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Knowledge Cohesion in European Regions: Convergence and Cohesion with Turkey

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ABSTRACT

In a knowledge economy, it is interesting to see that the concept of knowledge cohesion is a fertile soil for research. Despite the ongoing interest in investigating whether economic cohesion has been achieved in Europe there is no work that looks at knowledge cohesion. Though it is difficult to investigate such an abstract concept one can look at a more concrete concept such as convergence. Using the European Union Framework Programme data from 1984 to 2016 we show that there are signs of knowledge convergence within the NUTS2 regions. Despite the fact, the top performers persist over the years the convergence is much stronger among the less developed regions. The results also show that Turkey enhanced its position in knowledge exchange considerably where some of its developed regions are emergent knowledge hubs. These results indicate that Turkish knowledge system is tied strongly to the European Research Area which reduces the probability of conflict scenario.

ÖZET

Bilgi uyumu konusunun içinde yaşadığımız bilgi çağında bu kadar az çalışılıyor olması ilginçtir. Avrupa'da ekonomik uyum ve yakınlaşma konusunda pek çok araştırma yapılırken bilgi uyumu konusunda hemen hiç bir çalışma bulunmamaktadır. Her ne kadar bilgi uyumu konusu soyut bir kavram gibi dursa da daha somut bir kavram olan bilgi yakınlaşması kavramına bakılabilir. Bu çalışmada 1984-2016 arasında Avrupa Çerçeve Programı verisi kullanarak, Avrupa NUTS2 bölgelerinde bilgi yakınlaşması olduğunu gösteriyoruz. En iyi performans sağlayan bölgeler yıllar içinde pek değişmese de, daha az gelişmiş bölgeler arasında bir bilgi yakınlaşmasından söz edilebilir. Sonuçlar aynı zamanda Türkiye'nin bilgi paylaşımındaki pozisyonunu zaman içinde geliştirdiğini gösteriyor, öyle ki bazı bölgeleri yeni doğan ve gelişen bilgi merkezleri arasında yer alıyor. Bu sonuçlar Türkiye bilgi sisteminin Avrupa Bilgi Alanına güçlü bir şekilde bağlı olduğunu göstermesi nedeniyle çatışma senaryosunun olasılığını düşürmektedir.

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1. Introduction

The recent changes observed in the knowledge and learning economies is a result of increasing interaction occurred in the era of globalization. This era witnessed the changing significance of codified and tacit knowledge as well as intellectual capital in the course of economic growth and development. In this context, knowledge diffusion is a central element of innovation. The European Research Area (ERA), proposed in January 2000 and conceptualized in Lisbon summit of March 2000, is the basic backbone of the knowledge generation and diffusion strategy of EU. The basic aim of ERA is to combine European scientific and technological resources more effectively. This attempt of amalgamation produces considerable results for productive knowledge flows to increase the competitiveness of ERA with the rest of the world. Though started earlier, the framework programmes is the key policy tool with other supplementary programmes in the start of the new millennium. Until today the basic premise of this approach lasts. Given the importance of cooperation in the EU 2020 Strategy, investigating the patterns of cooperation and the knowledge flows between the nodes of wider EU networks is integral for building economic, social and political strategies according to the recent ERA progress report (EC, 2017),

> *An integrated ERA leads to 'a unified research area open to the world based on the internal market, in which researchers, scientific knowledge and technology circulate freely and through which the Union and its Member States strengthen their scientific and technological basis, their competitiveness and their capacity to collectively address grand challenges.*

Although the sub priorities gradually changed in the last two decades, this starting phrase of the report underlines that the spirit of the Lisbon strategy is still valid and will be a dominant political choice until 2020. The report also highlights the improvements in predefined indicators for EU member states. ERA is not only limited with the geographical coverage of EU but also includes a wider geographical area in the neighborhood. The RIO reports also verify the positive impact of ERA. [1]

The process of the harmonization of the EU acquis contributes to the research and innovation efforts of Turkey. Although not a Member State yet, Turkey's strategies and efforts in the field of S&T and innovation are, to a large extent, in line with the ERA pillars. The ERA developments have been closely followed by the policy-makers and the BTYK (Higher Council of Science and Technology) launched the "Turkish Research Area" (TARAL) in 2004 with inspiration from the ERA. TARAL, a platform for public, private and NGO stakeholders to coordinate future R&D priorities and collaboration, is aimed to be integrated with the ERA. In this respect, Turkey participates in the common programmes and is determined to be involved in the initiatives carried out at the European level. Further improvement of policy coordination across policy levels and in the policy mix would contribute to the alignment with the ERA pillars.

This paper is an analytical attempt to discuss the knowledge flows at the regional level within EU in general and between EU and Turkey in particular. While doing so, it employs two concepts:

[1] https://rio.jrc.ec.europa.eu/en/library/rio-country-report-turkey-2015

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Knowledge cohesion at the mega level and knowledge convergence at the macro and meso levels. The next section will be devoted to the theoretical discussion on why knowledge and its flows matter for economic growth and development and on conceptualizations for the rest of the study. Third section describes the data and the methodology. Fourth section will focus on the analysis of the empirical results that mainly utilizes micro data from framework programmes. The fifth section will carry out robustness tests. Finally, the findings will be summarized and policy implications of the analyses will be put forward in the concluding section.

2. Knowledge and Knowledge Flows: The Theory in Retrospect

Knowledge was not often studied by economists before 1980s though it is one of the central concepts in social science disciplines even going back to Plato and Aristotle. Before 1980s, the studies are indirectly engaged with the role of knowledge in the cases of human capital, research and development and technology. The rising interest especially in the last two decades is the result of globalization and ever increasing role of knowledge in the competitive position of countries and regions as an input to the innovative activities. In this process, we observe a rise in the number of theoretical and empirical attempts on the commodification of knowledge. In order to be treated as an economic good, knowledge must be out in a form that allows it to circulate and be exchanged. One of the main distinguishing stylized facts about the knowledge is that both its use and exchange value increase with its consumption since this process fuels the generation of new knowledge. The key transformation is the codification of knowledge. Through this process, it is objectively possible to measure and assess the impact of existing and new knowledge. Moreover, the output of this process is reduction of knowledge to the messages that employed by decision agents to shape their acts. However, there always remains a tacit component of knowledge.

Not all but considerable amount of tacit component can also be transferred from one agent to others such as through common labor pools. In any case, either codified or tacit, flow, diffusion and further generation of knowledge necessitate social interaction and a systemic reliable process. In 1926, Ramsey (1990) noted that truth is not composed of judgments but of systems of knowledge. Andersson and Beckman (2009:3) quoted Sahlin's work on Ramsey's reliability concept, that knowledge is not true justified belief but rather a belief is knowledge if it is obtained by a reliable process and if it always leads to success. Machlup (1962) provides a definition, measurement and interpretation of activities that result with production and distribution of knowledge. Education institutions are the most important channels in US for these activities. Industrial activities and R&D activities also seem to be significant channels. This tendency followed by US was also observed in other economies. The increasing significance of collaboration in R&D activities and positive contribution of knowledge sharing seemed to be considered as a vital process. Moreover, the importance of connecting industry and university R&D activities were treated as a prerequisite for economic performance. This explains why framework-like programmes are always on the policy agenda on a global scene.

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Granovetter (1973 and 1983) conceives the role of information and knowledge in the context of social network theory. The basic premises of these two studies may also provide evidence on how the knowledge in the networks, such as framework programmes or co-authorship networks, flows and is reproduced. What is striking is that, in these two studies, Granovetter (1973 and 1983) focuses on weak ties rather than strong ties. Instead of small well-defined groups, he confines himself with the study of weak ties for the relations between groups. Following Granovetter (1973 and 1983), we observe various applications of social network theory in the literature (Ahuja, 2000; Ozman, 2009; Partanen et al., 2014). However, we do not go into details though the empirical application of this paper utilizes social network theory. Our key target in this section, as noted above, is to explain why knowledge and its flows have significant consequences for economic growth and development.

In his pioneering study, Romer (1990) adds valuable contributions to mainstream growth theory. Growth is mainly explained by technological change, which is driven through the existing knowledge stock and creation of new knowledge. Knowledge is treated, at the first instance a non-rival good in the sense that the growth caused by knowledge about the technology is a non-rival input. In the production function, knowledge has two implications. A new design enables the production of a new good and it can be used to produce output. Moreover, this new design also increases the productivity of human capital through rise in the total stock of new capital. Although neoclassical economics provides significant insights for the study of knowledge in the context of growth, it ignores the development consequences of knowledge.

More comprehensive account of the impact of knowledge and learning is put forward by the evolutionary economics. Lundvall and Johnson (1994) underlines that knowledge is the main factor of production and learning is the most important process. They assumed that the stock of knowledge is determined by two flows, namely learning and forgetting (p. 31). In this context, knowledge lost its value when it is not used. It has to be kept by the process of remembering. Learning as an interactive social process necessitates social interaction at different levels. The fundamental characteristics of learning economy is its gradual and systematic development of its capability to learn (ibid, 32). This process drives technical change and growth. The 'learning economy' is a mixed economy in a fundamental sense that needs government intervention to stimulate the stock of knowledge. With further studies, this evolutionary tradition is enriched with both theoretical discussions and empirical evidence (Lundvall & Archibugi, 2001; Christensen & Lundvall, 2004; Lorenz & Lundvall, 2006; Lundvall, 2016).

The evolutionary tradition also searches for an answer for the differences between developed world and developing countries and concentrates on the peculiarities of developing countries (Lundvall, et al., 2006; Lundvall, et al., 2009; Lundvall, 2016). Although from the same tradition, Viotti (2002) criticizes the use of the national systems of innovation concept of these studies for the developing countries. Viotti (2002) proposes that there are great differences in the process of technical change between industrialized countries and late industrializing economies. In the late industrializing countries, the process of technical change is characterized by process of learning

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rather than process of innovation. Therefore, he proposes a new definition of learning, "Learning is defined as the process of technical change achieved by the absorption of already existing techniques, i.e., of innovations engendered elsewhere, and the generation of improvements in the vicinity of the acquired innovations" (Viotti, 2002: 658). Such learning ends up with the diffusion of technical change and incremental innovation. This type of learning is somewhat a "passive" process characterized by a passive National Learning Systems (p. 665). Viotti (2002) further differentiates the basics of passive and active learning and provide two country examples, Brazil and Korea where the former is a case of passive and latter is a case of active learning. Although Viotti (2002) provides constructive insights, we do not believe such a taxonomy since national learning systems is a sub-system of national innovation system in which one can find examples of passive and active learners inside the system.

The next question, in fact, builds up the skeleton of this paper. How do national innovation systems converge to each other through interactive learning and what is the role of knowledge convergence in this process? The first step to answer this question is to develop a conceptualization for knowledge convergence. This conceptualization brings about the discussion on collaborative learning. "Collaboration is a coordinated and synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (Roschelle & Teasley, 1995:70). In this process, learners generate knowledge by working on complicated problems together and finding joint solutions through collaborative learning. The mutual interaction enables knowledge exchange and, in turn, knowledge convergence in time. One approach of conceptualizing knowledge convergence utilizes the concept of knowledge contribution equivalence in which learners may contribute ideas to varying or similar extents (Weinberger et al., 2007). In the literature, two different yet complementary measurement methods are introduced to analyze the knowledge convergence processes, namely the knowledge level approach and the trans activity approach (Weinberger et al., 2007:418). The knowledge level approach allows an analysis of the type of knowledge, that is knowledge of the task and knowledge of the team, which must be shared in order to improve team performance (Cannon-Bowers and Salas, 2001). The trans activity approach suggests analyzing learners' social mode of co-construction, depicting how strongly and in what ways learners refer to the contributions of their learning partners (Teasley, 1997). Trans activity is the degree to which learners refer and build on others' knowledge contributions, and has been found to be positively related to individual knowledge acquisition in collaborative scenarios (Teasley, 1997). Furthermore, learners can also build a consensus in various ways through quick, integration-oriented or conflict-oriented consensus building (Weinberger & Fischer, 2006; Weinberger et al., 2007). This paper employs the insights provided by these two approaches. In sum, we can define knowledge convergence as the growth and intensification of common shared knowledge that brought by all the collaborating partners.

The European example is a typical one in the context of knowledge convergence that has an impact on the convergence of national systems. The Lisbon strategy can be treated as an

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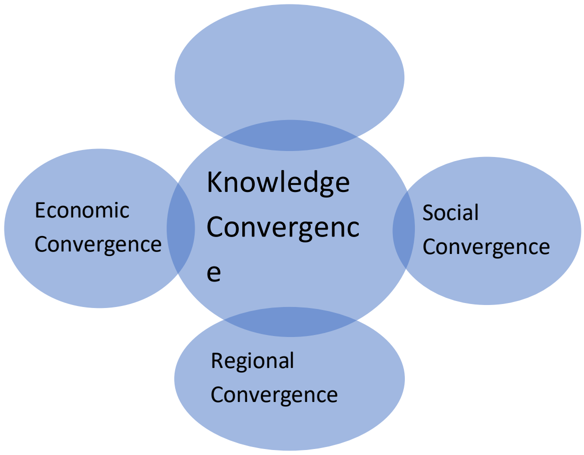
important step towards convergence at different levels such as political, economic, social, institutional regional and knowledge. All these types of convergences are indispensable elements for building a cohesive union. We observe a general tendency in Europe in accordance with the prepositions of trans activity approach. In fact, all types of convergence feedback each other and knowledge convergence is glue for overall convergence and cohesion as can be seen from Figure 1. The shared knowledge in the system reproduces itself, causing agents to develop a unique jargon and find similar solutions to similar problems. This knowledge convergence process enables other types of convergences and ultimately cohesion in the long run.

Figure 1: Interdependence between Various Types of Convergence



Source: Authors' own compilations

Godinho and Mamede (1999) put forward a taxonomy of convergence with three different versions (cited in Tomlinson, 2006), namely unconditional convergence, conditional convergence, and divergence. In the case of unconditional convergence, less developed economies are expected to converge with more developed ones. Social capabilities cause some countries to mobilize and utilize resources but not others for conditional convergence. Finally, there may be tendencies for some economies or regions to diverge instead of convergence. Some resources are concentrated in particular places such as labor supply, localized knowledge spillovers, and supply of inputs. This concentration creates industrial cores without there necessarily being any convergence in the periphery rather divergence (Tomlinson, 2006). We suppose that knowledge convergence is more easily realized through the interactions of regions rather than nations. This process of regional knowledge convergence helps to national knowledge convergence to lessen disparities and inequalities. Therefore, the stakeholders of the ERA will benefit from the knowledge flows for conditional and unconditional knowledge convergence. Cantwell and Janne (1999) and Cantwell and Iamarrino (2001) are the early examples of how leading multinational firms from the major European centres in their industry tend to carry out technological activity abroad, which is relatively differentiated from their domestic technological strengths. Caniels and Verspagen (2001) describe a model for knowledge spillovers based on learning capability of a region and the

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rate of knowledge generation through R&D. According to results of the study, borders between countries considered as barriers to spillovers and random differences in terms of structural characteristics may promote peripheral regions and cause them local centres. For European integration, this result underlines the importance of regional policies in establishing local growth poles and increased prosperity around them (Caniels & Verspagen, 2001: 326).

By using European regional patent dataset and tools of social network and multivariate analysis, Ho and Verspagen (2006) identified higher order regional innovation systems as the key hubs from which knowledge flows in the European innovation system. These hubs considerably shorten the distance for the receiving regions. According to results, ERA network is heterogeneous in terms of density and global connectivity. Therefore, different types of policies should be used for lower and higher order regional innovation systems. The role of lower order systems is crucial for local development while higher order systems are critical both for the performance of the system as a whole and knowledge diffusion inside ERA (Ho & Verspagen, 2006). These higher order systems act as decisive actors for knowledge cohesion.

There has been a surge of interest in the impact of spatial forces in innovation and economic growth. Estimates at the EU regional level using spatial lag models show that spatiality in knowledge factors that affect inventive activity is an important force (e.g., de Dominicis et al. 2013). This result achieved at the macro level is rather indirect as it basically tells that the results of the R&D and patent activities travels in geography which asks more investigation in "knowledge cohesion" (Akçomak & Müller-Zick, 2016). The EU prioritizes cohesion policy to reduce economic and social disparities among the EU regions. Though "economic cohesion" and "social cohesion" are frequently mentioned in EU documents no such record can be found for "knowledge cohesion". It is quite common to read elsewhere that we live in a knowledge economy where knowledge is a strategic asset and learning is the heart of business growth and economic development but it is hard to grasp why we still do not have a concept like "knowledge cohesion". The main of this paper is to investigate whether there are signs of knowledge convergence as a first step of knowledge cohesion.

3. Data and Method

To investigate whether there is indeed knowledge convergence in Europe we benefit from the EU Framework Programme data from the first round (FP1, 1984-1987) till the last round (FP8 -H2020, 2013-2020). FP data is rich, enables comparison over the years, covers a wide range of scientific areas and the selected projects reflect scientific issues at the world frontier. Thus, the analysis of the whole FP data can tell quite a lot about where knowledge is created and with whom.[2] Section

[2] A similar analysis can also be conducted using scientific publication data. However even a much shorter period from 1996-2016 requires analysis of 15.6 million papers (according to Scimago) and associated co-authorship network which is out of the scope of this research. Besides there are various issues of quality, missing information and scientific field specific issues that would cause problems in using such data.

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3.1 presents basic information on the Framework Programmes and detailed information on the raw data collected and the actual data used in this research. This section also presents information on the Web of Science co-authorship data that we used as a benchmark. Section 2.2 explains the methods we use to analyze the data to answer the research question.

3.1. Data

The CORDIS used in the scope of the project has been downloaded from the European Union Open Data Portal.[3] Table 1 presents summary statistics for each FP round. The figures displayed in parentheses indicate the number of projects used in the calculation of their respective column. For instance, in the downloaded raw data, there are 5,527 project records for FP3. However, *Average Duration* (931.29 days) is calculated over 5,236 projects because the start and end dates of the remaining projects are not found in the raw data. The same approach was also used in the calculation of the *Average Cost of the Projects* and the *Average Funding of the Projects.* According to the data, number of projects realized in all programmes increased, except for FP6. We of course do not include H2020 in such interpretations as the programme is still in progress. Projects with the longest duration were implemented in the 5th Framework Programmes. The projects realized in FP6 display a significant difference from the others. In FP6, both the average cost of the projects (4,135,682.23 €) and the amount of EC contribution (1,853,125.80 €) are the highest among all Framework Programmes. On the other hand, when the EC contribution per project is proportioned, it is found that the average financial support received by FP6 projects (44.80%) is lower than the other FP projects. The highest ratio of financial support per project is provided in FP7 (73.24%).

[3] https://data.europa.eu/euodp/en/data/dataset?q=cordis

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Table 1: EU Framework Programmes, 1984-2020

Title	Period coverage	Budget (in billions of euros)	# of Projects	Average Duration of the Projects (day)	Average Cost of the Projects	Average Funding of the Projects
FP1	1984-1987	3.3	3282	1073.74 (3,281)		
FP2	1987-1991	5.4	3896	1010.23 (3,452)	1,089,751.97 (187)	536,459.01 (188)
FP3	1990-1994	6.6	5527	931.28 (5,236)	1,435,484.87 (550)	1,031,637.3 (1,089)
FP4	1994-1998	13.2	14567	831.29 (13,676)	1,968,140.19 (3,772)	913,115.88 (4,027)
FP5	1998-2002	14.9	17202	1358.43 (16,121)	1,381,296.12 (15,441)	816,407.6 (15,439)
FP6	2002-2006	19.3	10091	991.19 (9,903)	4,135,682.23 (6,363)	1,853,125 (9,578)
FP7	2007-2013	55.9	25607	1196.01 (25,472)	2,358,498.29 (25,054)	1,727,511 (25,472)
H2020	2014-2020	80.0	9055	1088.14 (9,055)	2,101,884.92 (9,055)	1,712,488 (9,055)

Source: EU Research Framework Programmes 1984-2014, Horizon Magazine Special Issue, March 2015 and authors' own compilations.

Note: FP4 data is not covered in this research because the data do not have regional identifiers.

All in all, when the FP data is analyzed in a nutshell we can say that there are two structural breaks in the programme the first from FP3 to FP4 where the overall funding more than doubled and from FP6 to FP7 where the overall funding almost tripled. Given that the average cost and funding figures do not display such sharp changes we can expect that increased funding would lead to more projects being financed, increased number of nodes (project partners) and increased number of connections between partners which would mean a denser network over the years.

In addition to the above explanations, in order to implement network analysis, data obtained from European Union Open Data Portal were edited for each FP. First of all, projects for which no spatial data can be obtained howsoever were removed from the database. For instance, even when the spatial information of a project participant (town, municipality, city, province) is not provided, if the said spatial information could be found out by benefiting from the name or address of the participant in question, then this project partner is included in the network. Otherwise, they were excluded from the database used in the network calculations. After all projects with data input in different languages (for instance, Copenhagen or Østsjælland) or formats (METU or Middle East

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Technical University) were revised as such for all FPs, projects, for which spatial info could be found, were brought together. Afterwards, NUTS II (LAU 2 - NUTS 2013, EU-28, 2016[4]) equivalent of the spatial info of each project partner was found (Paris=FR10). Lastly, making use of the NUTS II data of project partners, networks were plotted for each FP and related network statistics calculations were implemented. As an example, data to be used for plotting this graph was prepared as follows: If a project has five partners as can be seen in Table 2, Panel A, 10 pairs consisting of NUTS II codes were established (Panel B) as can be seen in the sample network of Figure 2.

Table 2: Sample Project Structure

Panel A: Project with five partners

Project Name	Partner I	Partner II	Partner III	Partner IV	Partner V
XYZ	RO22	ES51	UKD3	NL42	BE25

Panel B: Paired data

RO22	ES51	ES51	UKD3	UKD3	NL42
RO22	UKD3	ES51	NL42	UKD3	BE25
RO22	NL42	ES51	BE25	NL42	BE25
RO22	BE25				

Source: Authors' own compilations

Figure 2: Sample Network Graph

[4] http://ec.europa.eu/eurostat/web/nuts/local-administrative-units

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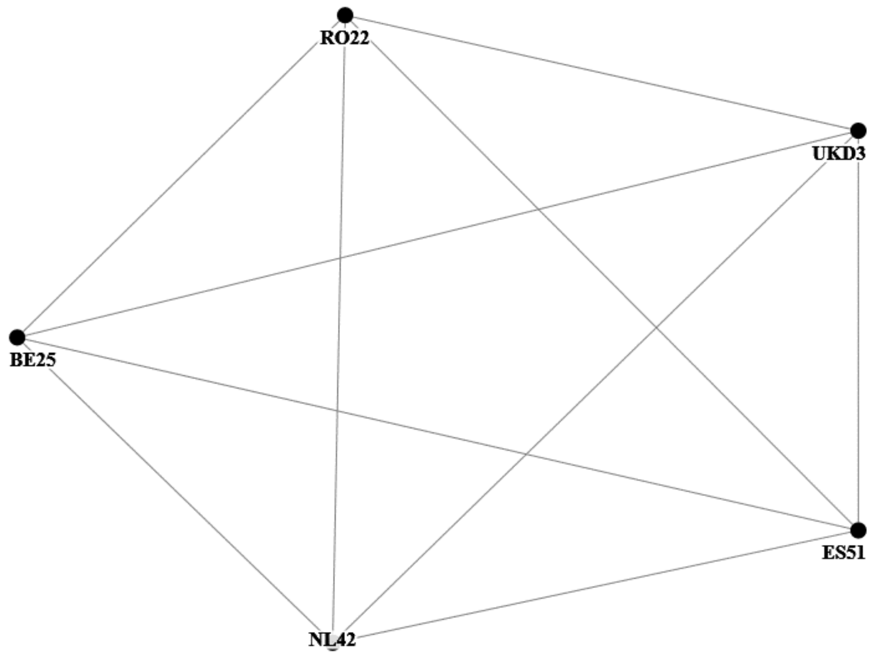

Source: Authors’ own compilations

3.2. Method

The method and the analysis of this research are by and large based on the network analysis. For this reason, it is better to start with basic network definitions that the methodology hinges on. Later we explain how we analyze the regional data that is constructed using network statistics (Wasserman and Faust, 1994; Scott, 1991).

Network (Graph) is a set of nodes linked with each other. A graph is an ordered pair of disjointed sets (V, E), where V={v1, v2, v3,…vn} shows the set of vertices and E={(v1,u1), (v2,u2), (v3,u3),…, (vn, un)} shows the set of arcs. E is the subset of the Cartesian products VxV. Adjacency matrix (AG), is used as a standard way to show a graph, as seen in Figure 2. Basic concepts used in network analysis and in this study are itemized in Figure 3.

Node (vertex, actor): The main unit of a network. In this study, nodes are constituted by the NUTS II level locations (e.g. TR 52, FR10, etc.) of the organizations that participated in FP projects.
Link (edge, tie): A line connecting two nodes. In this study, it is assumed that there are links among the organizations (firm, universities, etc.) that are partners of the same project.
Directed Link (arc): A link is called directed if it goes only in one direction.

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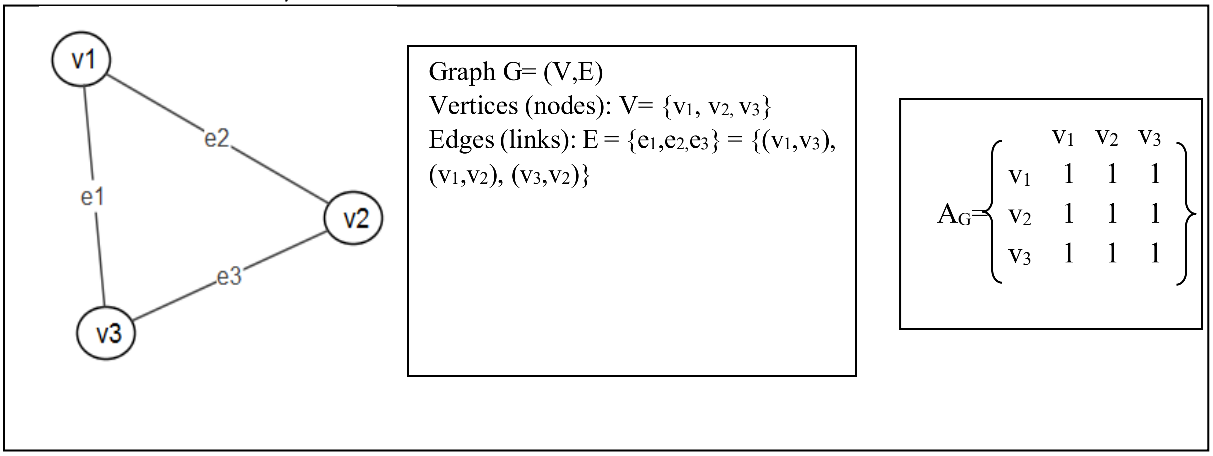
Figure 3: Basics of Networks

Source: Authors' own compilations



Undirected Link: A link is called undirected if it goes in both directions. In this study, links are considered as undirected, as the knowledge flows between links are assumed to be reciprocal.

Degree: Represents the number of links linked to a node. Demonstrates the number of projects that a node participated in.

Path Length (Geodesic Distance): Represents the number of links that passes through when travelled between two nodes. Shortest path length is the length of the shortest route between the two nodes. Average Path Length, used as a characteristic global property of networks, is the average of all shortest path lengths in a network. It has been assumed that the shortening of path length between nodes would facilitate knowledge transfer.

Betweenness Centrality: The betweenness centrality of a node *n* is the fraction of the shortest paths between any pair of nodes in the network, which pass through the *nth* node. In other words, betweenness centrality points out to the node's importance in the overall connectivity of the network. It has been assumed that playing a bridge or a gatekeeper role among nodes would bestow advantages, especially in terms of easy access to codified knowledge.

Closeness Centrality: Denotes the sum of theoretical distances from a node to all other nodes in a network. It has been assumed that, as in gossip networks, being closer to other nodes would prove to be beneficial in terms of early access to knowledge.

Clustering Coefficients: Clustering occurs if neighbors of a node are linked to each other and clustering coefficient *C* is the probability of neighbors of a given node being also neighbors of each other. Simply, average clustering coefficient gives the average of the clustering coefficients for all nodes.

Eigenvector Centrality: A measure of node importance in a network based on a node's connections. It has been assumed that playing a bridge or a gatekeeper role among *important* nodes would bestow advantages, especially in terms of easy access to codified knowledge.

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Graph Density: Measures how close the network is to become a complete (fully connected) network. A complete graph has all the possible edges and its density is equal to 1. Increasing density may, on the one hand, prevent opportunist behavior and loss of knowledge, on the other hand, due to sharing of the same knowledge repeatedly, may lead to the nodes' becoming the same and the structure's entrance into lock-in.

In order to demonstrate how the FP densities increased, partial network graphs have been plotted for FP2 and FP7 using only 2.5% of the links they contained. Comparing Figure 4 and Figure 5 it is clear that the network density increased.

The aggregated data present network statistics such as degree, betweenness etc. at the NUTS2 regional definition which are not comparable across FP periods. Thus, for each variable and for each FP period we divide the data in to 100 percentiles to arrive to a measurement unit, which is comparable across FP periods. To give an example, the network betweenness scores of Turkey TR51 Ankara region in FP5 and FP7 are not comparable but TR51 was in the 86th percentile in FP5 but reached to 43rd percentile in FP7 period. In terms of being a hub of information exchange TR51 moved from a bottom to an above mid-level performer comparing FP5 to FP7, so in about 10 years which is an achievement. In a similar manner there are also regions that lost significance as being an information exchange hub such as the NL34 Zeeland moving from top 25 to bottom 50 percentiles, or UKE2 North Yorkshire moving from 40th to 81st percentile.

Another source of data for collaborative knowledge generation is the co-authorship data that is available from the Web of Science. As mentioned earlier looking at the co-authorship data for all topics is a cumbersome activity as it includes millions of observations and associated links between co-authors. Therefore, we benefit from this source and acquired co-authorship data only on the articles that somehow linked to "European Union" using several keywords. Data is organized using the same NUTS2 definitions and the FP periods for comparability. We benefitted from this data only the robustness part (Section 4) to compare and contrast the findings of the FP data analysis.

Once percentiles of each variable for each FP period are calculated the data set is comparable across FP periods. Using this one can list for instance the top 5 percentile performers in different FP periods to see whether there is any change in top performers in the last 30 years; or look at the simple rank correlations to see whether orderings in different FP periods are similar; or perform simple analysis to see whether there is convergence or divergence in terms of knowledge among European regions over the years. In this regards we looked at two aspects in a more detailed manner.

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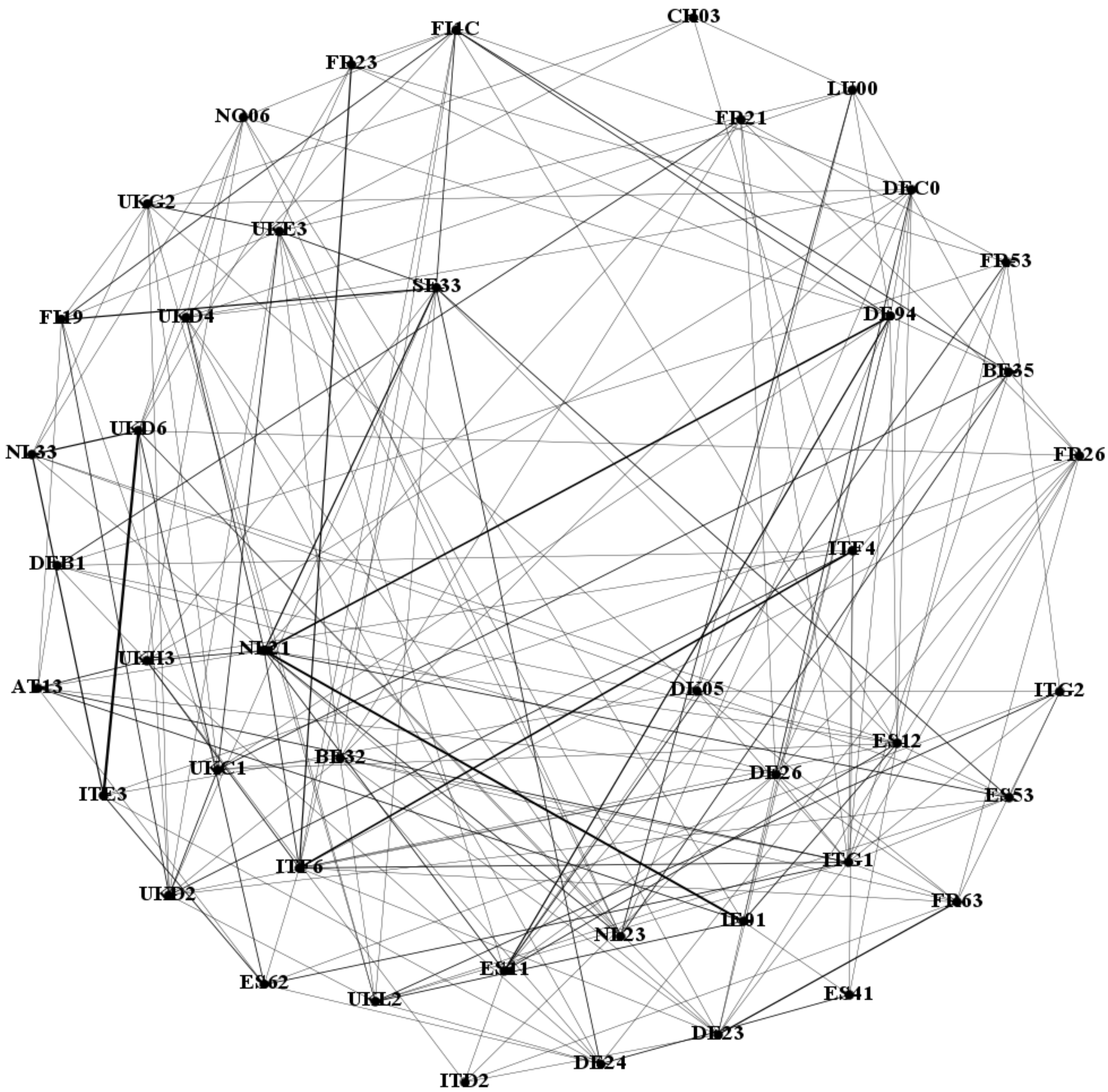
Figure 4: FP2 Density (2.5% of Links)



Source: Authors' own compilations

First of all, we looked at the relation between change in percentile rank over the years and starting level percentile rank. The idea originates simply from the convergence of Gross Domestic Product (GDP). A statistically significant negative coefficient of a simple correlation between percentage change of GDP in two time periods and starting level of GDP is accepted to be a sign for convergence (e.g., Barro, 1991; Sala-i-Martin, 1996). Thus, first we look at the relation between change in percentile rank from FP2 (1984-87) to FP7 (2007-2013) and the percentile rank in FP2. We did not include FP1, though we have the data, because the programme was new and its budget and scale were limited. In a similar manner, we did not include the first wave of H2020, though we have the data, because H2020 has just started. The results are presented in simple scatter

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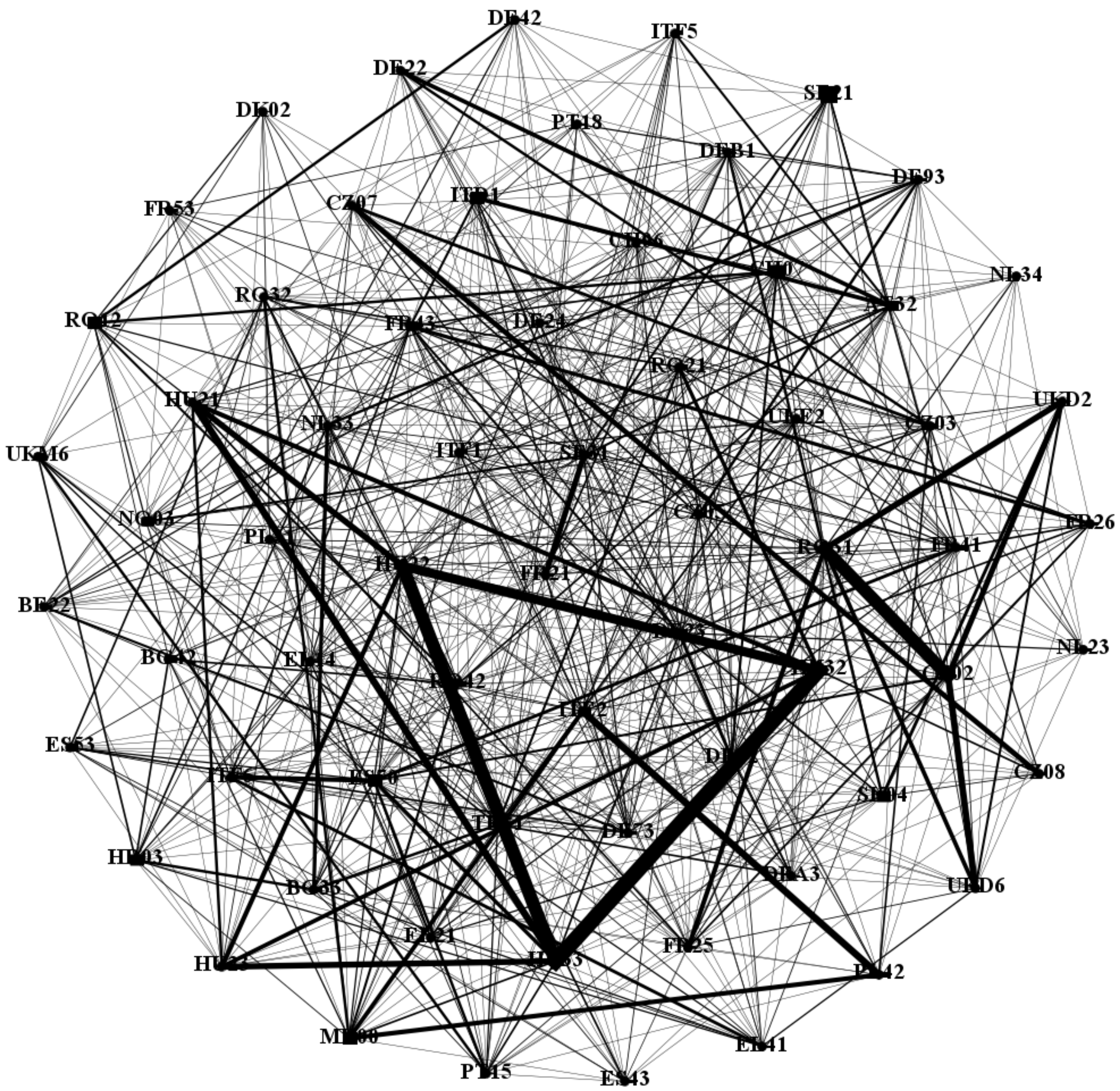
diagrams using four different network statistics. Moreover, we report the coefficients of a simple Ordinary Least Squares (OLS) where we regress change in percentiles on starting level percentile rank and country dummies. As in the case of convergence in GDP a negative simple correlation and a statistically negative sign of the coefficient of starting level percentile score signal convergence in knowledge among European regions. If there is convergence, we can talk about cohesion.

Figure 5: FP7 Density (2.5% of Links)



Source: Authors' own compilations

Second, we conducted an analysis comparing difference in percentile ranks of betweenness centrality and difference in percentile ranks of network degree. This association can be used to build a taxonomy based on the change in number of connections of a region (network degree) and

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its relation to change in the position of knowledge exchange of a region (betweenness centrality). Using median values for both indicators one can come up with four-quadrant taxonomy:

i) Lower degree and lower betweenness: These regions are losing grounds in knowledge exchange. They not only lose connections and partners thus have a smaller network but also lose critical position in knowledge exchange.

ii) Lower degree but higher betweenness: Though the network size of these regions shrink their position in the knowledge exchange strengthens.

iii) Higher degree and higher betweenness: These regions strengthen their positions both in terms of managing a wider network and being a hub in knowledge exchange.

iv) Higher degree and lower betweenness: These regions are extending their network but still do not have the grip to obtain a central position in knowledge exchange

In time, there has been an inevitable increase in the number of nodes that participated in the FPs, as well as the links among them. How this increase is formed, on the other hand, is important in terms of whether the structure is open or relatively closed to new participants. Unique edges established in each of the FPs will demonstrate us that the relevant two nodes have participated as partner in project at least once. Increase of unique edge ratio within the total edges (unique and duplicate), on the other hand, will demonstrate whether the structure supports establishment of links -*i.e.* project partnership- among actors without previous linkages. Otherwise, if the unique edge ratio within the total edges decreases, this will show that the structure supports project partnership among those, which previously entered into project partnerships.

Self-loops indicate that in the project, there are at least two organizations (university, firm, research institution, etc.) from the same region. The ratio of self-loops in the total edges demonstrates, in a sense, whether there exists a regional favoritism. Average geodesic distance (path length) demonstrates how many steps it takes to reach to a node from another node. In particular, the decrease of the path length or its relatively small increase as the number of nodes increases demonstrates that it became easier to reach to a node from another node. Short path length is a feature supporting knowledge transfer and cooperation.

Density shows us the ratio of actual connections to potential connections in a network. Increase in density indicates an increase in the number of nodes linked to each other in the structure (a value of 1 demonstrates all nodes in the structure are linked to each other). High density encourages strengthening of relationships and development of trust based relationships. This facilitates tacit knowledge transfer and minimizes free rider problem. On the other hand, excessive density is a factor that brings out the problem of nodes becoming the same, and thus, makes the production of new knowledge difficult.

Average Degree, in other words, the increase in the number of projects per nodes, shows us that the ability of nodes to establish partnerships has increased. Put differently, it demonstrates that

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the advantages of establishing partnerships exceeded its disadvantages. The value of average betweenness centrality gives us the average value of the actors that act as bridge in the network. Increase in this figure indicates an increase in the number of bridges to provide passes among actors (Borgatti et al., 2013). This will encourage knowledge transfer and cooperation.

Average closeness centrality shows the average distance of the actors to other actors in the network. It is normal that this value changes as the number of nodes increases in the network. The critical point here is from where the newcomers link to the network. If the newcomers link to the actors at the center of the network, *i.e.* actors with high number of links, in this case, it is expected that the average closeness value would increase. On the contrary, if the newcomers link from the network periphery, then, closeness value decreases, which shows us that the structure is becoming increasingly hierarchical (Newman et al., 2003).

Average eigenvector centrality value, in a sense, is a trimmed down version of the average betweenness centrality value. In other words, average eigenvector centrality indicates important actors, or actors with high number of links, and gives the average value of the actors that establish links with each other. Increase in this figure is important for the sustainability of network. Put differently, an increase in this figure on average leads not only to the establishment of cooperation, knowledge transfer, etc. among important actors via alternative means, but also to the decrease of the average path length value of the entire network. Increase in the average clustering coefficient is considered to contribute the improvement of trust based relationships, and thus, facilitating in turn the transfer of tacit knowledge.

4. Results

4.1 Descriptive Results

We start our analysis by looking at the top performers. The rationale is to see whether top performers in FPs have changed over the years. The recent uptake of the persistence story shows that the starting levels are an important determinant of the current situation for a variety of cases (e.g., Acemoglu, 2001; Guiso, et al., 2016). As such we expect to see that the list of top performers remained stable over the years. The idea is that due to economic and cultural factors some regions are more innovation prone compared to others (Rodriguez-Pose, 1999). These factors give a head-start to some regions in terms of knowledge generation which persist over the years.

Table 3 lists the top 5 percentile EU regions according to network degree. For each FP round the regions are ranked according to network degree. Higher network degree indicates a larger size of the network. In more practical terms network degree shows the number of direct links to other regions. For instance, the maximum degree of FP7 belongs to FR10 *Île de France* which means that FR10 is connected to 329 regions out of the 349 available. In a similar manner, Table 4 lists the top 5 percentile EU regions according to network betweenness centrality. Betweenness centrality shows how central a region is in information flow in a network. It could be the case that a region with even low number of degree connects important nodes in the network thus has a more central

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position compared to others. For instance, using only the FP7, DEE0 *Sachsen-Anhalt* can achieve the same position in information exchange as DEA2 *Köln* with much less connections (238 compared to 295).

Table 3: Top 5 percentile EU regions according to network degree

FP1	FP2	FP3	FP5	FP6	FP7	H2020
FR10	FR10	FR10	FR10	FR10	FR10	ES30
UKI	ES30	EL30	ES30	ITE4	BE10	FR10
UKJ1	NL31	PT17	PT17	EL30	UKI	UKI
FR71	PT17	ITC4	EL30	ES30	ITE4	BE10
DK01	ITC4	NL31	UKI	DE21	ES30	ITE4
NL31	EL30	IE02	FR71	ITC4	EL30	NL31
ITC4	UKI	FR71	ES51	ES51	DE21	ES51
BE10	FR71	ES30	NL31	UKI	ES51	DE21
EL30	IE02	UKJ1	ITE4	AT13	NL31	EL30
DE21	BE10	UKI	ITC4	HU10	AT13	ITC4
	DK01	DK01	DE21	BE10	ITC4	PT17
	DE21	ITE4	FI1B	NL31	DK01	AT13
		ES51	SE11	PT17	SE11	IE02
		DE21	DK01	PL12	FI1B	DEA2
			BE10	IE02	DEA2	FI1B
			IE02	SE11	ES21	ES21
			DEA2	FI1B	IE02	NL32
			ITD5	NL22	PT17	DE30
						RO22

Source: Authors' own compilations

However, as can be seen from Tables 3 and 4, there is high association between the top 5 percent lists of degree and betweenness centrality. The pairwise correlation coefficients of degree and betweenness in different FP periods range from 0.62 to 0.78 all of which are significant at the 1 percent level. However, the correlation coefficients tend to decrease in each consecutive FP round indicating that the relation between degree and betweenness was much stronger in the earlier periods. The within correlations of degree and betweenness for different FP periods are expectedly high. The correlation coefficient of network degree for different FP periods ranges from 0.63 to 0.96 and for betweenness ranges from 0.78 to 0.97 all of which are again significant at the 1 percent level.

Table 4: Top 5 percentile EU regions according to network betweenness centrality

FP1	FP2	FP3	FP5	FP6	FP7	H2020
FR10	FR10	NL31	FR10	FR10	FR10	TR51
UKI	FR71	EL30	PT17	DE21	BE10	ES30
ITE4	IE02	UKI	NL31	UKJ1	ES51	UKI

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DK01	DEA2	FR10	EL30	ITE4	UKI	FR10
PT17	ES30	PT17	ES30	AT13	DE21	DE21
UKJ1	UKI	FR71	UKI	EL30	EL30	ES51
FR71	PT17	ITC4	FR81	HU10	ES30	BE10
NL31	ITC4	DE30	ES51	ITC4	PT17	PL22
BE24	NL31	ES30	ITE4	ES30	NL31	ITE4
ITC4	EL30	ITE4	FR71	UKI	UKJ1	EL30
	DE21	DE21	FI1B	ES51	ITE4	PT17
	DE71	IE02	ITC4	BE10	DE30	NL31
		NL22	UKJ1	PL12	AT13	PL12
		ITC1	ITD5	FI1B	EE00	ITC4
			DE21	RO22	IE02	AT13
			ES21	NL22	PT11	IE02
			EL12	PT17	NL32	DE71
			SE11	SI02	DK01	DE30
				CZ01	FI1B	EL12
					ITC4	

Source: Authors' own compilations.

For a more detailed look, it is better to limit the analysis to FP2-FP7 because FP1 marks the introduction of the framework projects and H2020 has just started and still continues. We took FP7 period which turns the largest top 5 percentile regions as benchmark and looked at the percentiles of the regions over the FP2-FP7 period using network degree. Except 3 regions all others were at least at the top 15 percentile in any FP round which indicates that the top performers do not change that much. There are three success stories within the top 5 percentile performers which are SE11 *Stockholm* that moved from 77th to 96th percentile; AT13 *Wien* that moved from 46th to 98th percentile and ES21 *País Vasco* that moved from 73rd to 96th percentile between FP2 and FP7 so in about 25 years. When a more limiting period is considered from FP5 to FP7, so about 15 years, the persistence of top performers is more visible. Within this period top performers' percentile score ranges from 92nd to 100th percentile. When betweenness centrality is used instead of network degree the results are qualitatively similar except the appearance of regions in less developed countries. This is the only finding towards knowledge convergence within the top performers analysis. Though HU10 *Közép-Magyarország*, PL12 *Mazowieckie*, CZ01 *Praha*, SI02 *Zahodna Slovenija* EE00 *Eesti,* and RO22 *Sud-est* joined the EU and the FP at a much later stage and had very low percentile scores in FP3 they become top performers consistently in the last three rounds FP6, FP7 and H2020. The percentile scores of these regions in the last three FP rounds ranges from 84th to 96th percentile.

Thus, looking at the top 5 percentile regions we can conclude that the top performers do not vary much in the last 30 years. The top performers 30 years ago are still the top performers which suggest that top knowledge hubs are persistent over the years. However, the new emerging knowledge hubs in Czech Republic, Estonia, Hungary, Romania and Slovenia especially in the last three rounds of FPs may be taken as a sign of knowledge cohesion.

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After looking at the top performers one may wonder what the overall data show regarding knowledge cohesion. To analyze the overall data we use a simple tool from empirical economic growth. The neo-classical Solow growth model expects convergence of income over the years as the same steady-state conditions apply to all countries (or the geographic units). In empirical terms this means that the countries that have low income will grow more than the countries with higher income and the economic convergence story emerges (e.g., Barro, 1991; Armstrong, 1995; Sala-i-Martin, 1996; Fagerberg and Verspagen, 1996; Becker, Egger and von Ehrlich, 2010). Applying a similar idea to our case we look at the relation between changes in percentiles of the four network statistics over the FP5-FP7 period and relate them to their respective starting level (FP5) statistics. This period is specifically selected because using an early FP round significantly reduces the number of observations and do not include less developed countries integrated to Europe at a later stage. If there are signs of convergence within this short period where competition in obtaining funds was tight we can assume that there will be convergence in a much longer period.[5]

Figure 6 displays the results where we associate change in percentile scores over the FP5-FP7 period to FP5 percentile score. For consistency and robustness, we report the same analysis for network degree, betweenness, closeness and eigenvector centrality. A negative relation will be taken as a sign of convergence in knowledge.

[5] See section 4 for the robustness of this assumption.

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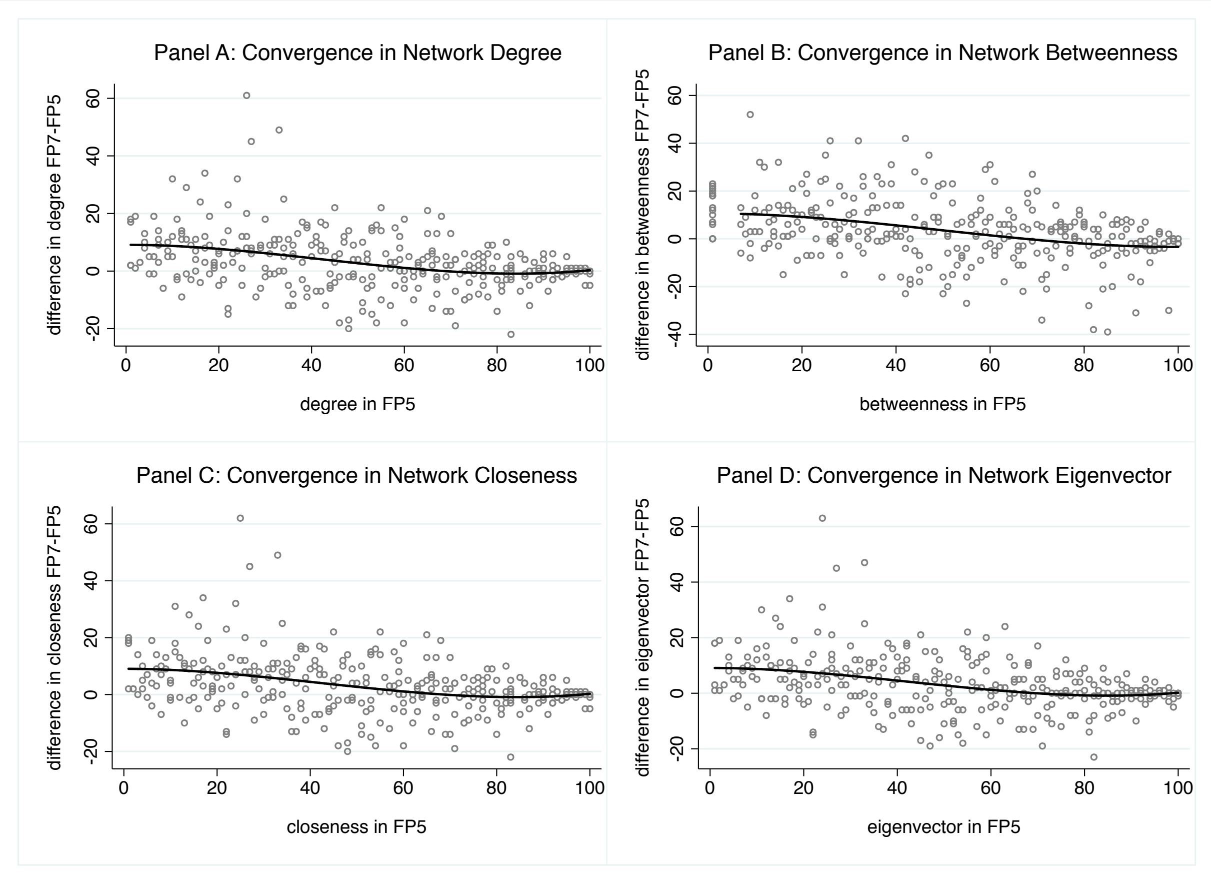
Figure 6: Convergence in knowledge in European Regions FP5 to FP7, 1998-2013



Source: Authors' own compilations.

As can be seen from Figure 6 all four panels display a negative relation indicating convergence. Thus, on average, regions that were less endowed in terms of knowledge caught up regions that were more endowed in terms of knowledge. Three observations can be made from Figure 6. First, the convergence story holds no matter what network statistics we use which introduces further robustness in to our analysis. Second complementary to the previous discussion on top performers there is almost no convergence in top 20 percentile regions. In all the four panels in Figure 1 the variance beyond 90th percentile is very low indicating that top 10 percentile performers do not change that much over the years. Lastly, we see the variance increases as we move down to lower percentiles. This indicates that the performance of regions in the lower 40 percentiles can vary in great extent. This analysis is discussed further in section 4 where we run simple OLS regressions to see whether this relation is statistically significant. Overall, we can say that there are signs of convergence in knowledge in European regions. Regions that are endowed less in terms of knowledge tend to build up capabilities to which definitely will help European integration.

As discussed in section 3, a more detailed look at the data may reveal a taxonomy of European regions in terms of knowledge generation. Figure 7 plots the difference in percentiles of network

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degree vs. difference in percentiles of betweenness centrality between FP5 and FP7.[6] The former indicates the change in the network size of a region whereas the latter indicates the change in the importance of a region in knowledge exchange. The straight gray lines indicate the mean values for each indicator which all together create four quadrants. Figure 7 shows that there is high correlation between the differences which reflects that an increased network size comes with a more central position in knowledge exchange. It also shows that the majority of the observations lie on the two quadrants.

i) <u>Lower degree and lower betweenness</u>: These regions have lost grounds in knowledge exchange between 1998 and 2013. They not only lose connections and manage a smaller network but also have lost central position in knowledge exchange. UKE *Yorkshire and the Humber* and FR81 *Languedoc-Roussillon* are the most notable regions that belong to this group. The 17 regions that are one standard deviation lower from the mean difference degree and betweenness are all from the richer countries such as UK, France and Germany. Less than the %15 of the 139 NUTS 2 regions that fall to this group are from the countries that joined the EU at a later stage, thus less developed compared to the EU15 countries. This may be taken as another evidence towards convergence in knowledge.

ii) <u>Higher degree and higher betweenness</u>: These regions strengthen their positions both in terms of bigger network and a more central position in knowledge exchange. The most notable regions are from Turkey, Spain, Croatia, Romania and Hungary such as TR10 *İstanbul*, TR51 *Ankara*, TR31 *İzmir*, ES23 *La Rioja,* HR04 *Kontinentalna Hrvatska,* RO11 *Nord-Vest* and RO31 *Sud - Muntenia*. The 27 regions that are one standard deviation above from the mean difference degree and betweenness are mostly from the less developed countries with the exception of a few regions from Germany, Austria, Spain and Italy. About %40 of the 44 NUTS 2 regions that fall to this group are from developed countries. Thus, it seems that more developed regions from the less developed countries and less developed regions from the more developed countries tend to catch-up regions with rich knowledge endowment.

[6] For reasons mentioned above, the analysis is bound to FP5-FP7. Section 5 replicates the analysis for a much longer period.

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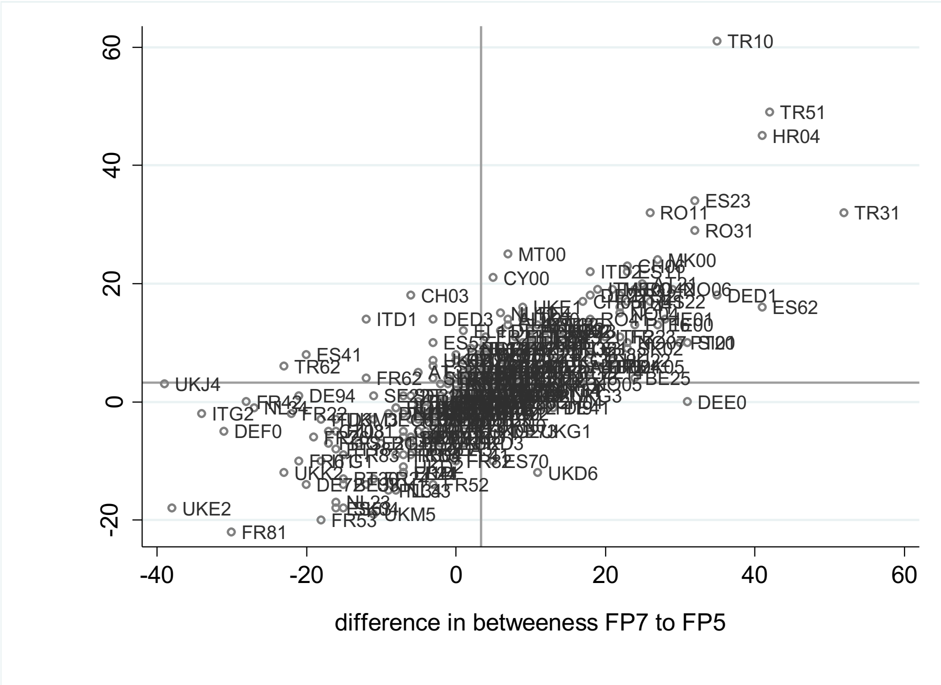
Figure 7: Taxonomy of knowledge cohesion in Europe, FP5 to FP7, 1998-2013



Source: Authors' own compilations

There are also regions that lie in the other two quadrants. There are only a few regions in the north-west quadrant where network size increased at the expense of central position in knowledge exchange. The possible explanation is that FP7 network includes less central nodes compared to FP5 network. Therefore, though the network size increased the position of the region in knowledge exchange is less central. Such regions may be in the exploration phase for new partners which probably have less central position in the network. The south-east quadrant also includes few regions but two are notable. DEE0 *Sachsen-Anhalt* improved its central position without extending its network. In a similar manner UKD6 *Cheshire* improved its central position with even managing a smaller network.

In summary, the descriptive analyzes show that there are signs of convergence in knowledge in European regions. Despite the fact, the top performers persist over the years the convergence is much stronger among the less developed regions.

4.2 Network Results

As seen in Table 5, the number of nodes (NUTS II) participated into Framework Programmes has increased in years. This shows us that the FP has gained wide acceptance and participation into the programme became prevalent. Starting from FP1, value of average degree rises; which means that the capacity of regions increases in terms of maintaining links with others. Number of unique and duplicated edge values increase from FP1 to FP7. When their increases are compared, it is observed that the increase in the ratio of duplicate values is much higher than that of unique values, which means vertices (NUTS II) primarily prefer to establish a link with the existing ones,

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instead of new ones. This situation can be explained using the notion of path dependency. That is, successful project management capabilities and experience acquired in the past projects let those actors to become coordinators or participants in the following projects. Acquired experience and project management capabilities may also let them decrease the marginal cost of coordinating or participating into each additional project. Furthermore, visibility or reputation attained makes them attractive partners for the newcomers, demonstrating the notion of preferential attachment. Finally, experience in past projects may also decrease the transaction costs among partners in subsequent partnerships, which process has the potential to augment mutual trust and understanding, as well as collaborations.

The ratio of self-loop value in each FP to the number of edges has been used to understand whether there is regional favoritism, as mentioned above. The lowest ratio is found in FP7 (0.034) and the highest ratio in FP1 (0.111). Rather than making a speculative evaluation along the lines of the restricted number of actors that are able to enter into projects at FP level, or those who participated into FPs cannot encourage the other actors in their region enough for participation, this result is considered to be in line with EUs aims of popularizing FP and making it common practice for parties to work together.

Table 5: Network statistics

	FP1	**FP2**	**FP3**	**FP5**	**FP6**	**FP7**	**H2020**
Graph Type				Undirected			
Nodes (Vertices)	182	216	245	312	322	336	324
Unique Edges	1,272	2,994	3826	5,674	5,613	5,749	6,265
Edges With Duplicates	11,818	73,653	130,260	417,130	591,753	774,172	193,349
Total Edges	13,090	76,647	134,086	422,804	597,366	779,921	199,614
Self-Loops	1,448	3,673	6,537	18,513	20,172	36,111	8,510
Average Geodesic Distance	1.94	1.60	1.54	1.46	1.43	1.45	1.61
Graph Density	0.18	0.41	0.46	0.54	0.56	0.55	0.40
Average Degree	32.81	89.79	113.32	168.33	182.80	186.00	131.43
Average Betweenness Centrality	86.18	65.02	67.18	72.86	70.25	75.65	97.40
Average Closeness Centrality	0.003	0.003	0.003	0.002	0.002	0.002	0.008
Average Eigenvector Centrality	0.0055	0.0046	0.0041	0.0032	0.0031	0.0030	0.0031
Average Clustering Coefficient	0.64	0.77	0.81	0.84	0.85	0.85	0.78

Source: Authors' own compilations.

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Average geodesic distance (path length) decreases from 1.94 to 1.45 through FP1 to FP7. This shows us that the distance between actors is shortened; in other words, the structure supports knowledge transfers and cooperation. This is a rather significant finding. Put differently, converging of the regions with different institutional infrastructures (norms, values, etc.) allows for the differences, required for the emergence of innovation, to have an easier access to each other.

Despite the change in the density of the network in time, it is observed to be fixed at a 50% ratio. The existence of regions that have not yet cooperated with each other as partners within any FP throughout all FPs that have been implemented for over 30 years, brings to forth, in general, the necessity for a reconsideration of the policies Europe implements for cohesion, and in particular, a need for EU support for cohesion in FP project supports, by setting different criteria.

Additionally, in both types of networks we see an increase in average betweenness centrality and decrease in average closeness centrality values. This change also demonstrates that the newcomers, in general, link to the periphery of the network. Actors with high Eigenvector value also fill in the structural holes in the network by setting links with important actors, *i.e.* actors with the highest number of links. Differently, these actors are considered to have more access to codified knowledge compared to others.

Moreover, the decreasing average path lengths and increasing clustering values of FPs show us that a small-world network emerged from the structure. Such type of networks, which have relatively high clustering coefficients and short path lengths, supports the knowledge creation and knowledge diffusion (Cowan, 2004).

Another important point is the link establishment preferences of the nodes constituting the network. It has been assumed that along with actors' increasing number of links in time, their establishing links with different actors allowed for the formation of knowledge cohesion at least at a minimum level. In order to calculate this, the number of different nodes that the nodes in the FP cooperated through project partnerships has been found, and the result has been proportioned to the potential number of partnerships that could be established with different actor in that FP. For instance, in FP1, ITE1 region cooperated with 71 different regions by means of the projects they participated. The total number of regions it can cooperate is 182. As such, the ratio of linking to different actors has been found to be 0.3901 for FP1. Similarly, calculations were made for all FPs. Results supporting the conclusions in the descriptive analysis stated above were found (Table 6). Over time, an increase is observed in the average of the number of regions that establish links with different regions. This demonstrates the formation of at least a minimum level of knowledge convergence among different regions in terms of knowledge level.

Table 6: Variety of the Regions Cooperated with

FPs	FP1	FP2	FP3	FP5	FP6	FP7	H2020

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Average	0.180	0.413	0.460	0.534	0.562	0.548	0.402

When looked at Turkey, a similar change to that of FPs is observed. Regions in Turkey increased the number of regions they cooperated with in each FP (See Figure A.2, A.3 and A.4). When Turkey's average performance in link establishment is compared with the general performance of each FP (Table 6), regions in Turkey are observed to display poorer performance in terms of establishing links. Even if the ranking of each region in Turkey shows slight changes, the main ranking remains almost the same at large, and among all, regions TR10, TR31 and TR51 in particular, come to the fore as the regions demonstrating the best performances in Turkey. These regions are followed up by other regions, primarily by TR42 and TR62, in different FPs (Table 7). These five regions are both regarded among the most economically developed regions in Turkey, and house most of the best universities in Turkey. These 5 regions, which demonstrate a significant positive difference in terms of accumulation of academic and production knowledge compared to the other regions in Turkey, also act as a gatekeeper between Turkey and other regions that participate in FP.

Table 7: Performance of Regions in Turkey in terms of Link Variety

Nodes	FP1	FP2	FP3	FP5	FP6	FP7	H2020
TR10				0.356	0.733	0.813	0.441
TR21						0.140	0.003
TR22				0.010	0.028	0.024	0.003
TR31				0.109	0.481	0.560	0.321
TR32				0.006	0.220	0.259	0.120
TR33					0.016	0.185	
TR41				0.006	0.227	0.247	0.151
TR42				0.099	0.323	0.318	0.043
TR51			0.008	0.439	0.795	0.792	0.586
TR52					0.022	0.143	0.012
TR61					0.177	0.098	0.040
TR62				0.288	0.137	0.375	0.136
TR63					0.059	0.143	0.034
TR71					0.019		0.065
TR72					0.037	0.208	0.040
TR82				0.022	0.047	0.131	
TR83					0.255	0.068	
TR90					0.102	0.140	0.040
TRA1						0.086	0.065
TRA2						0.137	
TRB1					0.022	0.003	
TRC1					0.040	0.098	0.068
TRC2				0.035	0.050		
Average			0.008	0.137	0.189	0.237	0.128

Source: Authors' own compilations.

Details pertaining to the regions that Turkey established links with from FP5 to FP7 are given in Figure 8. A general assessment shows that both the number and variety of regions that Turkey established links with has increased. When the top 10 regions that Turkey established links with

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from FP5 to FP7 are taken into consideration (Table 8), it is observed that Turkey never severed its links with some regions, while failing to keep with some others. EL30, FR10 and ITE4 have been the regions with which Turkey preferred to establish links in each FP. On the other hand, only in two FPs did Turkey cooperate with BE10, ES30, ES51, ITC4, NL31, RO22 and UKI (London).
Network literature also underlines the difficulty of entering into small-world type of networks due to difficulty in attaining access to cliques. As exemplified in (Uzzi and Spiro, 2005; Fleming et al. 2007; Schilling and Phelps, 2007), cliques have strong ties with each other and the inclusion of new actors to these links constituted by cliques take time. In other words, newcomers are tested, verified, and then accepted into the clique. A similar characteristic was observed in Tukey's linking to other FP regions. From FP5 to FP7, Turkey is observed to establish links with increasingly more important regions in terms of the number of links they have over time (Figure 8).

Table 8: Top 10 Regions Turkey established links with

NUTS	FP5	FP6	FP7
AT13		X	
BE10		X	X
BG41	X		
DEA2			X
EL30	X	X	X
ES30		X	X
ES51	X		X
FI1B			X
FR10	X	X	X
ITC4	X	X	
ITD5	X		
ITE4	X	X	X
MT00	X		
NL31		X	X
PT17	X		
RO22	X	X	
UKI		X	X

Source: Authors own compilations.

Over time, Turkey has increased the number of partnerships it established. Except for FP5, the countries Turkey cooperated the most are; Germany, Spain, France, Italy, and Great Britain. Only in FP5, Greece replaced Great Britain among the countries Turkey cooperated the most (see Table A.4: Countries Turkey Linked with).

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5. Robustness

The results presented in the previous section can be put under a more rigid investigation to see whether the results are consistent. This section includes four main robustness analyses.

First of all, in section 4 the convergence story was built on a comparison between FP7 and FP5. What if we extend the period and look at FP2 to FP7. This analysis is particularly interesting because only the more developed countries (EU15) were funded in the earlier rounds of the FP. Given that the time period is longer and considering the heterogeneity of regions within EU15 we expect to see a much stronger cohesion. Figure 6 is replicated for the FP2-FP7 period and the results are presented in Figure 8. As expected Figure 8 shows a much stronger negative correlation compared to Figure 6. FP7-FP5 analysis includes more than 300 regions compared to 214 included in the FP7-FP2 analysis. Thus, even within a sample with much more developed regions we can talk about knowledge convergence. However as also in the case of FP7-FP5 analysis especially the top 10 percentile performers do not change that much over the FP7-FP2 period. To conclude there are signs of knowledge convergence on average but top 10 percentile performers persist.

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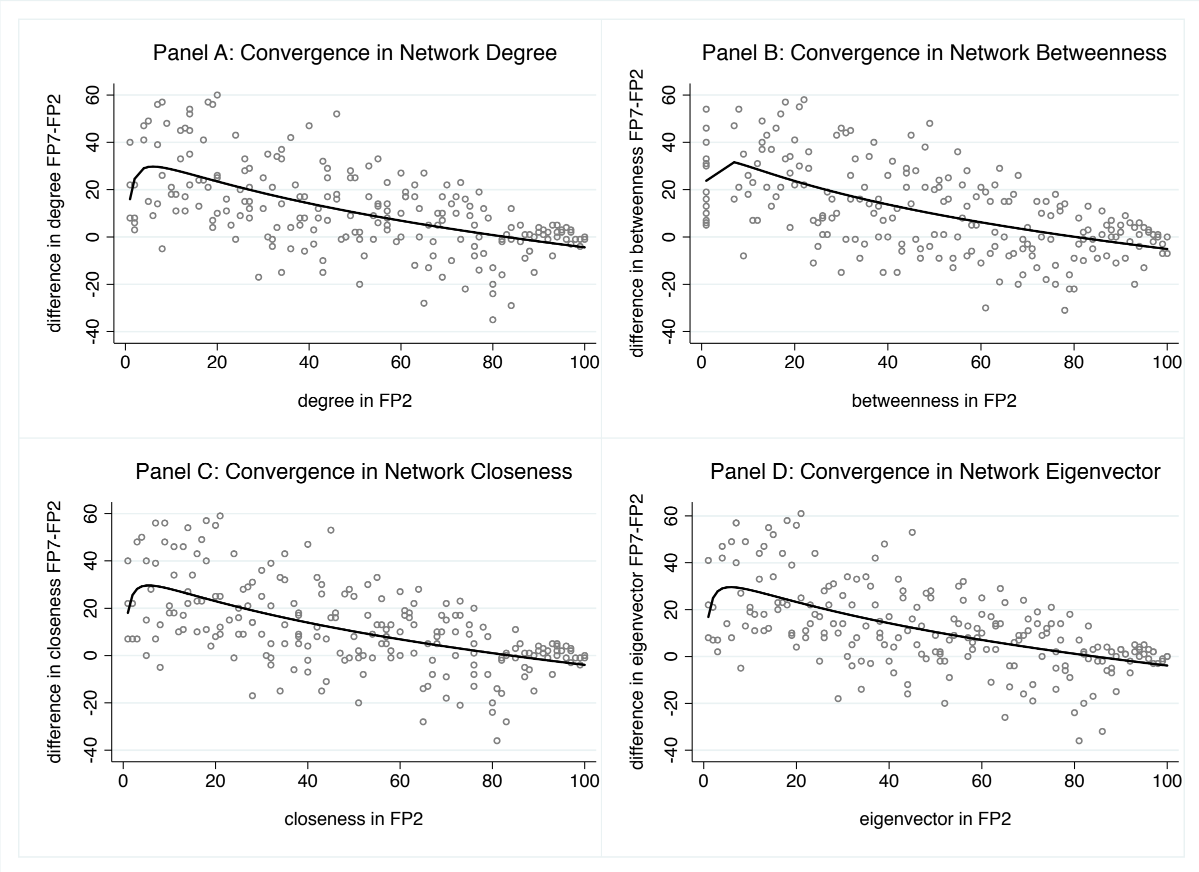
Figure 8: Convergence in knowledge in European Regions FP2 to FP7, 1987-2013



Source: Authors' own compilations.

Second the convergence story can be statistically tested using simple OLS regressions. The differences in network degree percentiles and betweenness centrality percentiles from FP7 to FP5 and FP7 to FP2 are used as dependent variables. The starting level network degree percentiles and betweenness centrality percentiles are used as independent variables. The OLS regressions always include country dummies to control for country level differences and robust standard errors to account for heteroscedasticity. 8 OLS regressions are estimated for each network statistics and period (FP7-FP5 and FP7-FP2). The results are summarized in Table 9. Regardless of the network statistics and the time period the results indicate that there is knowledge convergence among European regions. The convergence is much stronger in the FP7-FP2 period. It is surprising to see that even in these simple OLS analyses the fit of the model is high. Especially in the FP7-FP2 analysis the R-squared shows that on average the independent variables explain about 70 percent of the variation in the data.

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Table 9: Summary results of the OLS analysis for convergence

	degree	betweenness	closeness	eigenvector	degree	betweenness	closeness	eigenvector
	FP7-FP5	FP7-FP5	FP7-FP5	FP7-FP5	FP7-FP2	FP7-FP2	FP7-FP2	FP7-FP2
FP2					-0.258* (0.032)	-0.284* (0.033)	-0.257* (0.032)	-0.254* (0.032)
FP5	-0.075* (0.016)	-0.148* (0.023)	-0.074* (0.015)	-0.073* (0.015)				
Country dummy	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.46	0.35	0.46	0.47	0.70	0.65	0.70	0.71
Observations	306	306	306	306	214	214	214	214

*Note: Detailed OLS results are suppressed but available on request. Each column presents an OLS regression where the dependent variable is indicated on the top row. Numbers in parentheses are robust standard errors. * indicates the estimated coefficient is statistically significant at the 1 percent level.*

Next, we replicated the analysis that we build the taxonomy for the FP7-FP2 period. We expect to see a much stronger positive correlation as opposed to Figure 7. As can be seen from Figure 9, the correlation between difference in network degree percentile and difference in betweenness centrality percentile is much stronger. One can also see that the regions are clustered mainly in two quadrants. The south-west quadrant shows the regions that have lost grounds in knowledge exchange between 1987 and 2013. Of the 20 regions that are one standard deviation lower from the mean difference degree and betweenness 14 are from Germany and France. The north-east quadrant shows the regions that has strengthened their positions both in terms of size and a more central position in knowledge exchange. The 27 regions that are one standard deviation above from the mean difference degree and betweenness are more diverse compared to the south-west quadrant. The top performers in terms of difference in percentile over the FP2-FP7 period are from 11 different countries 7 of which are from Austria. There are five regions that are two standard deviations above from the mean difference degree and betweenness: DED2 *Dresden,* DE40 *Brandenburg,* FI1D *Pohjois- ja Itä-Suomi,* AT12 *Niederösterreich* and NO04 *Agder og Rogaland*. These regions have shown remarkable development over the past 25 years by moving forward about 50-60 percentiles both in network degree and betweenness centrality.

Figure 9: Convergence in knowledge in European Regions FP2 to FP7, 1987-2013

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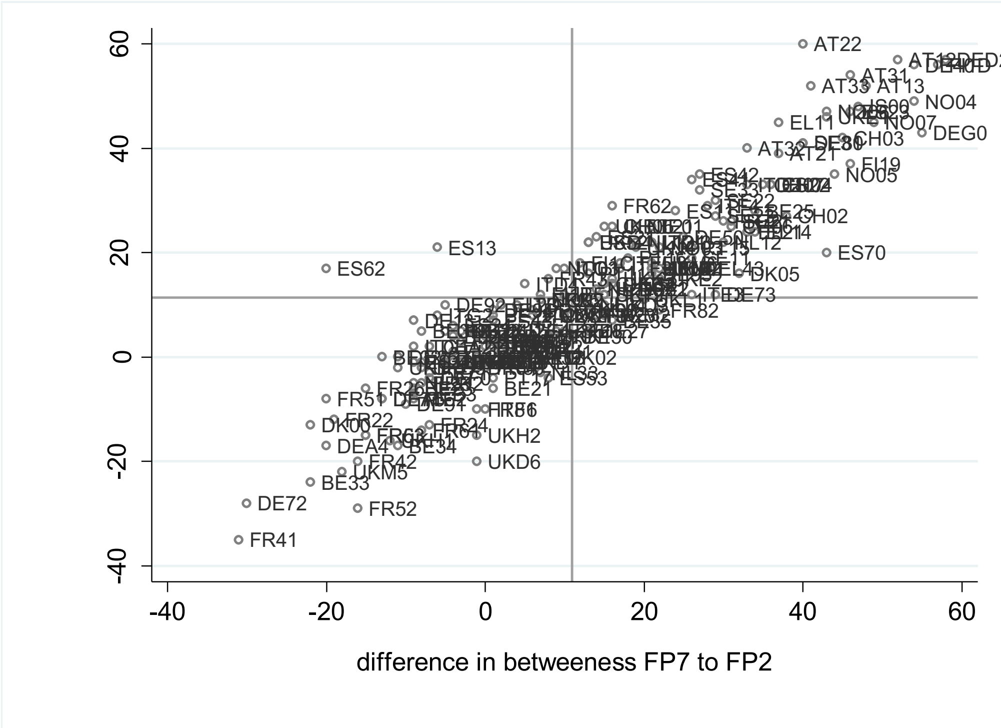

Source: Authors' own compilations.

Fourth, a healthy investigation of the existence of knowledge convergence requires a benchmark. The robustness of the results would increase if we can show more or less the similar results for a selected topic using a completely different data source that also reflects knowledge creation. We benefit from the web of science and acquired co-authorship data on the articles that are on the "European Union". Data is organized using the same NUTS2 definition and the FP periods for comparability. Before the beginning of 2000 there is not a significant number of observations so we limited our investigation from 1998-2013 that exactly match the FP7-FP5 analysis. Considering that this is a robustness analysis we present only the most salient points.

For comparability reasons, first we listed the top 5 percentile regions for three different time periods that match FP5, FP6 and FP7. The results can be seen in Table A.2 in the appendix. A different data set and quite a narrow topic do not change the main message. The top performers persist over the years. When regions in Table A.2 and Table 3 and 4 are compared one can see that list is rather similar. For instance, all top 5 percentile regions according to betweenness in WOS 1998-2002 are also in the top 5 percentile list for the FP5. The association is not perfect in other periods but it shows that top 5 percentile regions are major knowledge hubs regardless of topic. Then we replicated the convergence analysis. Figure A.1 is comparable to Figure 6 and it shows that even in the narrow topic of "European Union" the knowledge creation is characterized by convergence. This final point is statistically validated (see Table A.3 in the appendix) replicating the OLS regressions as discussed above for the FP data and as presented in Table 8. All in all, we can say that even using a very different data set based on co-authorship and a narrow topic such

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as the "European Union" the main result of persistence of the top performers and convergence of knowledge on average do not change.

6. Conclusion and Policy Implications

Flows of knowledge, created through the interactions between intellectual capital and physical capital, are ever more seen as being the main pillar of the modern era. The conversion of knowledge and new ideas into commercial products and services, and rise in the number of actors facilitating these conversion activities, is critical for economic growth and development. The systematic and reliable processes enable collaboration among the agents and create an ecosystem suitable for knowledge convergence. The successful knowledge convergence narrative, in turn, provides drivers for knowledge cohesion to decrease regional disparities. In order to unlock development potential at the local level, much of the local knowledge does not pre-exist exogenously either locally or centrally. The knowledge needed for this change can only be generated by means of a deliberative process of debate and engagement between local, regional and central parties, actors and institutions with different interests, preferences and competences (McCann, 2015).

This study is an attempt to present knowledge convergence as realized between regions of EU and Turkey in particular, and knowledge cohesion as a possibility for EU in general. In the empirical part of the study, the increasing number of nodes and links demonstrate that the regions in Europe display an increasing tendency to participate into FPs. The performance of the nodes in terms of diversification of the nodes they cooperate with is considered rather satisfactory (Table 6). On the other hand, the changes in all closeness, betweenness and eigenvector values show that the new participants enter into the network generally by linking to the regions which previously participated in a high number of projects (preferential attachment). As a result, while this process increases the sustainability of the structure; at the same time, diversification of the linked nodes shows us there is at least a minimum level of knowledge cohesion that began to be formed among these nodes. Had the newcomers preferred to establish links only with the regions that previously participated in a high number of projects, in this case, it might have been speculated that this relatively closed network (or the notion of path dependency), teaming up with previous partners, may not only lead to redundancy but also trigger the risks of lock-in (Leonard-Barton, 1992). Another important point is the increasing clustering value and decreasing path length. This demonstrates that the structure is evolving into a direction supporting knowledge convergence. Although they demonstrate a performance below average, the regions in Turkey developed partnerships with a high variety of regions (287 different regions, except for H2020). When the performance of the regions in Turkey in terms of establishing links with other regions is examined, a relationship that is gradually increasing in number and in depth is observed. While Turkey established links with 171 different regions in FP5, this figure has increased to 266 in FP6 and 276 in FP7. On the other hand, while the total number of links established in FP5 was 834, this figure increased to 7,104 in FP6 and 13,561 in FP7. The increase in the number and depth of links

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between Turkey and EU, which strengths trust and facilitates tacit knowledge exchange, shows us that knowledge convergence has already been started to establish and develop.

In this section of the study, we prefer a prospective approach, rather a myopic view, for EU’s knowledge cohesion policy, counterparts of Turkish policies as well as for interaction between them. In fact, the empirical part of the study produces common solutions to common problems for both EU and Turkey. EU cohesion policy has experienced a series of metamorphoses during its five programming periods since 1989 and become the most financed EU policy (Medeiros, 2017). The recent evidence shows that the policy has a positive impact on economic growth in all regions (Gagliardi and Percoco, 2017; Fratesi and Wishlade, 2017; Percoco, 2017). However, its impact together with Research and Innovation (R&I) policies seems to be conflicting in terms of convergence. Izsak and Radosevic (2017) conclude that these policies caused a further divergence between Northwest and South and convergence between Northwest and Central-East. Moreover, the positive impact of cohesion policy tended to be more pronounced depending upon the geographical proximity of regions to urban agglomerates. Favorable geography and progressive suburbanization or rural areas has increased the impact of the policy (Gagliardi and Percoco, 2017). Smart specialization policies already developed is an attempt for the improvement of political infrastructure of new policies in the next programming period. It is in accordance with the objective of cohesion policy to reduce disparities among the EU regions as a key problem of regional innovation policy (McCann, 2015; McCann and Ortega-Argilés, 2013, 2015, 2016; Morgan 2015). The concept of smart specialization is very much related with the knowledge ecosystem in which knowledge, technology and innovation generation and diffusion processes expedites entrepreneurship to unlock development potential of a region. The successful implementation of this idealization in all regions, of course, ultimately produces results towards knowledge convergence and cohesion. Moreover, the success also depends on proper functioning of both regional and national innovation systems. However, this is not always the case for laggard regions. The RIS3 smart specialization assessment wheel defines six steps for regions developed by smart specialization platform of EC. An example of RIS3 assessment wheel can be seen at Figure 10 on which red line denotes the performance of Turkey. In Turkey, regional development agencies are responsible to prepare regional innovation strategies. According to a recent study, only 7 out of 26 development agencies have already prepared these strategies yet only two of them are in line with RIS3 guide provided by EC (Erdil & Çetin, 2016). Finally, the discussion on whether smart specialization policy should focus on disruptive activities in the form of mission-oriented policies still continues in EU policy agenda
(Mazzucato, 2013; Frenken, 2016; Balland, 2017). We consider that such a general approach creates too much burden and risks for the regions.

Figure 10: RIS3 Assessment Wheel, Turkey 2016

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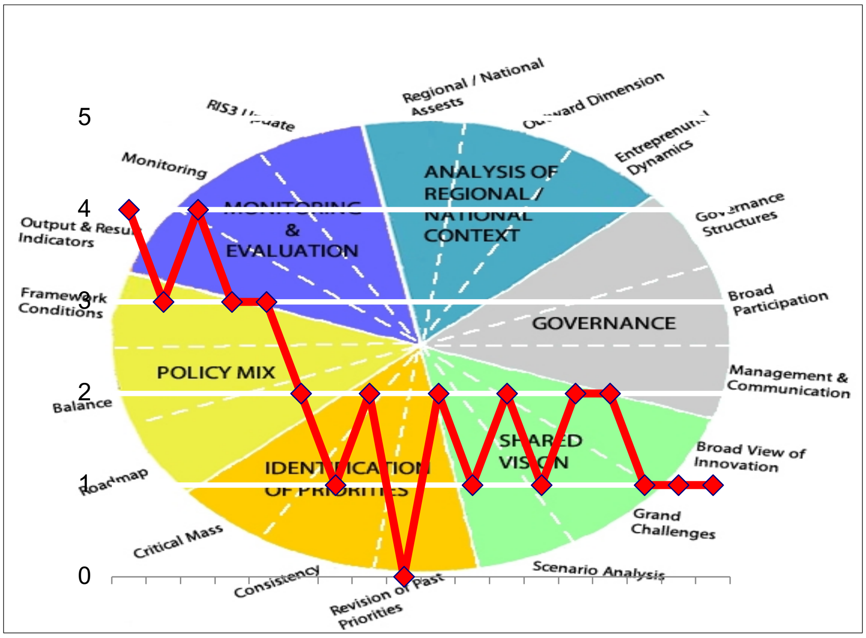

Source: http://s3platform.jrc.ec.europa.eu/ris3-assessment-wheel and Erdil and Çetin (2016).

The next issue we can discuss is the policies and strategies that will be followed in the post- 2020 period. The EU strategies will be supposed to a significant impact on Turkey since until today knowledge, science, technology and innovation policies is one of the areas where convergence is considerably realized. Medeiros (2017) provides a good account of European cohesion policy for the post-2020 period. Medeiros (2017) starts with presumption that the decisive target of EU policies is to promote territorial cohesion and development rather than growth. Based on this assumption, he proposed a “one goal-four targets” strategy, namely green economy, balanced territory, good governance and social cohesion as can be seen from Figure 11 (Medeiros, 2017: 9). He further claims that build on Europe 2020 strategy, the proposed strategic framework brings “a clear territorial dimension” (p. 10). At the first instance, this strategic vision seems to be consistent, it directly lacks to include knowledge cohesion into picture, though we see some components of knowledge cohesion. As we claimed in the introduction section, knowledge cohesion is a mega concept that links other types of cohesion. Therefore, the one-target formulation should be replaced as territorial knowledge cohesion and development.

Figure 11: European Cohesion Policy, Post-2020

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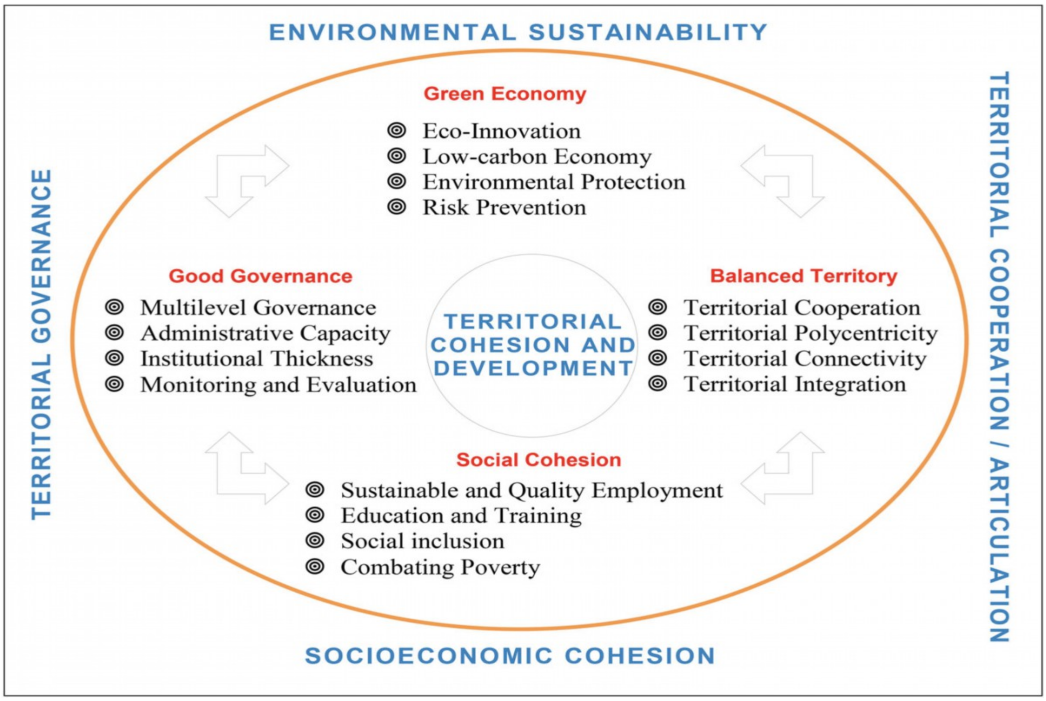

Source: Medeiros (2017).

The story is more or less same for Turkey for the post-2020 period as sketched by Figure 12. This figure is drawn ceteris paribus, given that harmonious relations with EU are established again and political and economic stability is prevalent. The policy has four dimensions that feedback each other. The first dimension of governance considers five sub-strategies. Multilevel governance ensures the bottom-up policy making process in which experts from several tiers of government and relevant interest groups play a role in policy making. However, as a second strategy the bottom-up approach is not satisfying alone for territorial cohesion, as noted by Crescenzi and Giua (2016), top-down approaches can be effective in order to provide resources to the socio-economical important areas. Thus, a mix of these two approaches seems to be an ideal reaction. Both transparency and corruption are must prerequisites for the effective spending of public funds that necessitates continuous monitoring and evaluation. Monitoring and evaluation also serves for evidence-based policy making. As noted by various studies (Arocena & Sutz, 2002; Chaminade et al., 2012; Erdil et al, 2016), countries like Turkey has infrastructural and process-based problems at both regional and national innovation systems. This brings the dimension of upgrading capacities and capabilities. The employment in knowledge-intensive business services in Turkey is well below the EU average (Erdil et al., 2016:10). On the quality of these services, no official data exists yet the current occupational accreditation practices provide no standards for capabilities of these employees. Another hot issue in the national agenda is related with the quality of education in general and vocational training and university education in particular. The rising number of universities seems to be a tool for regional development yet their links with the ecosystem in most of the cases are weak (Erdil et al, 2016). The recent attempts by the Higher Education Council for increasing the quality of higher education are not mature enough to make any evaluation. The

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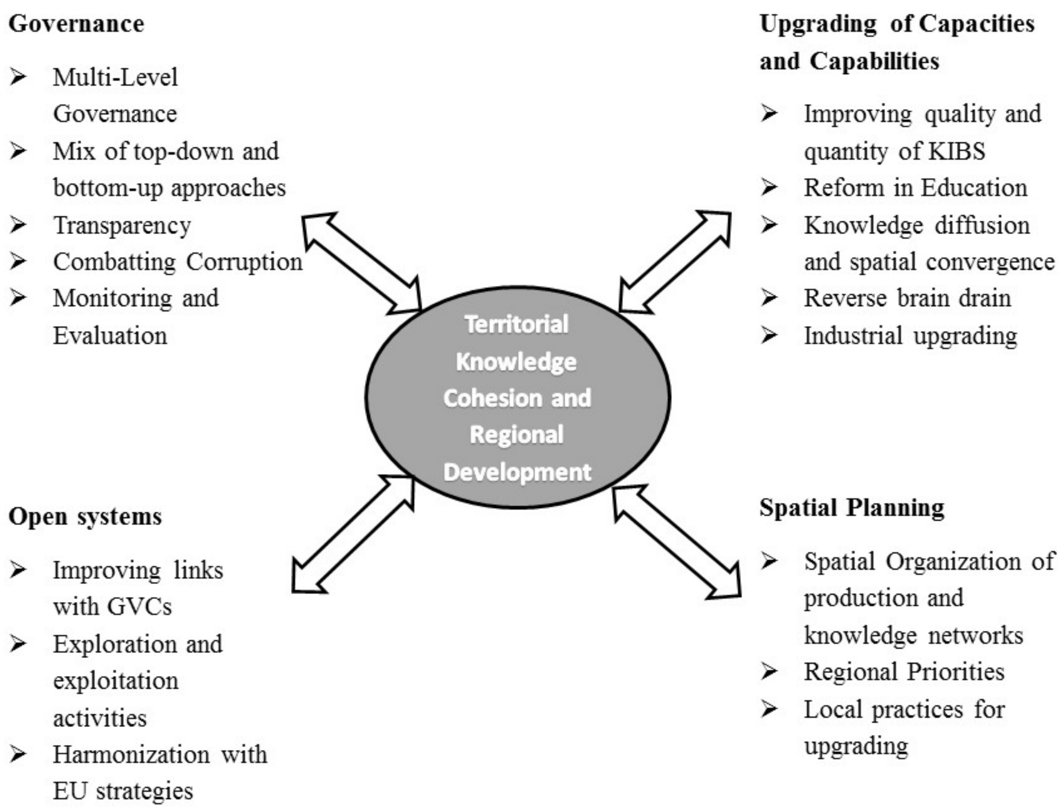
regional disparities existing in the country still persistent and we do not see any serious attempts for knowledge convergence inside the national borders. The recent political instability may further create problems for knowledge convergence. This situation seems to put pressures for brain drain towards Europe and U.S. Though pessimistic in the short run, if Turkey is able to reverse the brain drain in the post-2020 period, this creates an opportunity for knowledge cohesion with EU. Turkish economy is dominated by SMEs.

Figure 12: Turkey's Territorial Knowledge Cohesion Policy, Post-2020



Source: Authors' own compilations.

However, the low levels of absorptive capacity of the business sector, particularly which of MSMEs, is a barrier to increase R&D and innovation performance (Erdil, et al., 2016). Moreover, there are no studies concerning whether Turkish industry and knowledge-producing agents are ready for the recent trends named as Industry 4.0. The third dimension is the existence of open systems which prevent territorial systems from the danger of lock-in. The improvement of links with the rest of the world through global value chains (GVCs), continuous knowledge exploration and exploitation activities of economic agents, and further harmonization with EU strategies and implementations such as drafting and implementing regional innovation strategies with good governance will help remove the barriers for knowledge cohesion. The fourth dimension further

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feedbacks the third one by spatial organization of production and knowledge networks, determining regional priorities, and implementing local best practices for upgrading. In sum, these four dimensions of territorial knowledge cohesion policy for the post-2020 period will help Turkey to mitigate existing structural challenges as well as to provide proper policy options for knowledge cohesion both inside the national borders and EU. We do not see other options such as Eurasian Economic Union as viable alternatives for Turkey, they can be thought as complementary alternatives rather than substitute for EU.

In the context of 3C scenarios of FEUTURE project, the findings of this paper are very promising for cooperation and convergence scenarios. The knowledge relations between EU and Turkey has improved and become multifaceted in a positive sense with the participation of Turkey to the framework programmes. The findings point out a location between cooperation and convergence and close to convergence. As discussed by Figure 1 at the beginning of this paper, there is a feedback mechanism among various types of convergences and knowledge convergence is a catalyzer for overall convergence. The common and shared knowledge in the system reproduces itself, causing agents to develop a unique jargon and find similar solutions to similar problems in all areas of social life. This knowledge convergence process enables other types of convergences and ultimately cohesion in the long run. This process nonlinearly ends up with the minimization of disparities, inequalities and inclusive sustainable growth.

In conclusion, the current paper provides evidence for increasing knowledge convergence with EU. This process can be strengthened with the implementation of a policy framework consistent with the EU policy framework that serves for Turkey to be a competitive dynamic knowledge-based economy in the coming decades. In this sense, the concept of knowledge cohesion will be the common denominator in order to achieve this objective.

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8. Appendix

Table A.1: The presence of countries in Framework Programs from FP1 to H2020

Code	Country	FP1	FP2	FP3	FP5	FP6	FP7	H2020
AL	Albania				1	2	1	1
AT	Austria	2	7	7	9	9	9	9
BE	Belgium	10	11	11	11	11	11	11
BG	Bulgaria			1	6	6	6	6
CH	Switzerland	3	7	7	7	7	7	7
CY	Cyprus			1	1	1	1	1
CZ	Czech Republic			2	8	8	8	8
DE	Germany	33	35	41	40	40	42	41
DK	Denmark	6	6	6	6	6	6	6
EE	Estonia			1	1	1	1	1
EL	Greece	8	10	13	16	13	18	16
ES	Spain	14	17	16	17	17	18	17
FI	Finland	3	4	4	5	4	5	4
FR	France	21	24	25	28	28	28	26
HR	Croatia				2	2	2	2
HU	Hungary			2	7	7	7	7
IE	Ireland	2	2	2	2	2	2	2
IS	Iceland		1	1	1	1	1	1
IT	Italy	19	21	23	24	25	28	29
LI	Liechtenstein		1		1	1	1	1
LT	Lithuania				1	1	1	1
LU	Luxembourg	1	1	1	1	1	1	1
LV	Latvia				1	1	1	1
ME	Montenegro				1	1	1	1
MK	Macedonia				1	1	1	1
MT	Malta				1	1	1	1
NL	Netherlands	10	12	12	12	12	12	12
NO	Norway	4	7	7	7	7	7	7
PL	Poland			3	15	16	16	16
PT	Portugal	4	5	7	7	7	7	7
RO	Romania			2	9	9	11	9
SE	Sweden	4	7	8	8	8	8	8
SI	Slovenia			2	3	4	4	4
SK	Slovakia			1	4	4	4	4
TR	Turkey			1	10	20	21	17
UK	United Kingdom	38	38	38	38	38	38	38
Total		**182**	**216**	**245**	**312**	**322**	**336**	**324**

Note: The numbers in the table refer to number of NUTS2 regions that participate to FP programs. The last row gives the total number of regions that we have data for in each round of FP.

This project has received funding from the *European Union’s Horizon 2020 research and innovation programme* under grant agreement No 692976.

Table A.2: Top 5 percentile EU regions in EU studies according to network degree and betweenness centrality, 1998-2016

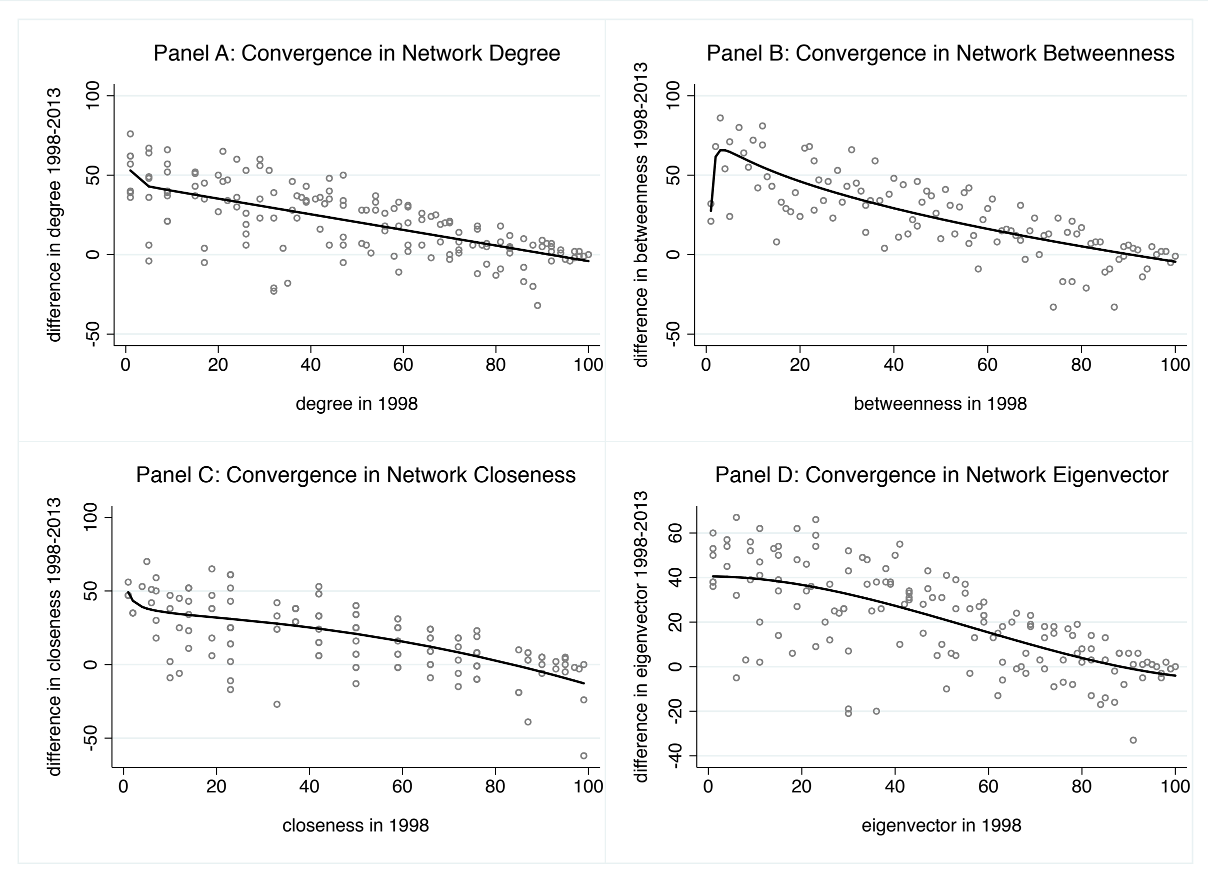
network degree				betweenness centrality			
1998-2002	2002-2006	2007-2013	2014-2016	1998-2002	2002-2006	2007-2013	2014-2016
UKI	FR10	FR10	DE21	UKI	FR10	ES51	FR10
NL31	NL31	UKI	UKI	SE11	NL31	FR10	ES30
FR10	UKI	ES51	FR10	FR10	ITE1	UKI	ES51
NL32	ES51	FR71	ES30	ITC4	FR71	ES30	DE30
ES51	ITC4	ITC4	NL31	NL31	ES51	ITC4	DE21
SE11	FR71	DE21	FI1D	ES51	DE21	SE12	UKI
DE12	ES30	NL31	ES51		UKI	FR71	
DK00	SE11	ES30	UKJ1		ITC4	NL22	
	NL22	NL32	NL22		NO01	DEA2	
	DE21	NO01			NL22	AT13	
	UKJ1	NL22			CZ01	NO01	
	NL32	AT13			ITE4	NL31	
	SE12	DEA2				CH04	
	DK00	SE11				DE21	
		ITE4				NL32	
		UKJ1				FR81	
		FI1B					

Source: Authors' own compilations.

Figure A.1: Convergence in knowledge in European Regions 1998-2013

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692976.

The case of EU Studies



Source: Authors' own compilations.

Table A.3: Summary results of the OLS analysis for convergence 1998-2013.
The case of EU Studies

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692976.

	degree	betweenness	closeness	eigenvector	degree	betweenness	closeness	eigenvector
	1998-2013	1998-2013	1998-2013	1998-2013	2002-2013	2002-2013	2002-2013	2002-2013
network 2002					-0.217* (0.025)	-0.315* (0.037)	-0.189* (0.026)	-0.220* (0.026)
Network 1998	-0.049* (0.054)	-0.633* (0.058)	-0.507* (0.063)	-0.486* (0.053)				
Country dummy	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.76	0.85	0.72	0.76	0.68	0.62	0.60	0.66
Observations	156	109	155	153	242	205	242	242

*Note: Detailed OLS results are suppressed but available on request. Each column presents an OLS regression where the dependent variable is the change in percentiles between two time periods in one of the four network statistics based on the co-authorship data on EU studies produced from the Web of Science. Numbers in parentheses are robust standard errors. * indicates the estimated coefficient is statistically significant at the 1 percent level.*

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Table A.4: Countries Turkey Linked with

FPs	AL	AT	BE	BG	CH	CY	CZ	DE	DK	EE	EL
FP3											
FP5	2	17	16	23	22	13	8	94	15	5	64
FP6	6	197	294	145	137	83	118	794	146	58	383
FP7	28	362	632	265	295	125	205	1416	251	113	703
H2020	5	74	133	24	31	23	26	230	52	27	136
Total	**41**	**650**	**1075**	**457**	**485**	**244**	**357**	**2534**	**464**	**203**	**1286**

FPs	ES	FI	FR	HR	HU	IE	IS	IT	LI	LT	LU
FP3											
FP5	72	17	82	4	11	10	3	147		6	4
FP6	501	140	672	48	159	87	32	785	1	58	12
FP7	1335	317	1228	108	229	238	48	1500		79	25
H2020	380	57	189	14	31	46	12	286		18	7
Total	**2288**	**531**	**2171**	**174**	**430**	**381**	**95**	**2718**	**1**	**161**	**48**

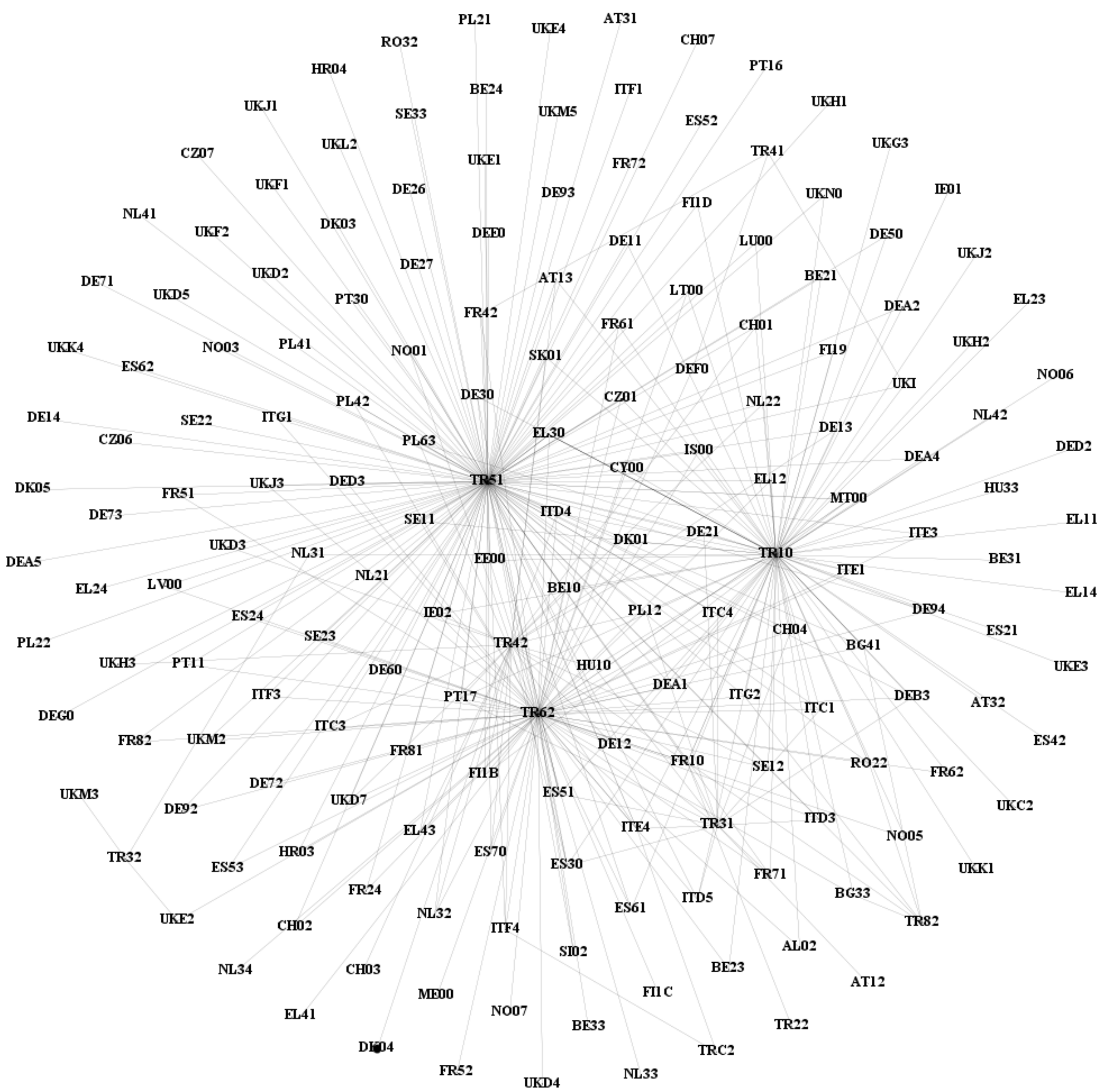
FPs	LV	ME	MK	MT	NL	NO	PL	PT	RO	SE	SI
FP3											
FP5	2	1		26	20	7	19	22	17	19	8
FP6	48	1	8	66	333	155	211	174	163	213	82
FP7	72	34	41	71	618	273	311	348	296	464	136
H2020	24	3	6	6	125	50	64	73	57	76	31
Total	**146**	**39**	**55**	**169**	**1096**	**485**	**605**	**617**	**533**	**772**	**257**

FPs	SK	UK
FP3		1
FP5	3	55
FP6	66	728
FP7	83	1312
H2020	20	244
Total	**172**	**2339**

Source: Authors' own compilations.

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692976.

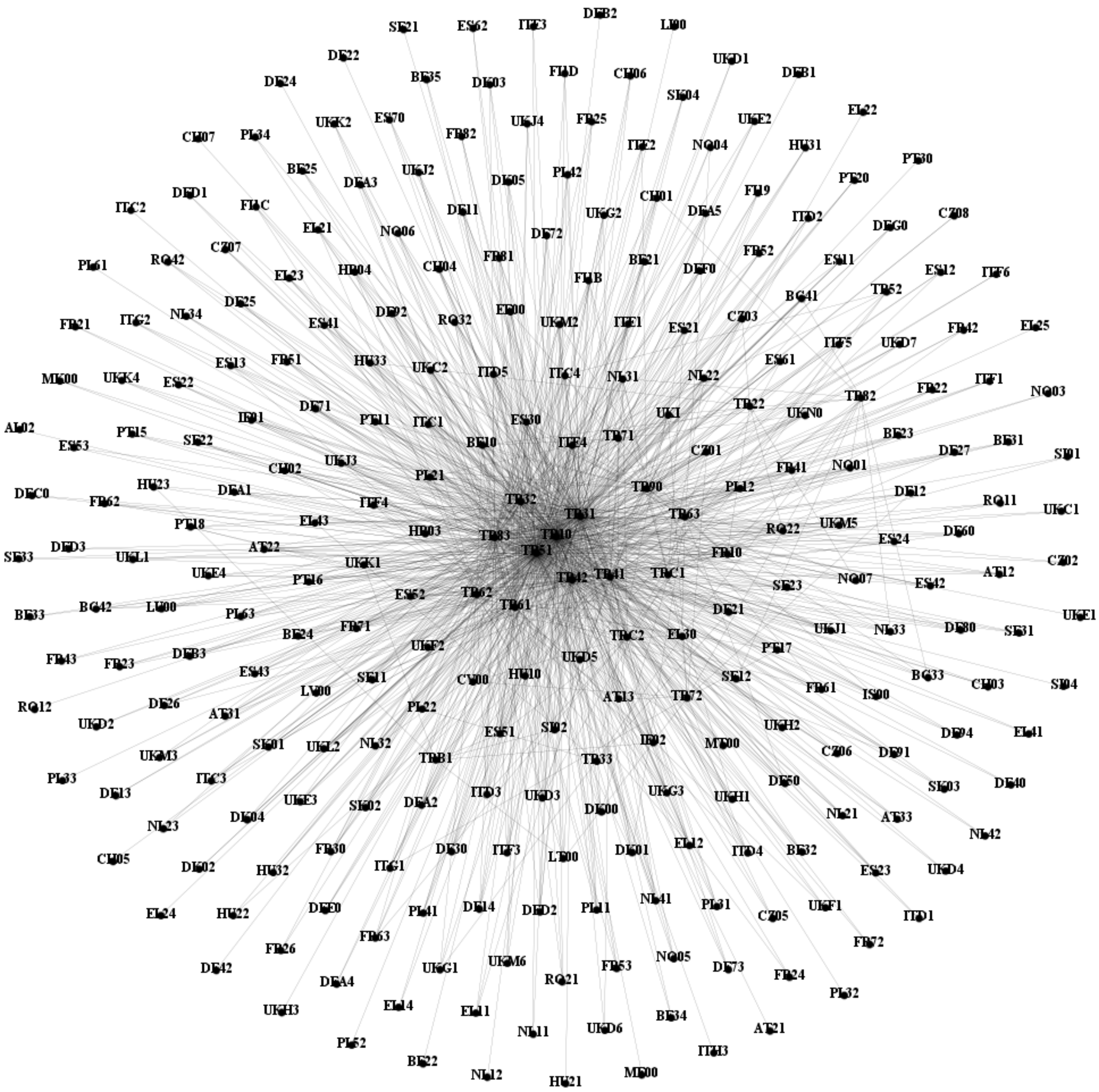
Figure A.2: FP5 Network of the Regions in Turkey



Source: Authors’ own compilations.

This project has received funding from the *European Union’s Horizon 2020 research and innovation programme* under grant agreement No 692976.

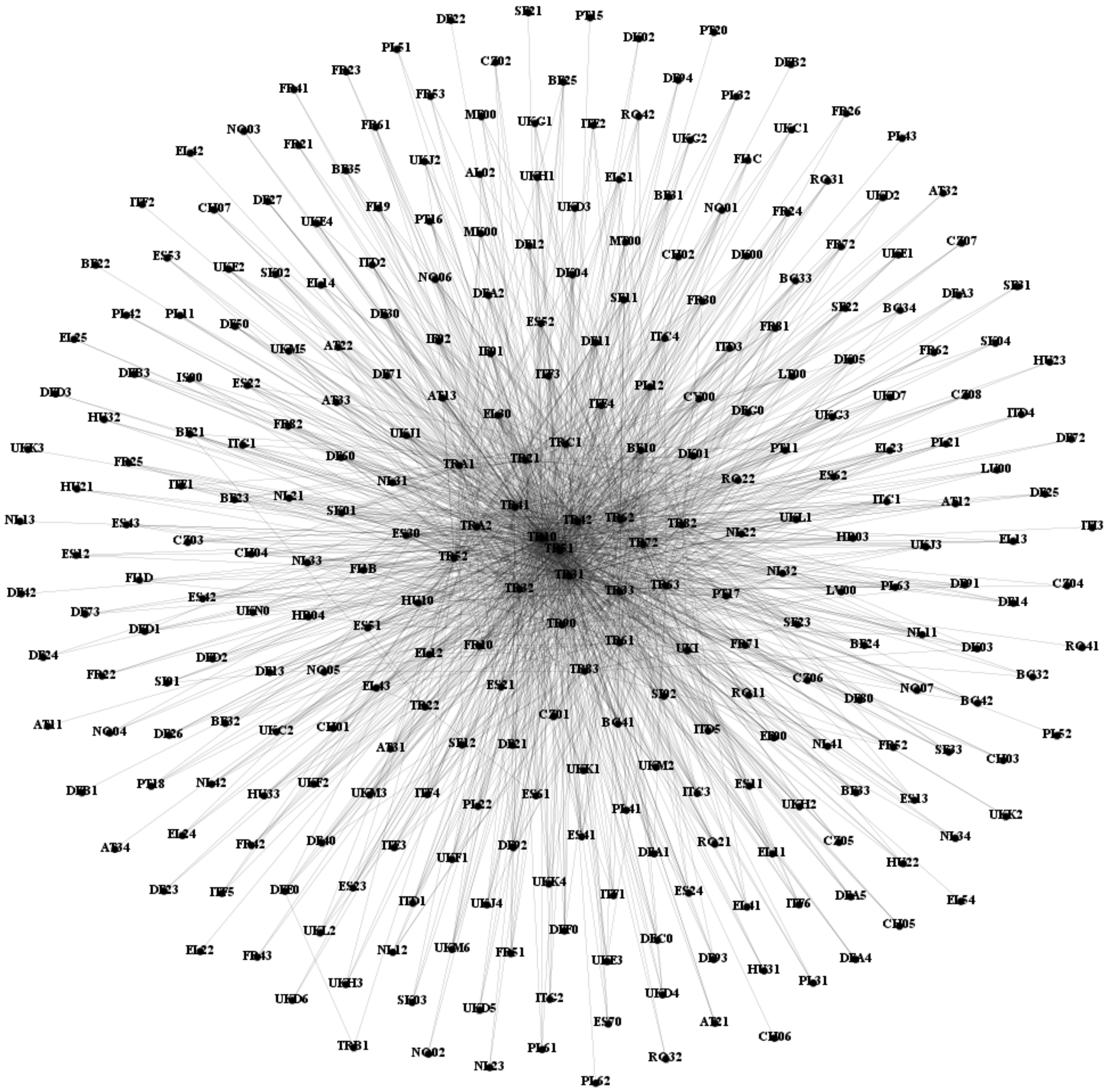
Figure A.3: FP6 Network of the Regions in Turkey



Source: Authors' own compilations.

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692976.

Figure A.4: FP7 Network of the Regions in Turkey



Source: Authors' own compilations.

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ABOUT FEUTURE

FEUTURE sets out to explore fully different options for further EU-Turkey cooperation in the next decade, including analysis of the challenges and opportunities connected with further integration of Turkey with the EU.

To do so, FEUTURE applies a comprehensive research approach with the following three main objectives:

1. Mapping the dynamics of the EU-Turkey relationship in terms of their underlying historical narratives and thematic key drivers.
2. Testing and substantiating the most likely scenario(s) for the future and assessing the implications (challenges and opportunities) these may have on the EU and Turkey, as well as the neighbourhood and the global scene.
3. Drawing policy recommendations for the EU and Turkey on the basis of a strong evidence-based foundation in the future trajectory of EU-Turkey relations.

FEUTURE is coordinated by Prof. Dr. Wolfgang Wessels, Director of the Centre for Turkey and European Union Studies at the University of Cologne and Dr. Nathalie Tocci, Director of Istituto Affari Internazionali, Rome.

The FEUTURE consortium consists of 15 renowned universities and think tanks from the EU, Turkey and the neighbourhood.

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