of the competences required, but these can be complemented by the transfer of knowledge and mechanical engineering which suits the opportunities.

Innovation and transformation start with existing situations and the opportunities these provide. Synergy based on matching these with additional knowledge transferred from other locations can provide for new opportunities. Thus, a concentration on manufacturing industries and process industries is important for modernization and higher values added, but there are further areas (e.g., agriculture and food processing industries) which allow for higher values added. Existing competences in areas which were considered to be out-dated can become critical and fundamental when matched with new knowledge or equipment to be applied. While strategies aiming at cutting costs are oriented in making the current situations more efficient and profitable there are also opportunities alongside higher values added. Such higher values are associated with development which takes advantage of the competences existing in the current situations but matching those with new knowledge from outside. Networking and the availability of competences will help to find a region's individual opportunity when transferred and added to incomplete innovative arrangements. The application of transferred knowledge and equipment provides for synergy and improved development.

This change, of course, is more than just another opportunity. Since it is based on new and additional knowledge, changing towards advanced products, additional skills and education, and different management and administration requires also a cultural change. Social structures will change towards a population associated with higher competences and more people will contribute to an orientation in higher values added. The pattern of organization is gradually changing as there is a building process of new competence and thus transformation and appropriate innovation increases. Such new attitudes are important to use all competences related to these processes and to identify areas of potential synergy. They will induce a cultural change which provides for the contributions required. When learning from examples such as East Germany the networking across industries and enabling policies of all governmental levels are important lessons related with the institution building that is important to conduct such change. Frequently, it is not leading-edge technology which creates innovative opportunities but the support to realise collaboration across industries to provide innovative products and to meet customers' needs. Since regions vary widely in competences and capabilities available the individual situation can be rather unique. It allows to continue economic development and employment based on synergy from collaboration within the region and also complemented by knowledge transfer from outside the region. The products can be new and innovative although the competences are traditional but modernized.

A tradition-based innovation can be realized and can continue employment and clusters, but sustainable development demands for policies which take into account the foreseeable future as well as strengthening the competences in the long run. Modernisation and intensification of skills, education and applied research takes time but will help to induce continuity of such processes. Last not least, the diversity of clusters, of the industries at a location or region, and the traditional competences of the workforce demand and allow for the design of individual industrial identities and a branding will support the recognition of these geographically localised capabilities. Such attractions also help to keep MNEs in the regions because they can take advantage of the cluster competences and networks as suppliers for the quality of their final products.

Although the Spanish regions, in general, face the need for transformation the individual situations of the regions are rather diverse. Industrial structures, traditions, skills and government opportunities vary and demand for specific strategies of modernisation. Despite the fact that current problems are most visible, such processes require strategies which help in the short run as well as providing for sustainable processes of socio-economic development. Such policies need to take into account both locations south of the Mediterranean Sea which provide simple industrial products and food for European markets and to find opportunities of long-term development based on higher values added. Thus, short term activities also need to consider whether these may contribute to a positive long-term effect strengthening the situation of the location or region. As a consequence, based on diversities of innovation regions need appropriate strategies towards modernisation and higher values added. Since there is manufacturing of important industries there are capabilities which need to be modernised and continued while there are strategies preparing for a future based on products of higher values. Thus, innovation by modernised manufacturing (e.g., related with digitisation and Industry 4.0) may help to continue related to a higher performance manufacturing and providing for a future which requires for improvement of industry, skills and education. While this will improve the situations new and modernised institutions can build the labour force required and establish R&D-capabilities which match the opportunities of clusters.

To complement incomplete innovative arrangements by R&D-institutions and the skilled labour force takes time. The transformation needs to start from the current situation and to identify the opportunities of future structures. Innovation by manufacturing helps to bridge the time required for the change of the societal and entrepreneurial structures. An awareness of enterprises embedded in clusters need to search for synergy formed with competences of others to engage in collaboration for new products. In addition, skills and university-educated labour needs to be provided by regional societies which share the view concerning the importance of labour to continue and improve innovation which suits the individual situation. Finally, there is a situation which demands for industrial capabilities matched by the appropriate labour forces and complemented by enabling programmes which are launched by different levels of government to help meeting opportunities that are actively developed over time and based on the diversities of innovation that exist or can be arranged at the individual locations.

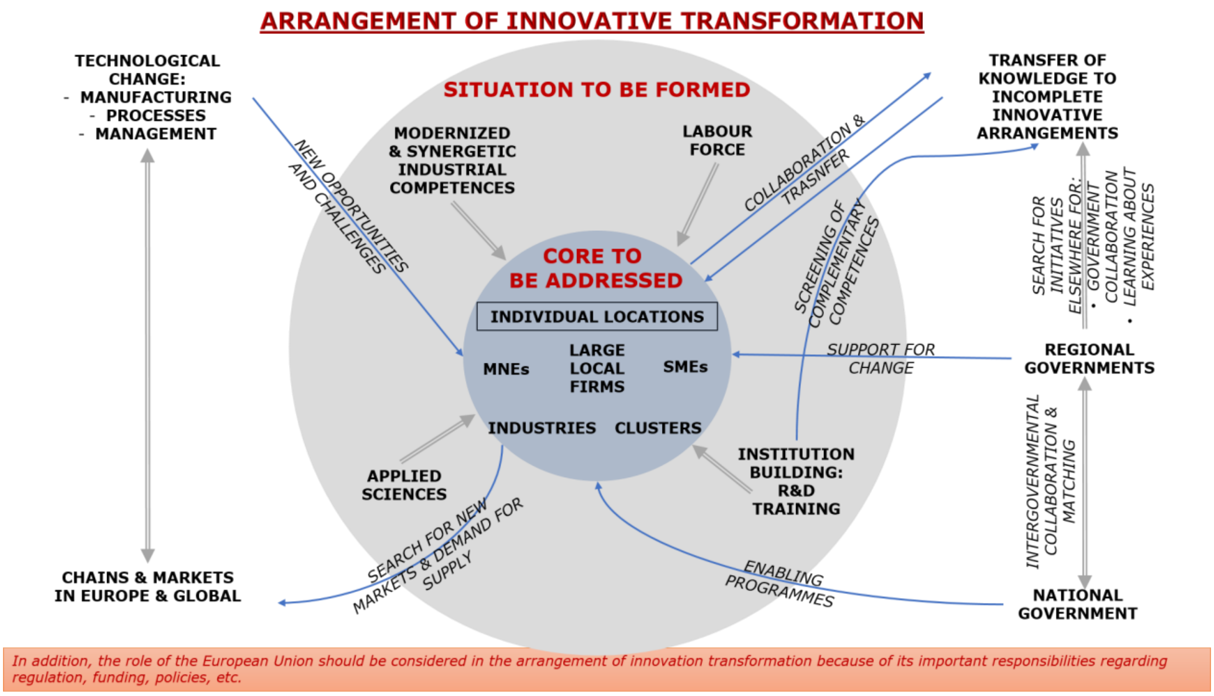

Figure 32: Arrangement of Innovative Transformation

Chapter 4 - Outlook

The analysis of industrial transformation is a complex task that would require further research. This report indicates areas of potential activities regarding a phenomenon which suffers a continuous change process. Nevertheless, this research describes the basic opportunities, limits and rules of the phenomenon which would be the playground of future political discussion. In this sense, more available data or the novelty of the process would allow to go deeper regarding some conclusions, which would support the evidence that point towards some specific interpretations of the industrial transformation phenomenon in Spain. This section describes some of these intermediate conclusions, which would require allow a closer and deeper analysis.

It is clear to all that manufacturing industries in Spain face the double challenge of rebuilding the industrial structure, seriously damaged by the negative spillovers of the construction industry crisis, and managing the increasing pressure of low cost competitors.

Exports have made it possible to recover production volumes prior to the 2008 crisis, but they have not recovered employment. The increasing presence of foreign companies in Spain, attracted by the internal devaluation and the decoupling of productivity and wages, has produced the strong growth of exports. However, it is still unclear whether foreign investment has simply involved a change of ownership or has actually implied a real productive investment and whether these investments, value and exports growth have reflected not only in value added but also in job creation. Either way, the growing importance of foreign ownership is causing a growing number of decisions on Spanish industrial sectors being taken outside Spain. From a political point of view, Spanish institutions need to find new ways to influence the decision centres of multinationals and reinforce industrial sovereignty. Recent examples show these risks such as Ford and Volkswagen decisions to concentrate the manufacture of electric vehicles in Germany, Airbus decision to prioritize production in French and German plants, or Siemens-Gamesa decision to close four Spanish plants in the last three years in search of lower labour costs. Overall, further research can help to understand whether these recent cases really reflect how risky it would be to build future economic development policies upon the uncoordinated action of foreign multinationals.

The Spanish economy is beginning to feel the effect of Skill Biased Technological Change, which increases wage inequalities among workers. It would be necessary to understand better to what extent a shift in the industrial structure towards higher value-added sectors could really drive a strong employment creation. In fact, sometimes the combination of high worker productivity with high skills and process automation means that a strong expansion of demand does not require a strong expansion of labour. For example, the report shows that Spain has strong engineering capabilities in aerospace, train, energy or automotive industries, which do not always translate into employment creation since the production of products designed in Spain is being located in plants outside Spain. There are some examples of this situation in the automotive sector with the Seat Tarraco or SEAT's first electric car, the Cupra Born, or in the renewable energy sector with the products of Siemens-Gamesa. In order to create a relevant number of jobs, recent research suggests that employment creation in industries experiencing skill biased technological change will occur only if strong entrepreneurial competences are developed in these industries so that knowledge spillovers from engineering activities are transformed into new business opportunities. However, Spain currently lacks these entrepreneurial competences in manufacturing industries, as shown by the limited entrepreneurial activity in Technology Parks, which are more successful in attracting existing firms than in creating new firms, and by the limited venture capital investment in manufacturing industries. In this sense, existing firms will drive an industrial transformation process which needs to be complemented by the action of start-ups in order to enlarge industries and create a higher number of employment opportunities.

The analysis of the Spanish industrial reality shows that the Spanish industrial policy must take into account the diversities of each industry and each region, since the distribution of competences, the strategic orientation and the competitive capacities have strong regional specificities. This research has analysed the specific reality of four regions that account for half of Spain's industrial production: Madrid, Andalusia, the Basque Country and Catalonia.

The industries of these regions have in common two extreme and opposite situations: the fragmentation of most of the industries and the high concentration of companies with a large presence of multinational companies. Some regions and industries, such as the Manufacture of metallurgy in the Basque Country, have large firms and microenterprises. On the one hand, fragmentation within a sector means that companies in these sectors have few capabilities and resources to innovate. On the other hand, the most exporting and innovative sectors are controlled by large companies, typically MNEs, which conduct less innovative activities in Spain than in other countries.

Two different facts explain the low level of innovativeness of large corporations in Spain. On one hand, in the case of large foreign corporations, R&D centres are located outside Spain, as shown for the pharmaceuticals or automotive multinationals in Spain. In this sense, large multinationals come to Spain attracted by the engineering skills and the manufacturing capabilities rather than by the innovative competences of the workforce and the local supply chains. On the other hand, Spanish owned large corporations have been quite successful in specializing in incremental innovation and process innovation, as observed over the past decades in the pharmaceuticals, food, car components or chemical industries, and therefore there is little pressure to change. Nevertheless, there are examples of successful micro-firms that have evolved into medium and large corporations because of their radically innovative competences. In the future, it would be important to learn how some Spanish micro-enterprises have managed to escape the fragmentation trap by building distinctive innovative competences, and to learn from these examples to know how to transform existing engineering and manufacturing competences of Spanish owned large corporations into more radically innovative competences.

The different industrial structures and institutions of Spanish regions imply divergent industrial challenges. How specific regions adapt to specific challenges can be answered when primary data to be studied more deeply. For instance, Madrid has to define industrial policies that may reverse the pharmaceutical industry's shift from product development to contract manufacturing. The region has to reconsider in its industrial policies the role of the potential complementarities between Madrid´s strong competences in engineering, software and high value-added manufacturing services with the manufacturing capabilities of industries in other regions such as the Basque Country or Andalusia. Moreover, the region needs first to transform the strong manufacturing capabilities of Madrid's automotive sector into innovative capabilities, and second to build opportunities for Madrid's aerospace industry outside the Airbus supply chain.

Andalusia, industrial transformation plans should focus its efforts on developing manufacturing and commercial capabilities in the food sector to increase the proportion of higher value-added food products produced in Andalusia. This strategy will allow Andalusian firms competing in a growingly specialized and sophisticated global food market. Additionally, food firms should consider to start taking advantage of the region's biotechnological competences in order to enter the markets which are at the intersection between food and health industries. The Andalusian chemical and plastic industries face the challenge of reinforcing and modernizing the manufacturing competences of the sector, especially for SMEs, which have lower innovative competences than those of the Catalan SMEs. As mentioned for Madrid, the Andalusian aerospace industry needs to invest heavily in competences needed to search and exploit business opportunities outside the Airbus supply chain.

Catalonia is possibly the Spanish region that suffered the greatest impact of the transformation of the automotive industry. The high proportion of local ownership of the firms in the automotive industry in the Basque Country has prevented temporarily the same deindustrialization Catalonia is facing. In Catalonia, the deindustrialization is explained by the greater presence of foreign suppliers such as Bosch, Magna, Magneti Marelli or Continental, which are the ones that are more likely to relocate outside Spain. The region is promoting the development of productive activities linked to the electric car to offset the effects of deindustrialization. However, the focus of these initiatives is very much centred on the low-cost manufacture of batteries and led by foreign companies such as Volkswagen. This approach may solve the problem of the Catalan automotive industry in the short term, but still entails a huge risk of relocation or offshoring in the medium term. In the long term, these initiatives should take advantage of the potential of the region's basic research capabilities. Therefore, it would be interesting to be able to integrate the strong basic research capabilities in the reindustrialization processes to create a new industrial model for Catalonia more oriented to the development of new differential products in the value chain of the zero emission vehicles, and less oriented to compete through production costs or public subsidies. Along the same lines, Catalonia has strong capabilities in the field of ICT that would allow the development of innovative competences in the field of vehicle digitization. In fact, Panasonic's purchase of the Catalan component supplier Ficosa, with strong capabilities in the field of vehicle digitization, is an example of the value of existing competencies in Catalonia in this area.

The food sector in Catalonia has grown in recent years. However, the presence of SMEs means that their lack of resources has an impact on the possible expansion and diversification strategies that this industry can undertake. For this reason, the main challenge of the Catalan food industry is the lack of greater access to private financing, for instance through venture capital mechanisms, which would allow Catalan SMEs to develop expansion strategies and geographical and product diversification. The third notable sector in Catalan industry is the chemical sector. It is an innovative and exporting sector, in which medium-sized companies play a major role in innovative activity. When it comes to expanding the sector's capabilities, it has been observed that the sector does not take advantage of the basic research capabilities of the region, and therefore so far focuses on the development of incremental innovations or on the improvement of production processes. Therefore, as in the case of the electric vehicle industry, basic research in Catalonia must be connected with SMEs in the sector. Likewise, the analysis reveals the lack of connections between the innovative activities of the sectors. For example, the plastics industry, heavily concentrated in Catalonia, interacts with the food industry in the areas of packaging innovation. However, there is an opportunity to use its innovative skills to develop new materials in the electric vehicle supply chain, which requires a reduction in the weight of components to improve the autonomy of vehicles, or in other sectors where regulation will increase pressure on the reuse or recycling of plastic components. Similarly, the more basic chemical industry has capabilities that could be harnessed in the development of more efficient electric batteries. This integration implies technological risks and investments that discourage innovation, so public policy action should be aimed at mitigating these risks and creating institutions that favour cross-industrial innovation.

The pharmaceutical industry in Catalonia faces two challenges, namely the contraction of product development times and the downward pressure on drugs costs by governments to counteract the increase in demand for drugs driven by the aging of the population. The integration of new technologies such as artificial intelligence or data management to address both challenges is still at an early stage, as these are completely new capabilities that pharmaceutical industries are not used to develop. However, if firms cannot reduce the costs of product development and production through digitalization, the easiest alternative for the industry would be to relocate production.

There are opportunities for inter-industrial synergies in the Catalonian pharmaceutical industry. First, as mentioned above, Catalonia has strong research competencies in the ITC area, so again, it would be necessary to study whether bringing together and integrating research agents in new information technologies with the pharmaceutical industry will raise the region's competitiveness. Second, another important opportunity for the pharmaceutical industry is to take advantage of the synergies between the Catalan food industry and the pharmaceutical industry in the development of joint value propositions.

Basque industry is characterized by higher productivity and larger firms than the rest of the Spanish manufacturing industry. However, the technological competences of main industries such as machine-tools, automotive, train and aerospace manufacturing, are facing the important challenge of the growing incorporation of intelligent robotics and additive manufacturing. In this sense, as in the case of the Catalan pharmaceutical industry, the Basque machine-tool industry lacks digital competencies in hardware and software development. Likewise, basic research on ICT, is not as developed in the Basque Country as in other regions such as Catalonia or Madrid. Proof of this situation is the increasing incorporation of ICT companies from these regions to the Bind 4.0 program. However, while Bind 4.0 program is a good start to access competences from outside the Basque Country, a larger number of Basque innovation programs should start considering mechanisms and incentives to increasingly integrate competences from outside the region into the value chains and innovation processes of Basque companies. For example, it has to be analysed what would be the effect of integrating the highly specialized Basque technological centres with Catalan chemical companies for the development of new materials or with software companies from Madrid or Andalusia for the transition to Industry 4.0.

The Basque Country is trying to develop competences in biotechnology starting from a very low initial knowledge base. Trying to build competences from scratch is a very frequent approach in many Spanish innovation policies. To be successful, this approach needs large investments and long times for a significant return to investment. Current innovation programs of the Basque Country do not provide enough funding to achieve the goal of developing a solid biotech industry capable of competing and collaborating with the existing competences in Madrid and especially in Catalonia.

Another important lesson from this report is that competencies and skills must be available to take advantage of the opportunities described for each of the regions. In this regard, a first challenge for the Spanish policies is to overcome the existing mismatching between research and education and industrial competences. The innovation system should integrate public education and research systems with the business sector. Integration between these two elements of the innovative transformation arrangement requires firstly a cultural change in public research policies. This cultural change should imply to abandon the model established in the 1990s, which was heavily focused on scientific publications as the final objective of public research institutions. A new culture in universities and public research institutions would be needed where innovation and not publication must be the final goal of public funds invested in research. This does not mean abandoning basic research, but rather creating a system based on three elements: competences in basic research, which is the basis for having truly differential product development competencies; regional institutions that act as a bridge in early stages between basic research and product development and between the different industrial sectors focusing more on co-creation of knowledge rather than on the inefficient model based on knowledge transfer; manufacturing competences that are highly consolidated in some traditional fields such as the automotive industry, but whose value will diminish over time if they are not complemented with modern competences. The combination of the three elements would make it possible to reduce dependence on foreign MNEs and develop the capacity of the Spanish productive system to be resilient in the face of technological change.

In this sense, it is also important to make an effort to develop the right skills at the right educational levels, in order to reduce the problem of theoretical over qualification. For instance, it is necessary to create dense communication mechanisms between vocational training institutions and firms. The Basque centre Tknika or the Catalonian VET Center in Martorell are examples of instruments, which although it has not yet managed to scale up for the whole region, could be useful to create a much denser network of social connections. These dense connections between VET educational centres and firms would allow creating bidirectional knowledge flows that would benefit workers and students and will upgrade and maintain up to date the knowledge and skills of VET educators.

Skills and competencies are the main drivers of innovation. Without skills and competences, it is impossible to search for and exploit new opportunities. As we have shown in this report, educational levels do not always imply a large base of skills and competencies. Spain has one of the largest populations of university students in Europe. However, the high unemployment rates suggest that many of these university students upon graduation do not have valuable competencies for the job market. Similarly, we have seen that different firms in Spain have started their own vocational training programs to complete and upgrade the skills of vocational training graduates. Therefore, increasing the number of graduate students of an industrial engineering bachelor or an electronics and electric vocational training program does not imply to increase the skills and competencies of the Spanish labour. Additionally, mastering a specific production process does not imply either to have the required skills and competencies to innovate. For instance, Basque firms in the Manufacture of metallic products or the Manufacture of machines and equipment have demonstrated over the years strong process innovation skills. The highly specialized research centres in the Basque Country have also shown strong skills in process innovation. However, both the firms and technological centres have realized that they lack the skills and competences to develop new products to enter new supply chains outside their knowledge field. Therefore, the assessment of the real skills of a region or an industry requires a more precise and less simplistic focus than just considering research or education.

Knowledge flows and spillovers are an important element of an innovation system. Knowledge exchange could take different shapes, from alliances, worker mobility between firms, training and education initiatives, networks, and joint technological centres. Despite a growing number of Spanish firms and institutions adopting open innovation practices, knowledge exchanges are not at the centre of innovation policies yet. There are some attempts of creating knowledge exchanges. For instance, in the Basque Country technological centres work as central knowledge repositories for the firms in a cluster. Since the centres have been participating for decades in joint projects with firms in a specific cluster or supply chain, technology centres have accumulated a large amount of technical knowledge. These centres share this knowledge with other firms in the cluster through joint projects or training and educational programs. However, this model apparently has two limitations. In first place, over the time, firms have developed adequate social competences to cooperate with technology centres, but they still lack the skills to build knowledge networks with nearby firms. In second place, technology centres tend to accumulate knowledge related to incremental innovation and process innovation in a narrow knowledge field. However, they do not have an orientation and the resources to create and accumulate knowledge outside their knowledge field. In that sense, the nature of the knowledge of these technology centres is path dependent on the technological trajectories of the firms in the cluster. These technology centres would contribute to solve this problem by developing enabling competences in the firms of the cluster, so that firms may establish wide and diverse networks and may search for business opportunities outside their traditional knowledge fields. However, the development of these competences cannot be done for all firms in the cluster at the same time, but need to be implemented through tailored projects, where only firms with real commitment to change and innovation should participate. As discussed above, the invisibility of the existing competences of a cluster could hamper the efficiency of these knowledge exchanges. Therefore, technology centres or other sectoral or regional institutions need to establish programs aimed at observing and revealing what are the competences available in a specific value chain.

It is important to consider the analysis, design and implementation of innovation policies under the wider umbrella of economic policies. Often, labour regulations or tax policies have hampered or improved the efficiency of innovation policies and programmes. For instance, Basque Country and Madrid have designed favourable regional tax regulations to attract venture capital firms and technological start-ups from other regions in Spain and Europe. In this sense, it would need further study to understand whether regulatory and tax competition between regions may have long term effects on the relocation of firms and labour with strong innovative or manufacturing competences, or may produce just short term shocks for specific projects that will dilute over the long term if these regulatory incentives are not completed with a set of policies aimed at creating a real innovation system.

Chapter 5 - Questions of strategic relevance which are to be addressed now

Based on the conclusions of this report, now, there are important strategic questions which can be discussed. The situation of innovative transformation is rather complex and challenging. While some areas are defined simply by new technologies to be employed (e.g. Industry 4.0 and digitization) others are still in a situation of being developed and decided (e.g. hydrogen related issues). This may match with the current industrial structures as embedded in European networks of supply chains and value chains or with particular potential of a country because of the climate. This view widely contains a bipolar idea of matching or mismatching situations of regions, industries and enterprises. Clearly, where there is a match there will be innovative transformation, but those face problems where there is both mismatch and incomplete potential.

Thus, a discussion about the design of a strategy towards innovative transformation needs to take into account all opportunities which exist but may not be shown in statistics, indicators or models. The heterogeneity of regions, metropolises, individual industrial structures, capabilities of R&D, industries and labour force shall be exploited appropriately to contribute to such a complex and broad process. Regions and metropolises show rich varieties of opportunities based on industrial competences, traditions and societal capabilities. Frequently, existing opportunities can be matched with new technologies or based on synergy these can be applied in new areas and situations. While statistics and economic indicators would not identify those situations and opportunities, in contrast, these can flourish and become areas of higher values added, better incomes and improved industrial competences.

In addition to new technologies and strategies which suit MNEs, such opportunities need to become transformed into newly formed situations which continue traditions and take advantage of synergy from making incomplete innovative arrangements to be completed by additional competences. No matter whether viewed from regional perspectives or taking the approach of industries based in regions there is potential and investment into such arrangements which exist to be used and which provide a basis to continue through transformation. It is wise to explore more deeply these opportunities, potential synergies and incomplete innovative arrangements, because this demands for a cost efficient add-up strategy.

In times of limited public resources, a decision of taking into account the existing situations allows for smart budgeting, having wider impact based on appropriate policies. This complements the programmes focusing on new technologies and equipment by raising the treasure of existing competences which are synergistically matched with new technological applications. The findings of this research show that aiming at innovative transformation is clearly multifaceted and needs to raise the potential of diversities of innovation as it matches industrial competences, technological opportunities and regional capabilities. Strategies addressing high performance manufacturing and new technologies to be introduced by MNEs and large Spanish companies, in addition, take advantage of SME-clusters as innovative suppliers. Simultaneously, these large companies and MNEs are some important customers for innovative clusters when they bring their new products to markets.

While it is clear that these networks, relationships, capabilities and opportunities are fundamentally important the realization of such a process of innovative transformation demands for an appropriate initiative of public policy. The rich diversities of opportunities in different regions demand for flexible and specific strategies which enable the transformation of the regions allowing for participation in transformation and development oriented in higher values added. Regions vary in both their existing capabilities and the deficits to be compensated. Thus, making regions capable to participate in national or European networks and markets policies need to allow for flexibility in modernization and competence building – consequently, because of the regional and industrial divergences, strategies of transformation realized need to be diverse but they will address and include converging dimensions and elements.

These divergences of situations are asking new and open questions to be answered based on important constellations to be considered:

- *Potential capabilities and divergent opportunities*. Previous processes of development have established capabilities and competences which are available now. They are frequently maturing and demand for modernization. Opportunities are highly divergent because of the industries in the region and institutions to provide R&D and skills.
  This leaves open the questions (i) which potentials can become subject of innovation, (ii) which are the competences available to be exploited newly or with high performance manufacturing and (iii) how to establish situations which is divergent from other regions but allows some sustainable development in the future?

- *MNEs, large Spanish companies and clusters of SMEs*. The situation of Spanish regions is frequently characterized by large enterprises. These are rarely drivers of innovation based on own research, but as important industrial plants they need to be considered when modernizing the structures and as important customers they have major influence on domestic supply chains. Modernisation processes of such large companies would create demand for improved supply from SMEs and SME-clusters. Since industries are highly diverse concerning the complexity of their products and the differences between manufacturing industries and process industries
  there are the questions (i) which potential and areas of innovation exist in different industries, (ii) what are their specific opportunities and how do these reach out into a sustainable future, and (iii) what impact will this create alongside the supply chain and concerning the orientation of SMEs into innovation of their products?

- *Incomplete innovative situations and synergy by matching competences across industries and regions*. Given the orientation on profitable business conditions for large firms and the rather narrow orientation of SMEs alongside the supply chain there are situations which clearly contain competences which suit the situation as these in the past, but they do not meet all requirements for a sustainable modernisation. Nevertheless, these situations refer to both a body of knowledge and competences from its previous industrial development and the enterprises represent the investments already realized. Modernisation requires R&D for new products and markets, and a skilled and educated labour force to provide for modern products – but this is highly diverse between individual situations of a region.

So there are the questions (i) which deficits exist in the different incomplete innovative arrangements, (ii) how can these regional situations be complemented to exploit their competences in modernized industrial settings, and (iii) how to establish such relationships to supply the innovative capabilities necessary?

- *Complementary competences and networks building*. A compensation of innovative deficits demands for additional and complementary competences to match the situation. This demands for both to surmount the very close orientation as suppliers to specific large enterprises and to develop an open attitude towards collaboration which is open to ideas and competences from different areas. Thus, existing clusters can improve their situation as suppliers or they can find new markets when merging industrial competences create new products of higher values added. Such processes can be introduced even across neighbouring enterprises within a region or across regions or countries.

  This raises questions for (i) what kind of synergies are generated with particular industrial competences in collaboration with other areas, (ii) how were such complementary opportunities identified and considered useful, and (iii) how was the modernization process funded?

- *Advantages of individual regions and European and international contexts need to be considered*. Regional competences are formed from the different industries and enterprises which are located there. Since these arrangements are formed also by the strength of individual enterprises and their products and the continuing improvement over time a traditional expertise is formed. This contains a mix of capabilities and provides for potential match of competences. Such traditions can refer to skills and knowledge and they often match with geographical or climatic situations. Wood processing or food processing in relationship with specialized agriculture indicate such traditions as well as different glassware or musical instruments point out such opportunities, but also optical or mechanical traditions provide potential for modernisation. Identifying a certain uniqueness of a situation may provide a basis for sustainable development. While it is worthwhile to explore the potentials of such competences it is important to learn about the European and international context. There might be existing or emerging situations which will be met in markets.

When exploiting such competences and opportunities the questions have to be answered (i) where are such specific situations and why are those rather unique, (ii) how can those situations be strengthened or being made more innovative, and (iii) will there be constraints to be considered by other enterprises or regions?

- *Institutions to match the situation and appropriate innovation.* Institutions can help building innovative situations. Since the regional situations are highly diverse institutions need to respond accordingly and offer support that helps to realise a process of innovative transformation. In federalized systems regional governments are oriented in the socio-economic development of their regions and thus give reference to the industrial structures, labour forces and demand for research as it emerges in their regions and metropolises. Consequently, the institutions established may vary according to problems asking for political activities (e.g. research institutions, education, skills, reintegration into the labour markets etc.) and even similar institutions may have divergent focus (e.g. support of SMEs in specific areas of competence, up-grading or re-education of labour). Nevertheless, all regions demand a full range of institutions although, in practice, the focus may be divergent.

  The situation as established in the regions raise the questions (i) which institutions exist in the different regions and how closely are these linked with firms, labour and regional society, (ii) which regions need to be established having divergent focuses, and (iii) do these regions support new opportunities of products referring to higher values added?

- *Innovative transformation towards higher values added*. While meeting the competition from low-cost countries in many areas and products and, on the other hand, not being prepared for a research-based high-tech strategy neither on the national nor on the regional level it is important both to strengthen specific advantages and to create new opportunities of higher values added. Leading countries and regions in Europe and abroad have significantly improved the content of knowledge in their products. As shown in relation with tradition-based innovation or incomplete innovative arrangements there is potential of relevant knowledge available which needs to be applied. This has limited demand for expensive, long-lasting and fundamental research but frequently is a matter of competition of elements of innovation required or merging competences from different areas to arrange for new opportunities of application. Thus, knowledge-intensity of products can be improved based on creativity and existing body of knowledge alongside with limited efforts in research and funding. This can introduce a process of changing from supply chains to value chains, it can increase the attractiveness towards MNEs and large enterprises in general, it may even improve the final products of OEMs, and it can contain potential of entering new markets.

  Based on the findings and opportunities mentioned there are the questions of (i) which bodies of knowledge can be matched for raising higher values added in existing firms and new or renewed products, (ii) how to identify the innovative potential of traditional competences and existing capabilities, and (iii) how to motivate and fund the potential partners to engage in new areas of activities?

- *What to do and how to enter sustainable strategies?* MNEs are still realizing good profits while running factories in Spain there is little intention to further investment into R&D which is carried out elsewhere. The important role of MNEs for Spain, of course, demands for including them into a process of innovative transformation. Since they and large Spanish companies provide potential markets for improved products of suppliers they need to be included. But, after all, clear pictures on the divergent situations of industries, enterprises, labour forces and regions need to be formed. Opportunities and challenges are highly diverse and so are clusters and activities of different levels of administration.

Strategically, this demands to deal with the question of (i) what are the situations formed from industrial sectors, size of enterprises, how complementary are innovative arrangements, potentials of labour markets and traditional competences, and which institutions are established, (ii) which opportunities exist of potential transfer of knowledge matching situations elsewhere and modernization of traditional competences, and (iii) how can a long-term perspective of sustainable development be introduced based on initiatives which are already effective shortly or in a medium time scale?

As a starting point, such areas to be dealt with and questions to be answered can be based on the results and data which are provided with this study. As it is important to ask the right questions when searching for solutions this report helps to develop individual and specific ideas of potentials and complementing deficits as well as aiming at smart budgeting when building upon already existing competences ready to match with others and to modernize. It is important to understand that there will be higher values added when the fundamental relevance of skilled and educated labour is considered. There are opportunities to improve the socio-economic situation in a shorter time frame rather than waiting for breakthroughs in science and hoping for individual regional aspects. Specific traditions and competences can be complemented by new technological opportunities – if applied carefully and with strategic confidence. Industry 4.0 and digitisation may provide opportunities to realise such processes and to learn for a sustainable future in many areas.

Table 15: Diversities of regional situations and policy opportunities

	Diversities of regional situations

Opportunities of policies	*Regional capabilities and divergent opportunities*	*MNEs, large Spanish companies and clusters of SMEs*	*Incomplete innovative situations and synergy by matching competences across regions & industries*	*Complementary competences and network building*	*Innovative transformation towards higher values added*
Advantages of individual regions and European and international contexts need to be considered	Which capabilities and competences exist? How unique is this in the EU and in the international comparison? Which potentials of modernisation exist?	Which MNEs, large Spanish firms & SME-clusters exist in the region? What do they produce and manufacture? How are these placed in supply chains and value chains?	Which arrangements are in the region but miss some elements of similar but innovative regions? Which of the regional competences are of interest to other regions? How to get in touch with regions to exchange competences?	Which regions in Spain or EU are potential partners to compensate deficits & build synergy? What makes the region a unique partner (e.g., tradition, climate, competences)? How to build a mutually beneficial network?	Which areas are ready or suitable for higher values added? How prepared are the enterprises of the region for higher values added? How well does it suit with the regional clusters and the regional labour force?
Institutions to match the situation and appropriate innovation	Which institutions do already exist and which areas are covered? How complementary are innovation and labour? Which level of innovation by manufacturing can be realised?	What can be arranged for modernisation of products and manufacturing? How to improve the placing of enterprises in supply and value chains? How to provide skills, R&D, and synergy required for the process?	Could deficits be balanced and compensated by existing institutions? Can individual competences make regions particularly attractive to MNEs and large Spanish firms? Can a branding of competences and exchange be arranged?	Can joint projects with other regions be launched? Which institutions help building of/ participating in networks? How to modernize competences to be contributed to networks?	Is there a need of institutions for R&D, networking, and training? Which institutions are ready to support or need to be established to realise these goals? Are there partner institutions available to help upgrading value added?
What to do and how to enter sustainable strategies	Where to build and support - industrial competences - R&D -skilled and educated labour - appropriate institutions How to arrange for matching competences and collaboration in the region?	How to support independence of SMEs concerning - products -markets - synergy competence and tradition Do MNEs, large Spanish enterprises form markets for higher value added products of SMEs?	To which area are activities to be addressed: - synergy - R&D - skills and education - branding of modernized tradition How to arrange for collaboration - intra-regional, inter-regional - intra sectoral, cross sectoral - cross firm, cross MNE/SME - cross SME cluster collaboration	Are there networks to link up with? Are there EU activities to be applied? Which regional competences should be strengthened when aiming at network participation and contribution?	Which long-term strategies can be developed and designed? How can such strategies be made sustainable? Which policies need to be designed to support - product design - R&D which suits the regional opportunities - skills and education required with these strategies

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