DETERMINANTS OF REGIONAL INNOVATION IN TURKISH NUTS 3 REGIONS FROM THE SPATIAL DEPENDENCE PERSPECTIVE

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ABSTRACT

DETERMINANTS OF REGIONAL INNOVATION IN TURKISH NUTS 3 REGIONS FROM THE SPATIAL DEPENDENCE PERSPECTIVE

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Combining the existing knowledge in different ways, production, and absorption of the new knowledge, and transformation of all these into innovation in a region are the main driving forces of regional economic performance and connect the region with national and international economies. The relationship of innovation with space has been the subject of many disciplines as economics, regional science, and planning. Innovation is defined as the innovation outputs accepted as an indicator of the knowledge base in the region when the literature within the scope of this study is consulted. This research aims to reveal the key components that affect innovation outputs in 81 NUTS 3 regions, also known as provinces in Turkey. These components are examined in three main axes in the context of human agency, institutions, and spaces. Secondary data obtained from public institutions, primarily the Turkish Patent and Trademark Office, are used in the statistical and spatial analyses. Variables affecting patent and utility model registrations in 81 provinces in Turkey for 2019 are analyzed via SPSS and ArcGIS Pro software. The key components that positively affect innovation output in Turkish provinces are innovative sector and R&D employment, R&D expenditures, OIDs, R&D centers, economic development level, population density, and newly opened innovative enterprises. Local models created with components that positively affect regional innovation show that geographical location has a varying effect on innovation outputs, specific to the provinces of Turkey. This research proposes the development of regional innovation policies in Turkey as a result of the analysis of local dynamics through both global and local models, based on the forms of production in the regions, the technology and R&D intensities of the sectors, with the recognition of the direct relationship of innovation outputs with production and space. This thesis aims to contribute to the discussions in the field of regional innovation and development in Turkey.

Keywords: regional innovation, spatial analysis, spatial dependence, NUTS 3, Turkey.

ÖZ

MEKANSAL BAĞIMLILIK PERSPEKTİFİNDEN TÜRKİYE NUTS 3 BÖLGELERİNDE BÖLGESEL YENİLİĞİN BELİRLEYİCİLERİ

Varış, Sıla Ceren
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Bölgelerde var olan bilginin farklı şekillerde birleştirilmesi, yeni bilginin üretilmesi, özümsenmesi ve yeniliğe çevrilmesi bölgesel ekonomik performansın temel itici güçlerinden olup bölgenin ulusal ve uluslararası ekonomilerle bağlantısını sağlamaktadır. Yeniliğin mekanla olan ilişkisi, ekonomi, bölge bilimi ve planlama gibi pek çok disiplinin çalışma konusu olmuştur. Yenilik, bu çalışma kapsamındaki yazına başvurulduğunda, bölgedeki bilgi tabanının göstergesi olarak kabul edilen yenilik çıktıları olarak tanımlanmaktadır. Araştırmanın amacı, Türkiye'deki 81 ilde yenilik çıktılarını etkileyen önemli değişkenleri ortaya çıkarmaktır. Bu nitelikler insan unsuru, kurumlar ve mekanlar bağlamında üç ana eksende incelenmiştir. Türk Patent ve Marka kurumu başta olmak üzere kamu kurumlarından elde edilen ikincil veriler, istatistiksel ve mekansal analizlerde kullanılmıştır. 2019 yılı için Türkiye'deki 81 ilde patent ve faydalı model tescillerini etkileyen belirleyicilerin analizi SPSS ve ArcGIS Pro yazılımları aracılığıyla yapılmıştır. Türkiye'deki illerde yenilik çıktılarını olumlu etkileyen bileşenlerin, yenilikçi sektör ve Ar-Ge istihdamı, Ar-Ge harcamaları, OSB'ler, Ar-Ge merkezleri, ekonomik gelişmişlik düzeyi, nüfus yoğunluğu ve yeni açılan yenilikçi girişimler olduğu sonucuna varılmıştır. Bölgesel yeniliği olumlu etkileyen bileşenlerle oluşturulan yerel modeller, Türkiye illeri özelinde coğrafi konumun yenilik çıktıları üzerinde farklılaşan etkisi olduğunu göstermektedir. Bu araştırma Türkiye’de bölgesel yenilik politikalarının, yenilik çıktılarının üretim ve mekanla olan doğrudan ilişkisi kabulü ile, bölgelerdeki üretim biçimleri, sektörlerin teknoloji ve Ar-Ge yoğunlukları esas alınarak, hem küresel hem de yerel modeller aracılığı ile yere ait dinamiklerin çözümlenmesi sonucu geliştirilmesini önermektedir. Bu tez Türkiye’de bölgesel yenilik ve kalkınma alanında yapılan tartışmalara katkıda bulunmayı amaçlamaktadır.

Anahtar Kelimeler: bölgesel yenilik, mekansal analiz, mekansal bağımlılık, İBBS 3, Türkiye.

To Milan and Defne

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ABBREVIATIONS

CHE: Council of Higher Education (YÖK)

GDP: Gross Domestic Product

GIS: Geographic Information Systems

KOSGEB: Small and Medium Enterprises Development Organization

NACE: Nomenclature statistique des activités économiques dans la Communauté européenne

NUTS: Nomenclature des Unités territoriales statistiques

OECD: Organisation for Economic Co-operation and Development

SSI: Social Security Institution (SGK)

SCST: Supreme Council of Science and Technology (BTYK)

TURKSTAT: Turkish Statistical Institute (TÜİK)

TPTO: Turkish Patent and Trademark Office

TUBITAK: The Scientific and Technological Research Council of Turkey

CHAPTER 1

INTRODUCTION

Innovation discussion has a long history starting from Schumpeter to the various valuable contributors combining several concepts especially knowledge creation and involving all inputs and outputs that affect innovation. Firstly, Schumpeter (1911 as cited in Cantner and Meder, 2007) defined innovation as a third motive for change and economic growth besides the generally accepted factors of capital and labor force. Schumpeter (1942) highlighted the importance of both diversified and specialized knowledge bases in the generation of "radical, disruptive and incremental innovative output" (Feldman and Kogler, 2010, p.392). Regardless of the type of knowledge, innovation is the ability to bring the knowledge together in different ways and to create new, different, and original conceptions that have not been formulated by then. Compared to other economic activities, innovation is at the forefront in terms of benefiting location (Feldman and Kogler, 2010).

The main focus in this research is to analyze the relation between innovation and space. There are multiple dynamics involved within the scope of this relation. Deducing from literature that a profound amount of research is compiled about the innovation determinants at different levels such as firms, industries, regions and nations (Tavassoli and Karlsson, 2021). These numerous determinants range from micro-economic features and inter-firm connections to macro-economic performance of regions (Avermaete et al. 2003). Spatially concentrated nature of innovation (Feldman and Kogler, 2010) has been the subject of many studies in the field (see Section 2.2). This research focuses on the spatial dependence of innovative activity in Turkey from the regional planning and policy making perspective.

1.1 Scope of the research

Numerous concepts and theories, which are used to explain the relationship between innovation and space, are compiled as proximity, local development, and regional externalities such as specialization, diversification, and relatedness. This research includes theories of innovation and space, and regional scale relations of these theories.

Innovation is utilized in order to fix market failure according to neoclassical theorists and based on the views of evolutionary researchers, and the aim is to create innovative systems at multiple levels. The spatial scales in which the concept of innovation is examined in general have been determined by Feldman and Kogler (2010) at national and local levels as well as the global level. In more detail, according to the collected work by Fritsch et al. (2019), innovation systems and research can be leveled in the senses of national, sectoral, technological, and regional. Whereas at the micro-level, companies and individual organizations are analyzed; at the meso-level clusters, networks, and industrial zones formed by the collection of organizations are examined. At the macro level, innovation is scrutinized in terms of its contribution to competitiveness and income creation for the whole region.

Although the research approach to innovation is different for each level, it would be insufficient to define innovation as only technical change. According to Malecki (2013), innovation is a broader concept that incorporates the returns obtained by synthesizing the knowledge, ideas, and experiences from learning processes. From the regional innovation perspective, topics such as the classification of innovation, the presence of innovation encouraging structural elements, and the analysis of cognitive processes behind innovation are scrutinized in the literature (Capello, 2011). The most common concepts of regional innovation theory are economy-space relation, nature and evolution of agglomerations, and the importance and force of innovation on future economic developments. The economy-space connection highlights the interaction of economic processes and geographic and socio-cultural types of proximity. The evolution of agglomerations is shaped according to change in innovation paradigms. Finally, innovation is recognized as a lead for path-dependency and economic change (Asheim and Schwartz, 2011).

There is a vast literature on the factors in particular localities technological advances realized and the impact of these factors on local economic growth (Iammarino and McCann, 2006). The scholarly work named the geography of innovation theory deals with the inputs of innovation in terms of agglomeration and also includes the effects of proximity theory and the relationship of knowledge diffusion in this context (Crescenzi et al., 2007). The adaptation of new knowledge, its production, and conversion into new products and processes are accepted as the incentives of regional economic development together with human capital. These features enable regions to be articulated to national and global economies (Crescenzi et al., 2016). In this research, innovation is considered as an output that emerges as a result of the relationship of various components at the regional level. In this context, the role of space and the dependence of innovation on space are analyzed.

1.2 Aims of the research

Innovativeness and innovation, which have been discussed on a national scale since the early 2000s and proposed to develop several policies accordingly, has not been able to move Turkey to the higher in the list among the countries in terms of OECD results. According to OECD (2021), the innovation and technology ranking of a country is based on several indicators. These indicators are roughly gross domestic spending on R&D, ICT value-added, internet access, mobile broadband subscriptions, and triadic patent families. With reference to the percentage of total expenditure on R&D (Figure 1.1), the OECD total is 2.5%, while Turkey's is 1.1%. In the world's total expenditure on R&D, Israel is the leader with 4.9%, followed by South Korea with 4.6%.

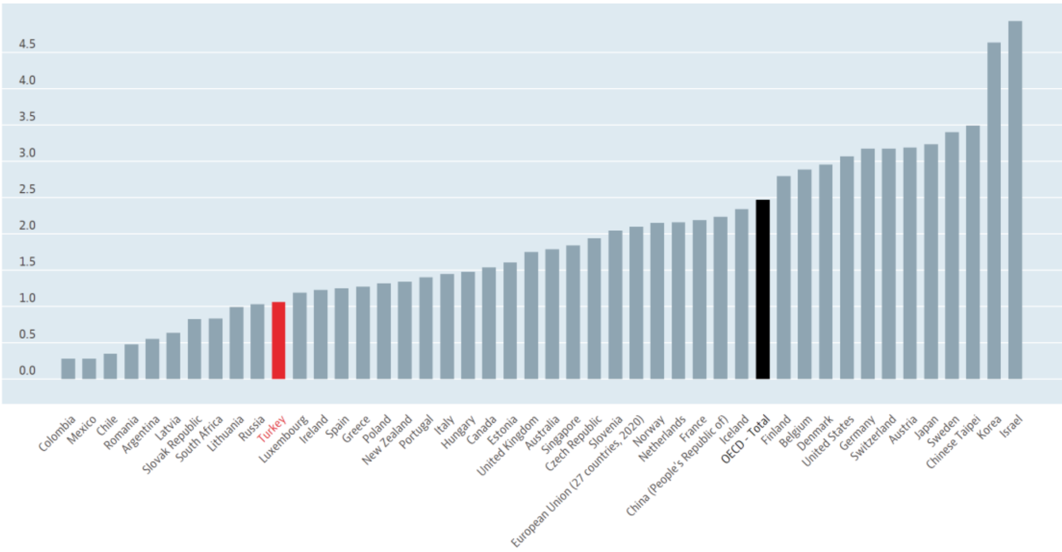

Figure 1.1. Ranking of gross domestic spending on R&D (%) in 2019 (OECD, 2021)

For the number of patents, one of the innovation indicators that are important within the scope of this research, the OECD deals with triadic patent numbers. The triadic patent family means that the same invention has been registered by the European, American, and Japanese Patent offices. The most recent OECD data is the number of triadic patents per country for 2018. Figure 1.2 shows the number of triadic patents that Turkey had from 2005 to 2018.

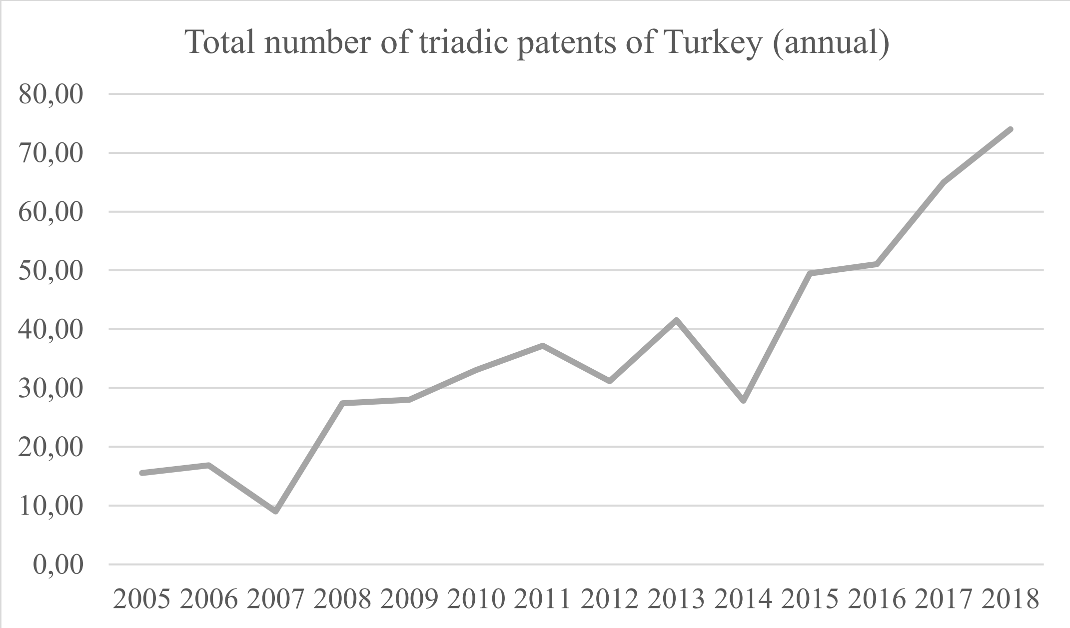

Figure 1.2. Total number of triadic patents of Turkey between 2005 to 2018 (OECD Triadic Patent Families database, July 2021)

While there are 57,230 inventions with triadic patents globally for 2018, the total number of patents in OECD countries is 50,201. In terms of comparison, while the total of all European Union countries is 13,106, Germany is 4,772, and Spain is 314, Turkey is behind in the ranking of countries with the triadic patents number of 74 in 2018. The Turkish Patent and Trademark Office (TPTO) reserves the number of registered patents only in Turkey. The number of registered patents in Turkey is 4,197 for 2018 (TPTO, 2020). It is observed that innovation in Turkey lags behind other countries in the world within the scope of triadic patents, but innovations registered and protected within the country are worth scrutinizing. It has been observed that the policies developed for innovation at the region and province level in Turkey are mostly developed without paying much attention to spatial dependency. For this reason, it is aimed to examine the factors that support the innovation outputs at the province level in order to provide input for the policies to be developed in the future. Statistical methods are used to provide an enhanced understanding of these factors in the context of Turkey. This research aims to answer three main research questions.

Research Question 1: What are the key components contributing to province level innovation output in Turkey?

Research Question 2: What is the relationship between innovation output encouraging key components and space at the province level in Turkey?

Research Question 3: Which key components show spatial dependency differences at Turkish NUTS 3 regions in explaining the innovation output?

1.3 Method of the research

In this section, how the method was developed is mentioned in general terms. More detailed explanations on method are in Chapter 5. Regional innovation is analyzed at three perspectives in Turkey. Firstly, key components for innovation in provinces are investigated. Secondly, spatial proximity and neighboring impact on innovation is analyzed. Last of all, individual geographical weights of components between provinces are discussed within this research. In the context of this thesis, the components that form the knowledge leading to innovation at the regional level are shown in the Figure 1.3. This methodological framework of the thesis is drawn as shown and subsequently it shapes the research models.

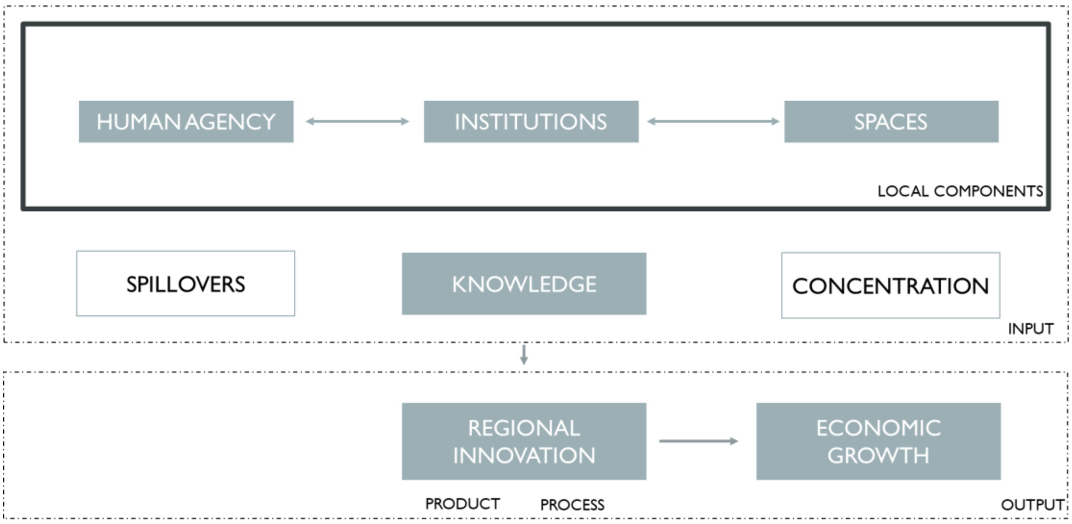

Figure 1.3. Methodological conceptual scheme of the thesis

Innovation performance in the region depends on the intensity of utilization and expansion of the regional knowledge base by regional stakeholders. Therefore, the determinants of regional innovation depend not only on the features of the knowledge base but also on the ability of the stakeholders in the region to interact with each other to benefit from, transform and enrich the knowledge base (Ott and Rondé, 2019).

The basic components that form knowledge and therefore innovation can be analyzed in three main constituents as human agency, institutions, and spaces (see Figure 1.3). In the literature, there are studies that examine the concentration and/or dissemination of knowledge that constitutes innovation. Both spatial and non-spatial components enable regional actors to interact and partake to the capacity of regional innovation. Regional innovation determinants are investigated through related scholarly work. There are the spatial and non-spatial components of innovation at regional level. For each component, the measurement levels are interchangeable in terms of the context of the specific research. The determinants of regional innovation are grouped as the numbers of patent and utility model, human capital, research and development (R&D), local structure, externalities, spaces and institutions.

In order to answer the research question and research design, existing formal statistical data is used. Several institutions in Turkey provides data on the necessary determinants. The patent application and registry data has been acquired from Turkish Patent and Trademark Office (TPTO, 2020) that covers the years from 2010-2019. The rest of the data is gathered from the available sources and the sources is explained in the method section.

The topic for this research is about the set of local components that influence innovation in Turkish regions. Dependent and independent variables based on the ontological and epistemological fundamentals of this research's topic are decided. Analyses have been done based on existing data and assumptions.

There is existing detailed research at the NUTS 2 level in Turkey compared to the NUTS 3 level. With the aim of filling this gap, this research aims to discuss regional innovation at the province level (NUTS 3) in Turkey. NUTS 3 regions in Turkey are efficient to observe for both encompassing a functional urban area historically and having related data for the research. Number of observations are for 81 NUTS 3 regions in Turkey. Explanatory power is assumed to be better compared to 26 NUTS 2 levels.

Maps at the province level of Turkey are used as existing data to make spatial analyses. Shapefiles are needed to make them operational in the ArcGIS Pro program. These shapefiles are in vector data format. Vector data is a data format produced by representing specific places with points, lines and polygons along with their geographic coordinates. Each point is represented by coordinates, whereas each line and polygon is represented by ordered lists of vertices (Esri, 2021). The feature of shapefiles is that they not only describe the geographical features of places such as location and shape, but also store qualitative information about these places. This place-specific information is used for mapping, spatial analysis, and management of geographic data in an application called ArcMap in the Geographic Information Systems program (Esri, 2021).

The shapefile which used in this thesis is obtained from the ArcGIS website. The file containing the borders of Turkey is called "Europe NUTS 3 Boundaries" produced by Esri and Michael Bauer Research GmbH. This source is acknowledged to represent the provincial borders accurately. This shapefile vector data, including the European NUTS 3 regions, is obtained from the Esri official website and is used for academic purposes only within the scope of this research. This vector data includes the demographic and economic characteristics of the NUTS 3 level regions in Europe. The data originally includes "the names of provinces across Europe, the NUTS 3 codes, population with age and gender classifications, household information, population growth, GDP, employment, and surface area". The 81 NUTS 3 region data belonging to Turkey from this shapefile containing the European NUTS 3 level borders are used in the thesis (Esri, 2019).

1.4 Limitations of the research

This research brings along various limitations within the scope of the definition, scale, data and method of the research. These limitations are explained in detail in this section.

Innovation is handled as an innovative output, taking into account the limits of data, method, and scope of research, without handling as a one-sided technical approach. The researcher is aware that she faces the problem of overlooking system, social, and attitudinal types of innovations (Blok, 2019), since innovation is based on goods and models by means of technological development and R&D within this research. Yet, these limitations are discussed in the theory and conclusion sections on a broader scale.

The limitations in the context of the scale are related to the data being collected at the NUTS 3 level in Turkey. In this context, data for research are obtained from a number of institutions. The fact that the data sources consist of various institutions means that there is no continuity for the data. The meaning of continuity can be explained as the fact that the data in different years do not overlap with each other. In other words, data may not have been produced by some sources/institutions in the year the analysis is aimed at.

Patent data is a frequently used resource in innovation studies, even so lacking definitions can lead problematic situations in analysis. In order to overcome these problematic situations, the data should be evaluated in a versatile way and explained in detail. In addition to the patent data, the utility model is included in the analysis because it is technically obtained with an easier process compared to the patent process for industrially applicable inventions and it indicates the innovation in SMEs. Utility model applications followed a trend that would surpass patent applications until 2010 in Turkey (TUBITAK, 2012). Since utility models have historically been a preferred method of protecting intellectual property rights in Turkey, they are also included in the context of this research. Also the reason for obtaining patent and utility model data covering the years 2010-2019 from the TPTO (2020) is that the employment data of the Turkish Social Security Institution (SSI) is codified in line with the NACE Rev.2 codes at the province level. TPTO produces and transforms data from IPC classification to NACE Rev.2 classification within the scope of patent and utility model. Screening of economic activities subject to patent and utility model with NACE Rev.2 codes is included to ensure consistency between data sets and to enable making classifications that are the subject of the research.

Various transformations are made in order for the existing secondary data to be included in the analysis to execute the research properly. One of the main reasons for making these transformations in the data is the different scales of the provinces and economic activities that are the subject of the research. The fact that the provinces differ in terms of population and production capacity has revealed the necessity of proportioning the variables included in the analysis according to these differences. Another reason for the transformations arose from the necessity of controlling the distribution of the variables in the data set in order for the regression models used in the analysis to work statistically properly.

Patent citations and scientific publications are used in the literature as well as patent registrations in measuring technological and scientific outputs. However, patent citations are not included in this study. The reason for this is that patent citation data has not been produced at the province level in Turkey. As also Lenger (2008) elaborated in his research, scientific publications and patent citations data are limited and not currently available for the NUTS 3 regions in Turkey. Indexed journal publications and citations data are also not available; therefore, these are not included in this research.

In order to talk about the limitations in the scope of the research method, the research focused on a single year. The reason for this is that, as mentioned in the data limitations paragraph, all the variables included in the analysis are not produced for each year. The year 2019, which is the most recent in the data set, is chosen to ensure compatibility between the variables. The subject of a single year in the analysis might lead to various problems. One of these is the fluctuations in industrial production, economic situation, and such for that selected year. This research is carried out by accepting these fluctuations in patent and utility model applications and registrations compared to other years. Therefore, the results of this research, which is carried out for the most recent year in the dataset, are evaluated accordingly.

The use of classical regression and knowledge production function models alone might lead to biased results. In addition to these methods, geographically weighted regression models are also involved in the analysis to measure the impact of space on innovation, which is one of the main questions of the research. Findings based on each model are explained in the related sections in detail.

The findings of this research are presented without overlooking the abovementioned limitations. For the findings of the research, the changing patent application trends of the economic sectors, patent acceptance rate, technology and R&D intensities are also taken into consideration.

1.5 Structure of the research

This dissertation is organized in six chapters. Introduction section includes scope of the research, aims of the research including main research questions this research aims to answer. These followed by the method explanations. The limitations section is substantial since it reflects the assumptions and readjustments with the data and research models additional to the explanations of data selection.

Introduction chapter is followed by the second chapter which provides theoretical background. In this part, the relevant literature has been reviewed according to the concepts of innovation and space. A special focus on the regional scale approach to these concepts is provided.

Chapter three includes a holistic approach to innovation at the national and regional scales in specific case of Turkey. This chapter provides information on the NUTS 3 regions, i.e. provinces, in Turkey. This section also provides more information about the innovation policies that have been produced so far at national and regional level in Turkey.

Chapter four unfolds the existing international and national empirical research on the regional innovation. All relevant determinants and methods used in the regional innovation literature are provided and discussed in this chapter. Main topics for regional innovation determinants are listed. Existing methods and research models are also discussed.

Chapter five provides information on the specific method and research models for regional innovation in Turkish provinces. This part shows the unique value for this research. All variables are explained. Transformed versions of the variables are shown and included in the analysis. Analysis models aiming to answer research questions are formalized. This chapter depicts the findings via mapping and additional types of visualizations. Additionally, data and method limitations are provided. Model outputs are debated with reference to the existing theoretical and empirical inquiries in the field.

Chapter six, the final chapter, concludes this research. It includes identification of problems and potentials for regional innovation in Turkey. Some policy recommendations are provided in the light of the research model. The novel contribution of this research is also explained in this final chapter. This final chapter poses questions and opens up dialogues for further studies in the field of regional innovation.

CHAPTER 2

THEORETICAL BACKGROUND FOR INNOVATION AND SPACE RELATION

Innovation is the state of creating something different from existing products and approaches. When Schumpeter (1942) introduced the concept of creative destruction, he argued that manufacturing systems must be innovative to generate economic returns. In other words, it is essential for the producers or the places, where the production takes place, to be innovative to maintain their economic existence and gain profit. Schumpeter (1942) argued that both diversified and specialized knowledge is important for the realization of innovation. Contrary to the classical view of economic equilibrium, innovation requires an ever-changing environment. Innovation occurs as a result of the variation of the existing equilibrium of economy and production. On the other hand, the spatial ties of production reveal the relationship of space in the emergence of innovation.

Innovation has profound relation with space. The spatial nature of innovation has been discussed by many scholars throughout the years. Feldman and Kogler (2010) assert that innovation is a concept that makes the most use of space. Innovation research at different scales have been and are being carried out. While these scales can be named global, national, and local (Feldman and Kogler, 2010; Fritsch et al., 2019); they also include different technologies, sectors, and companies (Tavassoli and Karlsson, 2021).

Regional science approaches spatial and innovation dynamics from a regional perspective. Within the scope of regional science, a wide range of topics are covered mutually with other social sciences over the years. Basically, the aim of regional science is to deal with the regions, the cities within the regions, the use of space, and their resources from a multidisciplinary and spatial perspective. It is to produce policies for sustainable spatial-economic systems by examining the people, production, and socio-economic dynamics in the region with location, distribution, and interaction methods (Kourtit et al., 2021).

By looking at regional science from the perspective of regional planning, the theoretical framework behind regional planning's approach to metropolitan areas should be examined. According to Galland et al. (2020), regional planning, on metropolitan (meso) level, is influenced by four main domains which are "political, economic, socio-spatial, and socio-environmental" (p.247). While the political domain covers institutions, policy-making, spatial visions, planning approaches; the economic domain, on the other hand, involves strategies and decisions of single economic actors, technical developments, employment dynamics. The third domain, the socio-spatial one, includes increased inequalities, and issues of population and migration. On the other side, the socio-environmental domain discusses environmental issues such as climate change, food security, and pressures stemming from these issues. At the regional level, this framework is supported by concrete outputs and the generalization of empirical developments. The main focus is the evaluation of regional issues in a logical framework without overlooking the temporality (Galland et al., 2020).

Before going into more details on the theoretical framework, it is essential to explain what this chapter entails. This chapter involves four sub-sections. First is the innovation concept in detail. Second is the space and the importance of spatial dependence within terms of innovation. These two subsections are followed by the regional knowledge section which comprises the backbone of the theoretical scheme. In the last sub-section, regional innovation is discussed in detail in order to connect all terms mentioned within this chapter and provide a continuation to the following chapter.

2.1 Innovation

Innovation is a complex concept discussed from many angles in terms of regional economic growth. Innovation has multiple components that contribute to economic growth and some of them are defined in the literature as knowledge base, actors, space, and institutions. In his work, Schumpeter (1911 as cited in Cantner and Meder, 2007) suggested innovation as a third factor, the precursor of change and economic growth, in addition to labor force and capital. OECD describes innovation as the production and development of a new product or method, as well as a new marketing method, organizational approach and various regulations for workplaces (Malecki, 2013). According to Malecki (2013), innovation can be defined beyond technological development as the situation where ideas and knowledge that are formed in a place which are learned through experience and that profit is aimed to obtained by synthesizing knowledge and ideas thanks to this learning process.

As mentioned in the introduction of this chapter, innovation is defined as the economic activity that makes the most use of space. Innovation basically aims to generate economic value from different knowledge and ideas by combining them in a way that has not been done before. It can also be said that it is a form of creative expression like art. However, unlike art, the way of valuation is measured by the economic return, growth and prosperity it brings to the place, firm or society where it is created, rather than the audience's evaluation of an artistic work (Feldman and Kogler, 2010).

The feature that distinguishes innovation from the invention is that innovation is an effective and novel approach to the implementation of a product, service, or process. Product and process innovations are considered complementary processes. This is because large-scale product innovations are driven by differences in processes (Gordon and McCann, 2005). Basically, three characteristics of innovation can be mentioned. These are efforts to innovate, improve and eliminate the uncertainty. Innovation can occur thanks to the special relations between economic actors and institutions (Farias and Tatsch, 2014).

The difference between invention and innovation also emerges in the measurement methods of innovation. The Oslo Manual, another resource prepared by OECD and Eurostat (2018), which is referenced in the literature in the context of definition and measurement of innovation, evaluates a new-to-market product as evidence of innovation outcome. The Oslo Manual describes product innovation by means of a firm launching a product or service with a significant change from previous products or services. Differences such as adding a new function and improving existing functions can be given as examples of these changes. These changes are multidimensional and can occur in different stages. Examples of related functional features are improvements in quality and technical conditions, enhancements in usage, robustness and economic efficiency, and modifications in price, user experience, and convenience.

Variables such as intra-firm dynamics, inter-firm relations, and regional economic performance measures affect innovation in different ways. Although characteristics such as the size of the firm and duration of the establishment are effective on the innovative behavior of the firm, scientists and policymakers working in the field have begun to question the effect of the environment in which the firm is located on innovation (Avermaete et al., 2003).

Although the innovation output is accepted as the determinant of innovation, it is not sufficient companies to present new goods and processes to the market alone in terms of regulating innovative economic activities. In general, the geography in which the companies are located plays a major role in organizing their production activities. In addition to the economic dimension of production, geography lays the groundwork for multidimensional social relations, community, and creativity (Feldman and Kogler, 2010).

Crespi (2004) states that in determining the growth rates of an economic system (referring to Solow, 1956; Romer, 1990; Aghion and Howitt, 1992; Metcalfe, 2003), the innovative capacity of the system and its ability to imitate new technologies are accepted as main factors among economists and policymakers. Schumpeter (1939 as cited in Crespi, 2004) accepts technological change as the main factor of industrial development and argues that it includes new introductions in the fields of product, process, and management. The Schumpeterian perspective examines the technological change in three phases; “invention, innovation, and diffusion” (p.1).

Innovation is a complex and multi-layered concept, and has multiple determinants. The economics and innovation literature reached a consensus that technological development is necessary for economic growth. This consensus reveals the importance of public policymaking on innovation and technological development (Crespi, 2004). Pinto and Guerreiro (2010) compiled the evidence that the indisputable impact of innovation and technological development on economic growth in economic theories of growth accounting, new growth and the models of technological gap.

In addition to these research, looking at the history of spatial development, it is seen that the dynamics that carry the spatial economy forward are related to creating new production opportunities. It creates these production possibilities as process and product innovations within the scope of leading technological possibilities in its field, new production conditions in the context of costs and pricing, and supply factor (Storper, 2011).

In the literature, the types of innovation are discussed which indicates the best economic outcomes. The results of firm-level studies in different countries generally show that product innovations have greater economic returns (Capello and Lenzi, 2019).

The relationship among innovation and economic development is scrutinized by firm-level research. According to Freeman (1982 as cited in Blok, 2018), one of the leading theorists of innovation theory, “not to innovate is to die”. This perspective maintains its validity more than three decades later in today’s world that in a constant state of flux. Therefore, the production of innovative products and services is a challenge that firm executives still have to approach with great care (Blok, 2018).

There is academic literature that accepts knowledge, learning, and innovation as indispensable factors for the competitiveness of firms as well as for the development of regional and national economies (Tödtling and Trippl, 2011).

There are research conducted by following a firm-level approach as part of examining the effect of regional aspects on innovative outputs of firms. On the other hand, studies are carried out to measure the innovation performance of regions. But this may not be as easy as it seems. There might be problems encountered when transferring the variables used to measure innovation outputs from the firm level to the regional level. With the intention of overcoming such problems, innovation inputs and outputs should be well defined in regional innovation performance research (Brenner and Broekel, 2011).

In the literature, it is known that researchers, policymakers, and practitioners from different disciplines examine the impact of innovation on economic growth, competitiveness, and dynamism. These examinations aim to increase the economic performance of firms and regions with both theoretical and experimental methods and to reach more information about the sources and returns of innovation performance (Ganau and Grandinetti, 2021).

According to Ganau and Grandinetti (2021), in the studies in the literature, the effect of outputs on innovation capability and performance has been given more thought than the effect of inputs. What is missing in the literature is that the mechanisms constituting the innovation have not been adequately measured.

When measuring the innovation performance of a region, it should be understood that the spatial unit is not responsible for producing innovation activities. Regional innovation performance, which is the responsibility of the actors in the region, can be measured by the method of variables in which the actors are involved. The effect of space on these variables and its contribution to innovation performance can be measured empirically with different variables in different studies (Brenner and Broekel, 2011).

The variables that stimulate regional innovation are grouped as human capital, R&D studies, institutional quality and capacity, culture, and agglomeration externalities (Hauser et al., 2018).

In another research, the innovation drivers are grouped differently. Three main drivers of innovation are adressed by Brenner and Broekel (2011) as innovation generators, facilitators and attractors (see Figure 2.1). While innovation generators are described as people or community of people, facilitators are the factors that cause innovation producers within a spatial unit to function more or less efficiently. Finally, the factors that attract innovation are defined as education, geographical location, and socio-economic characteristics of a place.

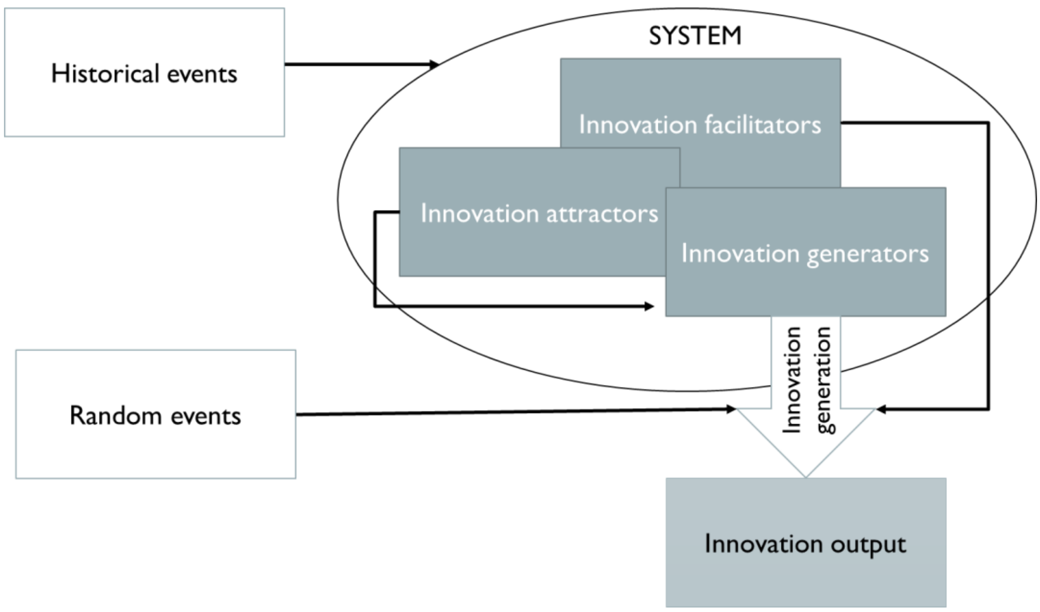

Figure 2.1. Innovation interactions

Although there is no consensus on the effect of the concept of social capital on the economy within the scope of regional innovation theory, it is widely discussed in the literature. The concept of social capital is referred to a series of customs and morals that serve in the establishment of relations between people, institutions, networks, and society. Camagni (2009, p.124) has defined social capital as a “glue” that attaches societies together.

Rather than using the concept of social capital as a direct variable in measuring regional innovation performance, it increases the effectiveness of other factors in the economic system in which it is located. For this reason, Camagni (2004 as cited in Camagni, 2009, p.125) includes social capital into the equation as “technological knowledge level”, which positively changes the effectiveness of production factors.

Camagni (2009) put forward the concept of territorial capital by progressing the theory that he called social capital (Camagni, 2004) in his previous research and which he related with the regional development theory. In his work “Territorial capital and regional development”, Camagni (2009) highlights the need for novel formulations and theories on the development paths of regions. It is of great importance that regional development strategies are individualized growth paths for each region and are specific to that region only. Camagni (2009) asserts that in company with the development of regional theories, regions should have distinct features in order to have advantages compared to the rest. For regional growth, reliance and use of local assets and capacities, which is refer to “territorial capital”, are required (Camagni, 2009, p.119). Not only based on traditional regional growth factors such as capital, labor, local assets and infrastructure, the territorial capital concept expands on local competitiveness by local trust, connection to community, creativity developed from present skilled labor in the region, connectivity, relationality, and local identity. Territorial capital categories are defined as public and private sourced goods, social, relational, human capital in the context of human agency, and R&D agencies, collaborations, private services in the construction of local networks in the context of institutions. In other words, the concept of territorial capital enables the utilization of a wide range of territorial assets such as physical, intangible, private, and public (Camagni, 2009). Camagni (2009) recapitulates the territorial capital theory by putting emphasis on the economic aspect that develops effectiveness and productivity of local actions. The territorial capital categories should be treated separately for individual impacts rather than accumulating all in order to show “technological progress” (p.129). Additionally, Camagni (2009) recommends new roles for policy-makers on facilitating collaborations between regional, interregional and international actors instead of provision of direct monetary support to well-known institutions of system such as firms, institutions of higher education, and research.

The factors in the formation of innovation have been examined in different sectors and spatial scales, and it has been observed that the variable that measures innovation output the most is the patent. Patents are accepted as a good indicator of innovation because their properties are officially registered (Autant-Bernard, 2001). The fact that enterprises of different scales such as SMEs register their inventions through patents helps them attract the investments to create radical innovations (Crespi, 2004). Patents are also important in terms of displaying the creative capacity of the economies in which they are produced and registered (Cabrer-Borras and Serrano-Domingo, 2007). Patents provide a point of view to behold the accumulated knowledge (Benner and Waldfogel, 2008). Patents reflecting the geographical intensity of R&D activities (Feldman and Kogler, 2010) are accomplished indicators of exceeding existing knowledge base (Fritsch and Slavtchev, 2011). In addition, patents that represent technological positions (Bar and Leiponen, 2012) are expressions of technological knowledge that provide comprehensive information about large-scale data (Mewes and Broekel, 2020). Patents are also accepted as an indicator of innovative activities of regions in current studies (Ascani et al., 2020).

According to Brenner and Broekel (2011) patent data provides researchers with a comprehensive database in many ways. In this database, there is information such as the technological classes, time intervals, and protection periods of the patents, and what kind of collaborations are formed in order to apply for patents. One of the most important advantages of patent data is free access to the database in many countries. In addition to these advantages, there are also disadvantages to patent data. The most important of these disadvantages is that patents contain inventions, not innovations directly. Patent applications and patenting might not be realized for all inventions though, and patent applications differ on the basis of sectors. Considering all these advantages and disadvantages, the use of patent data when measuring innovation is not considered impeccable. In order to explain the importance of the situation by means of Schmookler (1966)'s explanation, it is observed that the patent data is chosen in the absence of any data, rather than making a choice between patent data and better data sets. Looking at the studies in the literature for the last 50 years, it is seen that better data sets are still not available in most cases than the patent data. While investigating the relationship between innovation and geography, it is observed that despite all the difficulties, patent data is used to measure technological change and provides a more "unique" value than other data (Griliches, 2000, p.1702). It is possible to observe that this situation has not improved much in the last decades in the literature. Patent data is still used in most of the studies carried out in the field of regional innovation.

Widely and constantly used as an indicator of innovation in empirical studies, patent data proves that the benefits of data outweigh its shortcomings. However, when using patent data, controls must be made to achieve good empirical results (Gonçalves and Almeida, 2009; Araújo and Garcia, 2019).

2.2 Space and spatial dependency

In this subsection, the importance of both space and spatial dependence in regional innovation is scrutinized. The location choices of innovative production are directly related to economic growth and development. The effect of spatial proximity on innovative production needs to be considered in common with other types of proximity. The field of innovation geography contains wide discussion on these relationships. In this context, while discussing innovation, territorial models have been constructed, and social spaces have been included in these models in addition to space recently. These theories in the literature have been analyzed using different methods with empirical studies from different countries and regions, and inferences have been made on their results. In recent discussions, it is suggested that while establishing the relationship between innovation and space, the unique features of the place should be brought to the fore developing strategies and policies in the light of this. This section discusses all these mentioned concepts in detail.

In addition to the what, how and for whom questions about production in global economies, a fourth question of increasing importance has been asked recently: where? The importance of space in production is scrutinized in the framework of efficiency and productivity. The spaces where innovation emerges are related to the spaces that production takes place in global economies. Although the characteristics of spaces change over time, economic actors in a place are accepted as the main factor in the formation of production and innovation (Feldman and Kogler, 2010). Discussions in the literature have evolved to a ground where not only where production and innovation occur, but also the relations of a space with other spaces around it. Proximity discourse is a field in which many research has been done.

The concept of proximity and its discourse do not approach the space only in terms of physical distance. Socio-economic relations are important in proximity. In other words, space is "a socially constructed phenomenon" and prepares the ground for the construction of certain relations between actors. However, space alone is not sufficient for all types of proximity and relations (Gilly and Wallet, 2001, p.554). The proximity discourse has two dimensions: "time-geography" of entities and proximity in "a socio-cultural and institutional sense" (Malmberg and Maskell, 1997, p.29). It has been discussed that proximity provides a common organizational arrangement that facilitates knowledge exchanges in the institutional context, finally contributing to innovation (Tödtling and Trippl, 2011, p.462).

Policy makers and researchers in the field build a logical framework by focusing on the effects of different types of proximities in the process from production to innovation while reaching the conclusion that innovation creates economic growth and labor force. Proximity studies also benefit from network theory within the scope of this relationality in terms of methods applicable at actors and spatial units scales (Balland et al., 2020).

The contribution of spatial proximity to the collaboration and learning processes that lead to innovation should not be explored without including non-spatial proximity types in the analysis. This is because there is a high correlation between spatial proximity and other non-spatial proximity types. In order to explain this situation, Balland et al. (2020) support the view that spatial proximity provides an environment for other types of proximity. It has been proven by many studies that forms of proximity lead to cooperation and therefore play an important role in the creation of innovation. These studies also suggest that the deficiencies of one type of proximity are assumed to be improved by another proximity type (Davids and Frenken, 2018).

Feldman and Kogler (2010, p.384) summarize the accepted facts of geography of innovation as follows: innovation tends to spatially agglomerated; geography provides the "platform" for organizing economic dynamics; each place has different externalities; knowledge is disseminated on a local level; innovation benefits from both local and global dynamics; measuring the dissemination of knowledge is not an easy task; spaces are formed as a result of evolutionary processes.

Another view of the geography of innovation belongs to Malecki (2013). Malecki (2013) discusses the importance of innovation in economic growth and spatial aspect of innovation in various economic development processes. He defines innovation as a dynamic process, and also states that innovation causes creative destruction in various sectors and locations. He reviews the literature on innovation and refers to knowledge production function as a standard economic approach to innovation; especially the way innovative output is measured through patents, innovative inputs outcomes, and firm R&D. Malecki (2013) argues the impact of distance on the knowledge spillovers between universities, various R&D generating organizations and industries from the regional innovation perspective. He focuses on how innovation works from linear approach towards more complex recent approach. Malecki (2013) concludes that innovation is modelled as a system based on learning by geographers and evolutionary economists. This understanding shows the chaotic and highly diverse nature of innovation. Geography of innovation is under constant change due to global scale R&D and knowledge locational change which have huge impact on regions and localities. Additionally, innovation capacity is harder to accumulate since constant growth on technological complexity and availability of required knowledge in numerous places.

It is possible to observe different types of classifications in the literature in constructing the relationship of innovation with space. Two researchers explain a classification, which they named territorial innovation models, as in the following parts. In their exceptional and highly referenced work, "Territorial innovation models", Moulaert and Sekia (2003) scrutinize the different models of regional innovation which embrace local institutional aspects. Local institutional aspects are classified as human capital, local systems of education and employment, infrastructure, quality of production constituents, and learning from regional practice (p.290). The territorial innovation models are based on these different features of innovation according to the classification of Moulaert and Sekia (2003, p.291-293). The models are respectively "innovative milieu, industrial district, regional innovation systems, new industrial spaces, local production systems, and learning regions" (p.291). Innovative milieu, in basic terms, includes production, market and the support space. There is culture of trust and cooperation between the actors of the innovative milieu. Research entities such as universities, firms and public agencies play significant roles in the provision of innovative environment. Industrial districts are formed by the SMEs, and their innovative capacity stems from functioning in the same industry and local space. Sharing common values and norms within the industrial districts support innovation and development. Territorially industrial districts have both spatial solidarity and flexibility. In other words, networks formed in industrial districts both make room for cooperation and competition. Regional innovation systems aim to form interactive processes in between entities that set of research and development, and eventually innovation. Learning is key for the regional innovation systems. Individuals interactively learn from each other. New industrial spaces discourse gathers insights from many concepts i.e. industrial districts, flexible production, social regulation and local community characteristics. Most importantly, the implementation of R&D and application of new methods for production are the essence of innovation dynamics in this discourse. Local production systems have a characteristic of "an explicit artisan tradition" located in urban or rural areas. The diffusion of industrialization is the key for regional development in local production systems. It goes hand in hand with the industrial district and innovative milieu discourses. Learning regions, which emerged as the synthesis of innovation systems and evolutionary economic discourses, view learning within the scope of regional institutional characteristics. The role of institutions has stronger focus in learning regions compared to regional innovation systems (Moulaert and Sekia, 2003, p.291-293).

New concept of space is unfolded by the central approach of endogenous development theory. Space is no longer only conceptualized by its functional features but territorial ones. Space does not only support the economic functions in the primary sense but also the content of the space, such as parts of local history and socio-cultural appraisals, supports regional development. Regional economic space is living environment where individuals share common economic, cultural and historical values. Territorial space, on the other hand, stimulates frameworks for action for specific groups within the society (Moulaert and Sekia, 2003, p.297).

All in all, Moulaert and Sekia (2003) aim both to conceptualize and contextualize the territorial innovation. Moulaert and Sekia (2003, p.300) concludes that in the event of community based multi-dimensional approach to regional innovation, actors and institutions should follow "diverse but inter-culturally networked rationales" beyond the territorial innovation models and integrated area development.

In the literature, elements such as knowledge, learning, technological change, and innovation are accepted as the basic conditions of economic development, welfare, and competitiveness of spaces (Bathelt et al., 2011; Kogler et al., 2013). However, a consensus has not been reached on what type of socio-economic relations these phenomena are shaped in different spaces and scales, and how resources should be organized in order to create innovation and positive welfare results. With empirical studies, this phenomenon continues to be scrutinized in different case studies. The important point in carrying out these research is that each place has its own dynamics and the contribution of these dynamics in the formation of innovation should be evaluated in a place-based approach.

As mentioned before in the context of physical proximity, being located in a region where innovative companies are located or being close to such an innovative region supports innovation. There are studies supporting the existence of spatial dissemination and studies proving that innovative activities concentrated in one region can also benefit its neighboring regions (Araújo and Garcia, 2019). The conclusion that can be drawn from this is the importance of space, location, and spatial dependence in terms of innovation.

There are various analysis methods used in examining the relationship between innovation and space. Explaining these analysis methods here is aimed to show how these approaches shape the discourse and theoretical background. Econometric models, spatial econometric methods and analysis methods that measure spatial dependence are used in regional innovation research.

Regional innovation analysis using the output method includes space in the analysis in two ways. Space can be a ground that "attracts innovation activities" and a factor that "supports the effectiveness of innovation activities" (Brenner and Broekel, 2011, p.24). The spatial unit includes various interactions and dependencies. Thus, the innovation output of the space is assumed to be the outcome of this relationality that that place can offer for innovation performance.

When the regional innovation is scrutinized as a part of the innovation efficiency of the region, the historical process of the region is included. In the historical process, the "innovation generators" in the region, in other words, the actors in the region should not be overlooked. The contribution of these actors' innovation activities to regional innovation can be measured by the quantity and quality of the actors. The amount of R&D firms and employees working in research and development and their qualifications in terms of size, sector and experience can be given as examples of these features (Brenner and Broekel, 2011, p.24-25).

Space is considered as “a black box” in the analyses of innovation output for regions and nations. As stated in the former section, the number of patents for that place represents the innovation created. The purpose of including all variables in the space in the analysis simultaneously is to concentrate on the innovation outputs that the variables create jointly. The peculiarity of this approach is its simplicity. The final effect of the factors contained by the spatial unit on the innovation output is measured (Brenner and Broekel, 2011, p.26).

The knowledge production function is used in analyses that address regional innovation in terms of output perspective. What should be considered when using this function is the distributions and features of the variables included in the equation. Since the variables differ according to spatial characteristics, they are ought to be proportioned with other innovation-related variables and transformed by clearly specifying the rules in order to give more accurate results in the equation (Brenner and Broekel, 2011, p.30).

In analyzes where the effectiveness of regional innovation is measured, in addition to the innovation generators, a region’s “population characteristics, policy environment and policy activities” are added to the equation (Brenner and Broekel, 2011, p.30).

The common ground of the theories of endogenous growth and economic geography reveals that innovation is unevenly distributed and therefore places have different growth dynamics. This is based on the assumption that knowledge externalities have a local dimension. Knowledge externalities provide a base for economic returns concept in the understanding of technological change and growth relation. Knowledge externalities are assumed to limited to space by nature, innovation and growth show different patterns in the geography such as polarization and localization. Spatial econometric analysis approaches to spatial autocorrelation and spatial heterogeneity of innovation are used in the analysis of the economic geography of innovation. These methods are useful for quantifying the knowledge externalities, measuring its spatial extent, investigating its causes, and examining how it is affected by physical and social distances (Autant-Bernard, 2012).

In addition to econometric and spatial econometric methods, there are several methods that assess spatial dependence. These are named as Moran's I, Geary's C and Getis Ord local statistics. A special function of the research hypothesis is used for spatial autocorrelation (Getis, 2010). Spatial dependency methods are methods that provide opportunities such as spatial visualization in addition to mathematical calculations.

In Moran's I method, a covariance is constructed as a null hypothesis based on the expectation that neighboring units would not change consistently (Getis, 2010). In this method, the existence and degree of spatial agglomeration are measured, specific to the variables determined in cases where two entities share borders with each other. Inputs called contiguity weight matrices included in the analysis take the values of 1 when the spaces share borders, and 0 when they do not. Spatial clusters are displayed visually on the maps created on account of the analysis. The degree of spatial agglomeration can be interpreted as positive or negative and strong or weak according to the results of this analysis (Moreno et al., 2005). In the Global Moran's I measurement, a summary z-score is calculated to define the spatial concentration or distribution degree for each value (Scott and Janikas, 2010).

In Geary's C method, the basic assumption is that the spatial units related to each other are not different from each other. Large to small differences between neighboring spatial units are considered as irregular and prospects. Geary's C method is in negative correlation with Moran's I calculation. In other words, values less than and greater than 1 indicate positive and negative spatial autocorrelation (Getis, 2010).

Getis Ord local statistics assist researchers in seeking answers to hypotheses about spatial proximity and agglomeration. In other words, the main hypothesis of this method is that there is no association between neighboring spatial units up to the pre-determined distances. This approach is mathematically related to the global Moran's

I method. In order to avoid the bias caused by the effect of neighbors compared to the other two aforementioned methods (Moran's I and Geary's c), the distance is also included in this analysis. The case study area and distances included in the analysis should be clearly defined. Hot spots that emerge as a result of the analysis are interpreted as agglomerations or signs of spatial nonstationary (Getis, 2010). With these methods, it is possible to observe the importance of place and its influence in regional innovation research and policy-making.

Regional innovation is formed as a result of the combination of different dynamics in each place. Beyond the financial support that the state invests in regional innovation, the state should also take a part in the formation and development of linkages between stakeholders that encourage and support innovation in the region. However, instead of developing general innovation policies applicable to each region, there is a need for policies that take into account the unique problems, challenges, and opportunities called "tailor-made" for each region (Tödtling and Trippl, 2011, p.461).

The characteristics of territorial contexts in which innovation processes take place are among the reasons for the complexity in defining regional innovation capacity and performance (Ganau and Grandinetti, 2021). "One-size-fits-all" analysis methods for regional innovation are not effective given the levels of complexity and geographic heterogeneity of spaces (Farole et al., 2011 as cited in Ganau and Grandinetti, 2021, p.6).

Institutional capacity and intangible features are assets that regions have developed over time. The fact that regional innovation policies that have given the best results would not work everywhere is due to the individual characteristics that have accumulated over time in regions. Successful local solutions and policies for innovation can be developed if the endogenous dynamics, knowledge resources and networks of a region are taken into account (Asheim et al., 2011, p.900).

Place-based policy development is an area where awareness of policymakers has begun to increase in recent years. The Regional Policy Contributing to Smart Growth in Europe (EC, 2010) document published by the European Union in 2010 can be given as an example as the first official step taken in this regard. In the document, impromptu and place-based innovation policies are developed rather than the general and place-neutral policies (Capello and Lenzi, 2013, p.120).

In their policy expo named "Every place matters: toward effective place-based theory", Beer et al. (2020) scrutinize the importance of developing special approach for the needs of each and every locality. Each place has its own opportunities that bring welfare. Beer et al. (2020) classify the place-based policies as proactive and reactive ones. According to Beer et al. (2020), measures taken by local and central governments together with local institutions to respond to the socio-economic challenges in the regions and to meet the needs of regions as a whole are called place-based policies. Region, in this context, is explained as homogeneous place having similar assets of organizational, cultural and communal characteristics.

Place concept embraces individual and group motives. Since these motives are subjective, development and change differ from one place to another. The different institutional backgrounds of each place needs close attention. Institutions as the OECD emphasize the need to conduct research on underdeveloped regions, as well as the research on economically developed regions (Beer et al., 2020). Promoting innovation is accepted as the long-term success of regions or cities that both sustain existing industries and enterprises, and encourage new ones. This brings the need for creating "spaces for innovation" where people and organizations that have knowledge for innovation interconnect with each other (Beer et al., 2020, p.25). Key features of successful place-based policy have economy, timeframe, and people focuses. These policies work in a place, relate with local institutions, value governance, leadership, and local assets, focus on long-term development, advocate needs for disadvantaged people and groups (Beer et al., 2020, p.41). Although the increased need for place-based policy, this policy approach faces challenges such as resistance for sharing the power, controlling over expenditures, suffering obscurity of long-term attempts, facing both the global economic and political challenges, and "local discontent" from governmental point of view (Beer et al., 2020, p.78).

2.3 Regional knowledge

The fundamental element of innovation is the use of knowledge in different and novel ways. In this subsection, the definitions of knowledge at spatial scales and its effective role in the formation of regional innovation is discussed in detail. Likewise, the relationship of knowledge with the geography of innovation, types of knowledge, externalities that have an effect on regional knowledge generation, knowledge production function as an analysis method and the criticism of the method, and the way knowledge is scrutinized in classical and modern innovation and regional development discussions are included.

Innovation and technological development are created through complex ways of generating, distributing and applying knowledge. From an evolutionary point of view, technology is a concept in which knowledge, skills and artefacts are the basic elements. The creation of artefacts with new approaches and combinations of knowledge and skills and the creation of economic values suitable for market demands from these works are examples of technological innovations (Wolfe, 2011, p.43-4).

Knowledge inputs are linked to innovation outputs. Geography provides the basis for this connection, the generation and use of new knowledge and its transformation into innovation to create value in the market. Knowledge inputs analyzed by a method called the knowledge production function model give more favorable results in observing spatial units than isolated units as enterprises (Audretsch and Feldman, 2004). While establishing the relationship between knowledge and innovation, Schumpeter (1942) states that diversified sectoral knowledge plays a role in producing radically innovative outputs, while specialized knowledge plays a role in improving existing technologies (as cited in Feldman and Kogler, 2010).

With the research of Griliches in 1979, the knowledge production function (KPF) method began to be used in studies of investigating the determinants that cause innovative activity. Although the relation of externalities with geographical space has been established since Marshall (1920), Jaffe (1989)'s research in which he analyzed the externalities created by universities in the spatial context can be considered the first in the field. Jaffe (1989)'s approach includes that the knowledge produced in universities is a local public asset in a way and can be transferred by establishing personal relationships due to its tacit nature. It is seen that the common feature of the KPF method in the related research is to obtain evidence of knowledge spillover. However, other mechanisms causing local spillovers were only marginally included in the analyses. The fact that other mechanisms were not included in the analysis was criticized by Breschi and Lissoni (2001) in the literature, as it was adopted on the basis of the homogeneous acceptance of knowledge spillovers (Moreno et al., 2005, p.1794-5).

Basically, two types of indicators are used in the KPF method. These are called technology inputs and technology outputs. For technology inputs, variables such as R&D expenditures, employees; for technology outputs, variables such as patents and new products are used (Moreno et al., 2005). There are highlighted points to be considered when using the KPF method. According to the KPF method, all the features of a place are included in the equation as input factors. However, it is seen that this is not enough to measure the effect of the space on the generation of innovation. The most important reason for this is that it is not the places that create the innovation, but the people in those places. The effect of the space in this process should not be overlooked since it is believed to provide the environments and local conditions for people in the creation of innovation (Brenner and Broekel, 2011).

What type of knowledge is included in the method used to examine the knowledge production functions of a spatial unit? In literature, it is observed that knowledge is also divided into different categories within itself. In addition to the well-known discussions on the codified and tacit knowledge classification, there have been different classifications produced in the discourse recently. First of all, it is necessary to talk about the difference between codified and tacit knowledge. Gertler (2003 as cited in Feldman and Kogler, 2010) defined codified knowledge as technical information that can be accessed from published materials. Since codified knowledge can be easily transmitted by traditional methods, it has a widespread spatial range. On the other hand, tacit knowledge includes different characteristics of individuals. Individuals are located where variable social and institutional environments contribute to the individual's characteristics. Therefore, tacit knowledge is shared through direct contacts and that long distances create difficulties in this knowledge interchange.

The tacit knowledge is formed and disseminated as a result of the interaction between various economic entities. Examples of these entities are firms, research institutions, and public institutions (Asheim and Gertler, 2005 as cited in Malecki, 2013). Geographical proximity, which is a factor that positively increases the exchange of tacit knowledge, allows firms in the same region to interact face-to-face and cooperate with each other (Knoben and Oerlemans, 2006).

There are also new classifications of knowledge beyond the discussion of coded and tacit knowledge in the literature. Davids and Frenken (2018) argue that different knowledge bases are more dominant at different stages of production and in different departments of firms. These knowledge bases are called "analytical, synthetic and symbolic knowledge bases" (p.24). Analytical knowledge is assumed as the key point of research and development; while synthetic information allowing production and marketing units to work together; symbolic information lays the groundwork for studies in the field of sales and public relations. This new classification approach is useful in investigating the spatial logic of innovation that results from the collaboration between actors. Analytical knowledge refers to the knowledge generated by scientific research methods. Analytical knowledge is also known as "know-why". Although this type of knowledge is highly coded, there is still a need for tacit knowledge to be understood and put into practice by actors. Synthetic knowledge, defined as "know-how", is used to produce solutions for problems by using tacit knowledge, and it is associated with production and marketing as mentioned earlier. The third and last type of knowledge is symbolic knowledge, also called "know-who", which is used in the creation of cultural artifacts and value (p.25).

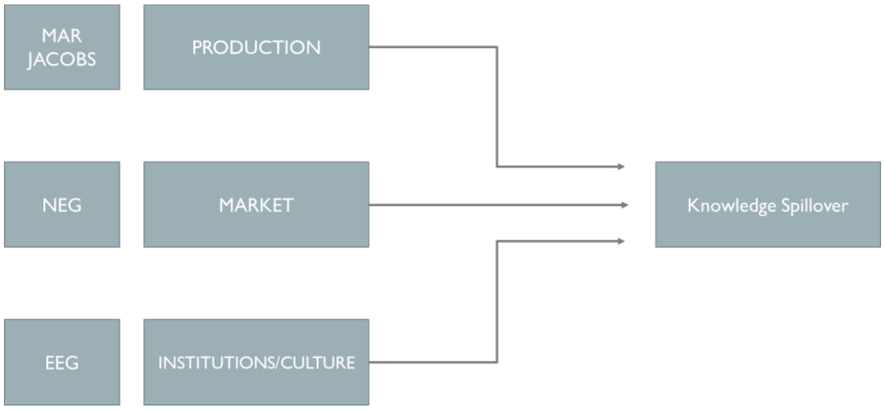

Figure 2.2. Impacts of different externalities on knowledge spillover

In chronological sense, the issue of knowledge externalities should be addressed in the literature to the research which discusses the concepts of production and space (see Figure 2.2). There is a number of research that support and/or question the theses of the other research in the field. The first group of research, namely those of Marshall (1920), Arrow (1962) and Romer (1986, 1990) (also known as MAR), argues that knowledge externalities produced by industries inclining geographical agglomeration have positive effects on innovation and economic growth. This line of research argues that the way to improve the knowledge spillovers is possible by concentrating a single industry in a particular place. One of the main arguments of this line of research is that communication and knowledge transfers are assumed to be cheaper in a single industry concentration compared to a diversified one. The second group of research by Jacobs (1969) has contradictory arguments with MAR. Jacobs argued that knowledge can only be disseminated by diversified industries and the actors working in these industries. Another group of research was conducted by Porter (1990), which agrees with the MAR group on the positive impacts of geographic concentration of industries. Nevertheless, Porter's approach differs from others since its emphasis is on the importance of competition among firms in the related industry in defining the rate of innovation. In Porter's (1998) definition of cluster, the role of local institutions in forming the ground on which the actors that create innovation interact is stressed. The part of institutions in innovation creation has been addressed in the literature that entitled national and regional innovation systems (also known as NIS and RIS) (Cooke et al. 1997, 1998). Regional innovation systems (RIS) can be defined as the interaction of companies, establishments, and institutions within a local system in the formation and development of innovation. Elements such as local institutional habits and social traditions ensure the interaction between the aforementioned actors, enabling the use of new information and increasing the use of technology. Research investigating knowledge externalities empirically can be examined under three main headings. The first approach is on the importance of knowledge spillovers from local perspective. Another is to investigate the differences in the innovation production of clustered firms compared to non-clustered firms. Finally, there are studies investigating which type of externality contributes more to innovation generation (Crespi, 2004).

As part of the national innovation systems, the national policy environment, higher education, and institutions that support innovation across the country are discussed by Furman et al. (2002) while Porter focuses on the microeconomic foundations in national innovation clusters. These foundations are defined as local input supply-demand dynamics, presence, and consistency of related industries, nature, and intensity of local competition. Furman et al. (2002) examine the variables used to measure national innovation capacity in three categories. The first category is innovation infrastructure with regards to the size of R&D employees and expenditure, the second is innovation clusters defined at the national level, and the last is the links established between the first two categories. These categories are defined as the variables to be included in the input part of the innovation generation. In the literature, the effect of these inputs on measurable innovation outputs, in other words, on the number of patents of countries is examined.

Regarding the effect of innovation on regional growth, economic theories have been developed in addition to the theories that examine the externalities of knowledge. In order of time, these can be named as the theories of new growth, new economic geography, and then evolutionary economic geography. Contrary to what was assumed in previous theories, evolutionary economic geography does not discuss knowledge externalities and diffusions only as a result of the concentration of production and actors in space. It is argued that cultural and institutional factors also affect knowledge flow. The region is not defined as an input in production function or a venue for the sake of innovation. From an evolutionary economic geography perspective, the definition of a region is made as “an active innovation agent” (Cooke et al., 2011, p.6) with traditional and geographical characteristics that cannot be simply replicated by other places (Felsenstein, 2011).

One of the concepts that has been frequently discussed in recent years within the scope of evolutionary economic geography theory is related variety. The concept of related variety reveals the situation where innovation is catalyzed as a result of the knowledge spillovers among complementary industries with low cognitive distance (Frenken et al., 2007 as cited in Feldman and Kogler, 2010). Knowledge spillover is possible only when the complementarity of the sectors is ensured in terms of sectoral competencies and capabilities. The contribution of the concept of related variety to innovation is close to Schumpeter’s definition of innovation. The reason for this connection is the acceptance of the interaction between sectors and the feedback mechanism to use old and new knowledge in totally new ways (Kline and Rosenberg, 1986 as cited in Iammarino, 2011).

The causality of knowledge resulting in innovation and innovation to economic development has been examined in the context of economic development theory (Arrow, 1966 as cited in Felsenstein, 2011). Felsenstein (2011) draws attention to the fact that information is not distributed independently and freely in every place. In some places, it is concentrated, while in others it passes by. These critical places may appear at diverse spatial extents as “cities, metropolitan areas and regions” (p.120). The regional scale is frequently encountered as an analysis unit in related research. According to Felsenstein (2011), the region does not reflect the national economy entirely, it has an independent identity and should be analyzed accordingly. At the regional and national level, universities, research centers and service companies are considered typical sources of knowledge. At these levels, tacit knowledge is disseminated through exchange among actors. Meanwhile, at the international level, it is observed that codified knowledge is exchanged more compared to the regional and national tacit knowledge sources. The contributors involved in the production and spillover of knowledge can be broadened as public research organizations, intermediary institutions for the development of technology, likewise the institutions that mediate education and employment (Tödtling and Trippl, 2011).

It is observed that the sectoral agglomerations in the region still being discussed currently and especially the relative concentrations of some sectors, which is also called “industry mix”, continue to play an important role in the knowledge production processes (Grillitsch et al., 2021, p.4). The capacity of a local economy to generate new knowledge, use new ideas and transform them into innovation, new technologies and market changes is significantly related to human capital and innovation efforts in the region (Grillitsch et al., 2021).

In order to summarize the classical and modern debates on regional growth, innovation and knowledge, while classical regional development and innovation theories focus on location and agglomerations; modern discussions scrutinize the importance of institutions and the nature of knowledge by focusing on the infrastructures that produce knowledge and the proximities that must be between the actors for learning to take place (Vatne, 2011). The path and space dependency aspects of innovation have been discussed in the fields of innovation economics and economic geography so far. There are also research focusing on the complementary role of external links in reaching new knowledge for regions (Ascani et al., 2020). Moving on to the regional innovation part, up to the final subsection of this chapter, the importance of innovation, space, and knowledge is summarized. In the regional innovation subsection that follows, it is observed that the statement of this thesis is presented with the help of the foundation provided in the previous subsections.

2.4 Regional innovation

In regional innovation, which is the last subsection of the theoretical background section, the concepts mentioned in detail in the previous subsections are assembled and summarized. In this subsection, the approaches to innovation at different scales, the importance of the regional scale, the main regional innovation theories, the relations of these theories with regional growth, regional innovation systems, the roles of institutions and actors in regional innovation, and research methods used in the analysis of regional innovation are examined (see Figure 2.3).

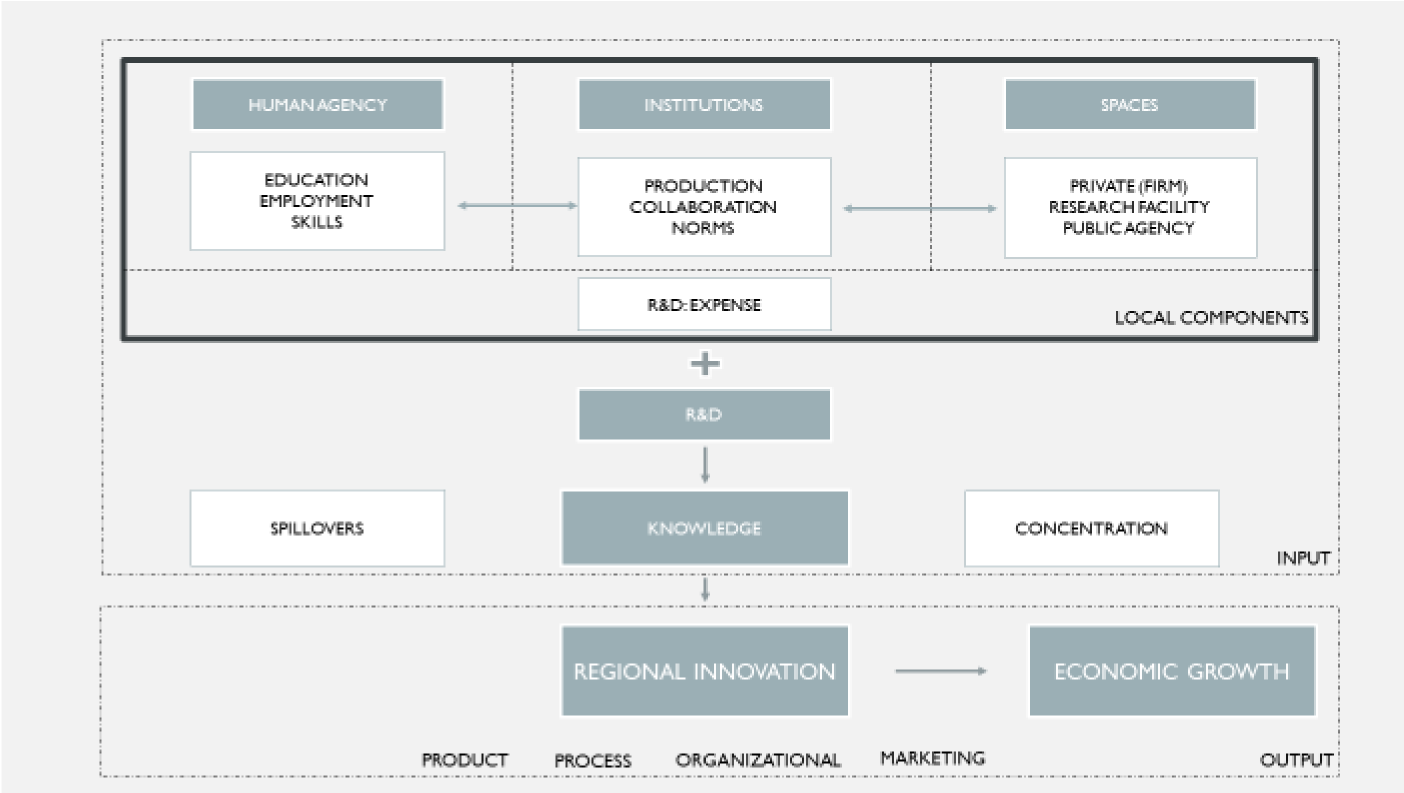

Figure 2.3. The theoretical scheme for the regional innovation

As mentioned in the previous sections, the concepts of technology, innovation, and production location behavior are included as the key elements of regional development in the recent discussions in the literature. Many research and policy approaches explore the contribution of the spaces where technologies develop and contribute to the local economic growth and the factors behind this contribution (Iammarino and McCann, 2006). Although the concepts of creative destruction, evolution, and entrepreneurship that Schumpeter coined are not aimed to describe regional innovation directly, they are frequently used by theoreticians in regional innovation and growth discussions (Asheim and Schwartz, 2011).

Regional innovation theory takes its foundations from the theories of Schumpeter and Marshall as well as from the research of regional scientists such as Hoover, Vernon, Perroux, and even Weber (Asheim and Schwartz, 2011). There are three main features that link these theorists and regional scientists within the scope of regional innovation. Asheim and Schwartz (2011) state these three features respectively as follows. The first is the argument that economic development is directly related to geography and socio-cultural proximity. The second is to investigate the nature of agglomerations and their impact on innovation in this context. The last one is the "solvent" effect of innovation on path-dependence and the importance and power of adaptation to economic evolution (p.31).

Innovation systems have begun to be analyzed at the national and technological levels, and sectoral and regional dimensions have been added to research in subsequent studies (Tödtling and Trippl, 2011). As the research expanded, overlaps and border relations between different scales have emerged. The fact that national innovation systems cross international borders indicates that countries are increasing their welfare levels by being more innovative and competitive (Malecki, 2013).

The strength, variety, and success of innovation actions are among the factors that shape the qualities of the region. These factors, on the other hand, influence the regional income and, as a result, the long-term development of the region. Since many different regional factors affect innovation, the impact of innovation on regional development is complex to analyze directly. Innovation processes differ in national, industrial, technological, and regional contexts. For this reason, all actors affecting the innovation process should be involved and analyzed. For this, factors such as institutions, inter-institutional interactions, and the innovative employment distribution in the area under analysis should be considered (Fritsch et al., 2019, p.1235). The intangible but influential element of regional development is the differences in human interactions elsewhere and the context of these differences. What is meant by context is explained as actor behaviors shaped by institutionalization and place-based factors (Storper, 2011).

The regional knowledge base includes scientific, educational, and technological knowledge. Since the innovation performance of the region depends on benefiting from this knowledge base as a result of the communication of regional actors, regional innovation emerges not only from this knowledge ground, but also from the capability of the actors in the region to benefit from and contribution to this knowledge base (Ott and Rondé, 2019). The interaction of the actors in the institutional system with each other affects the innovative performance of countries, regions, or sectors by enabling the generation and application of knowledge. The level of compatibility of these institutions with each other and their capacity to respond to sudden technological changes affect the innovative performance of the units (Wolfe, 2011).

The theoretical contribution of regional innovation systems is assumed to enhance the efficacy and success of local innovation outputs by providing a high-quality institutionalized productive environment (Ganau and Grandinetti, 2021). The regional innovation system is defined by the presence of "local, intangible, institutional, and relational resources" of the space created by actors and institutions involved in regional innovation and learning (Pinto and Guerreiro, 2010, p.317). It is argued that the setting created by regional innovation systems affects the innovation actions in the region and the innovation performance of businesses. This is because of the role of local and irreplaceable factors in the generation of innovation. Examples of these factors are local organizations, institutions, and tacit knowledge. Innovation usually occurs with a combination of both codified and tacit knowledge (Tödtling and Trippl, 2011). Factors such as organizations that produce knowledge on a regional level, educational establishments, and the structures that implement knowledge such as companies, industries and clusters constitute regional innovation systems. The quality of a regional innovation system depends on both the quality, intensity and quantity of the aforementioned factors, also, the capacity of the interactions between them (Tödtling and Trippl, 2011).

Spatial econometric analyzes used in the field of innovation geography allowing the development of models that measure the spatial dependence and heterogeneity of innovation. The main motivations of spatial econometric analyzes are on the one hand, to examine clustering of innovation and inequalities of distribution on space; on the other hand, to scrutinize spatial heterogeneity due to polarized economic activities on space (Autant-Bernard, 2012).

The linear model, which is used in innovation studies in the literature, analyzes the condition of innovation activities and factors for certain times, provides convenience in data collection, and is frequently preferred by policymakers due to its logic and simplicity. Linear models and patent data are still frequently used in regional innovation analyses (Malecki, 2013). The linear model explains the innovation processes described in previous sections in a logical sequence from the production, acquisition, and commercialization of knowledge leading towards the increase in production. Although this linear model approach has been criticized for the inconsistent nature of innovation processes, research using this approach presents innovation outcomes (Capello and Lenzi, 2013).

Capello and her colleagues have conducted comprehensive and frequently cited research in the field of regional innovation. These research, which deal with regional innovation from many aspects, have also contributed significantly to this dissertation. Extended summaries of these studies, especially those made in recent years, are included in the following parts.

Regional innovation is analyzed, classified and addressed by Capello and colleagues (Capello, 2011; Capello and Lenzi, 2013; Capello, 2017; Capello and Lenzi, 2019) throughout the years of research in the literature. The taxonomy for regional innovation developed by Capello (2011) has been amplified by the following research on the EU regions. The relations between the innovation, knowledge and space have been scrutinized from different angles. According to Capello (2011), the approaches to identify regional innovation are a sectoral and functional, a structural and a cognitive approach. She considers innovation as "the smart use of advanced knowledge" in present forms (p.107). Different levels of this advanced knowledge used are explained by some determinants. First approach, namely sectoral and functional one, presupposes the existence of state-of-the-art sectors or functions lead to innovation. There is tacit knowledge sharing and dissemination facilitated by the proximity of actors. Second approach, structural one, puts forward the existence of constituents that make a region inclined to innovation. At last, cognitive approach appraises collective learning and social integration among the region resulting in innovation.

On the other hand, Capello and Lenzi (2013, p.120-1) suggests a taxonomy not only based on the presence of various territorial features but on different innovation performances at different phases. Researchers question the validity of existing regional innovation classifications by asking questions such as: Does knowledge and innovation creation exist at the same time? Does the productivity of regions increase when there is interactive learning process existing? Are territorial conditions included when creating regional innovation taxonomies? Or are the endogenous local elements are disregarded? A "sound" taxonomy is needed for regional innovation which shifted away from mainstream typologies based only on knowledge production and disengaged to the local conditions. It is necessary to prevent innovation policies from being the same as sectoral policies and to produce comprehensive regional innovation policies by combining contextual features of regions and different innovation process phases which highlight the territorial patterns of innovation. Territorial elements alone and their combinations with innovation modes are elaborated in the scholarly work of innovation patterns from territorial perspective. Local knowledge generation and dissemination, external knowledge utilization and innovation imitation are embraced in the related literature. Three main approaches to regional innovation patterns have been introduced by Capello and Lenzi (2013). These patterns are classified as endogenous innovation, creative application, and imitative innovation. The reason this classification is suggested by Capello and Lenzi (2013, p.150) is the necessity of creating "ad-hoc policy interventions" for regional innovation. Contrary to the known classifications, Capello and Lenzi (2013) suggests a different classification method. While creating their new classification approach, they reject to equate knowledge to innovation, and to use input-output models of innovation which do not have conceptual links between their variables and lack territorial connections.

Follow-up research from Capello (2017) displays the arrangement of context conditions and performance styles of innovation. In her work, Capello (2017) makes classifications of different ways of regional innovation. Capello (2017) mainly argues that regional innovation does not follow same path in each locality. Innovation is not a single process and it has different performance stages. Capello (2017) proposes a classification for different territorial patterns of innovation, and specific conditions for each pattern. Besides only counting on the R&D activities and expenses, additional thinking is necessary for generating region-specific policies. Existing scientific contributions on the knowledge creation, knowledge spillovers and their relation to regional innovation provide a basis for Capello (2017)'s classification of regional innovation in terms of context conditions and performance modes. Capello (2017) puts the scientific theory about space, and knowledge and innovation relation in order. She aims to demonstrate how scholars approach to knowledge and innovation beginning from the end of 1960s towards today. She proposes an alternative approach to local innovation processes with keeping in mind all scientific paradigms created so far. Scholarly work in economic geography, evolutionary innovation theory, and evolutionary geography fields have common feature as appreciating only one side of innovation process. While some value specifically the knowledge creation, other takes innovation diffusion as crucial for innovation. The context conditions that characterize the region and the achievement of different stages of innovation define the territorial pattern of innovation of that specific region (Capello, 2017). The essentials that constitute the regional innovation models are intermediary actors, stages of the innovation process, local interaction for knowledge and innovation dissemination (Capello, 2017). By taking into account the different context conditions and innovation performances, Capello (2017) emphasizes three leading patterns namely endogenous innovative, creative application, and imitative innovation. Capello (2017) made this innovation comparison, taking into account the existing development levels of the regions. She includes different characteristics of the territorial innovation patterns such as knowledge or technology used within a region, region's role in the course of innovation generation, knowledge and innovation sharing and cooperation among regions, existing regional context and innovation policy aims. Regions with endogenous innovation pattern are where basic knowledge is utilized, regional dynamics are actively involved, knowledge created and metropolitan regions. These regions have territorial receptivity. On the other hand, regions show creative application pattern involve creative applications of technology, active space functioning as platforms for local actors to recombine knowledge, entrepreneurs. These regions have territorial creativity and are in general second-ranked urban regions. Third approach is the imitative innovation pattern. In such regions, region has passive role via receiving innovation from external resources. There is no invention, knowledge creation or innovation generation in such regions. These regions have territorial attractiveness and in general catching up regions. As for conclusion, Capello (2017) draws attention to specific policy and strategy making due to the fact that each region has local specificities which affect its pathway for innovation and transformation.

In their recent research Capello and Lenzi (2019) analyze the relationship between regional economic growth and regional innovation pattern evolution in the light of the previous research. The existing scholarly work contains serious findings about the regional conditions which lead to innovation. The first approach in the literature ranks the regions according to the strength and mix of knowledge and innovation activities. The second approach focuses on the importance of functional and mental elements, including informal relations between actors that support knowledge and innovation. They approach regional innovation as a relative concept. This means not classifying regions as being innovative or not as in the first approach in literature, but the point they concentrate on is the effect of the capacity of the innovation modes of the region to develop into alternative modes and become more complex over time, on the economic dynamics of the region. In conclusion, Capello and Lenzi (2019) highlights the impact of structural change of regional innovation approaches on the regional economic growth. They approach the regional innovation from a different perspective including structural changes. Greater economic returns are expected from structural changes from more complex innovation modes. More empirical inquiry is required for this theory to be widely discussed.

Regional innovation debates have gone beyond the question of whether space matters. The role of space in the innovation process is being examined from various aspects. Is space a ground that is not included in the process of innovation, or an active actor or an indispensable element? So, how does the role of the space on innovation guide the policies to be produced? It varies according to the answers to be obtained from the analyzes (Felsenstein, 2011). Beyond presenting a taxonomy or classification, within the scope of this dissertation, the aim is to measure the effects of structural and territorial variables that play a part in innovation at the regional level in Turkey.

CHAPTER 3

NATIONAL AND LOCAL SCALES OF INNOVATION IN TURKEY

After explaining how theoretical concepts are discussed in the literature within the scope of regional innovation, it is important to extend the subject by explaining the Turkish context. This chapter examines in detail how approaches to innovation and technology have been developed over time in the framework of research and policy development in Turkey. The policies developed on a national scale are analyzed historically. The actors involved in the historical process and the policy documents are analyzed. In this process, the breaking points and their relations with the national five-year development plans are stated. For the local scale part, information specific to the provinces and regions in Turkey is given. At the local level, academic research on innovation and technology in Turkey is examined. In addition, innovation policies developed by regional development agencies are analyzed and critiqued.

A framework about Turkey is outlined, which is the subject of the thesis, before moving on to the variables and methods used in measuring regional innovation. Outlining this framework is of great importance in assessing the results of the analysis and understanding the regional innovation policies that can be developed in the future based on these results.

3.1 National approach to innovation in Turkey

In the evaluation of innovation policies developed on national level in Turkey, the main focuses that have changed and developed over the years were examined. In addition to these focuses, the actors included in the policy-making, the documents, and the plans in which the policies are included should also be examined in order to understand the scope of the subject.

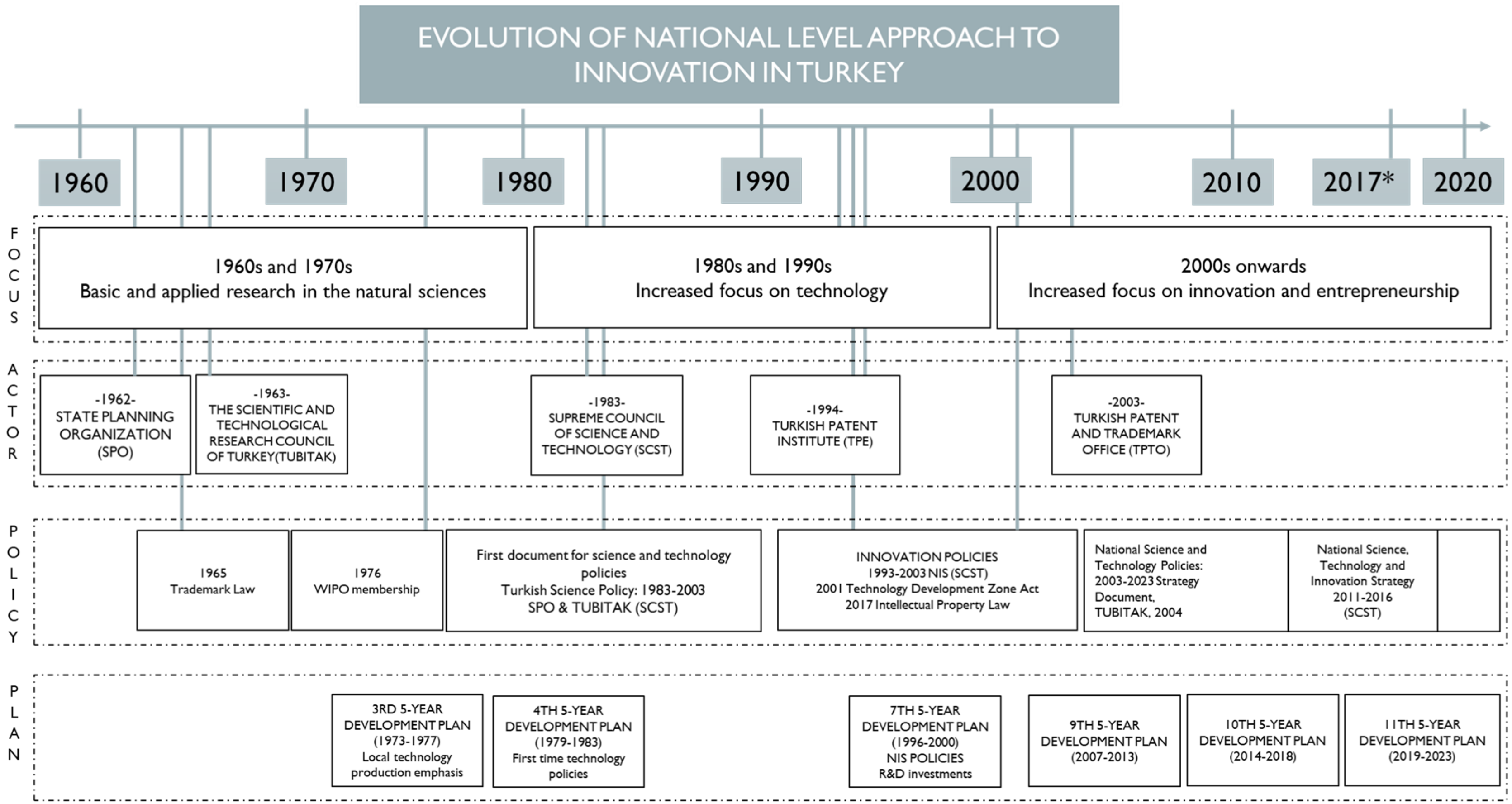

Figure 3.1. History of national approach to innovation in Turkey

Figure 3.1 can be used to provide a complete view of innovation from a historical perspective. In the 1950s, R&D investment, capital, technological intensity, and information and communication sectors' employment were considered as innovation inputs in the world. Turkey was trying to find solutions to the economically underdeveloped regions' problems at about the same time. The incentives given to the private sector were aimed to support industrialization in Turkey (Işık Maden and Kutgi, 2019).

Sat (2005) asserts that attempts in which the concepts of technology and innovation take place for the first time in the history of Turkey began with the "Planned Period" (p.88). After the State Planning Organization was established in 1962, the organization prepared the First Five-Year Development Plan comprising the years between 1963 and 1967. Within the extent of this development plan, the Scientific and Technological Research Council of Turkey (TUBITAK) was founded to direct scientific and technological endeavors throughout Turkey. In the following 2nd and 3rd development plans, technological developments and their transfers were discussed. The technology policies were mentioned for the first time in the 4th development plan. In the document of this plan covering the years 1979-1983, it was suggested that sectors should produce their own technologies and that industry, labor and investment policies should be handled together with technology policies (Sat, 2005).

In the context of legalization and institutionalization processes, important steps have been taken in Turkey in the name of innovation and technology. The Trademark Law No. 551 was accepted in 1965 in Turkey, and the brands were protected and accepted as an innovation output (Işık Maden and Kutgi, 2019). Turkey joined in the "World Intellectual Property Organization (WIPO) Establishment Agreement" in 1976. The establishment of the Turkish Patent Institute in 1994 is considered also as an important development for Turkey in terms of the protection of industrial property rights (Işık Maden and Kutgi, 2019). Another significant development is the collection of legal documents issued for trademarks, patents, designs, and geographical indications in one place in Turkey, by means of the Industrial Property Law No. 6769, which entered into force in 2017 (TPTO, 2021).

In the early 2000s, the concept of innovation have begun to come to the fore in the policies created. Studies such as innovation surveys and indices, which have been conducted and calculated in the rest of the world, have been introduced in Turkey as well. It is observed that innovation, R&D and regional development are the main goals and principles that are taken as basis in the implementation of the 9th 5-Year Development Plan for the years of 2007 to 2013 (Işık Maden and Kutgi, 2019). In the same development plan, R&D and innovation are accepted as essential elements in increasing competitiveness (Yiğit, 2018).

Various projects on science, innovation and technology are being developed under the leadership of TUBITAK. Although TUBITAK was established in 1963, the projects in the context of science, technology, and innovation developed by the institution in the national context do not coincide with this establishment period (Yiğit, 2018). In the following years, examples of the national projects are "the National Innovation Initiative (2008), the National Innovation Strategy (2008-2010), the International Science, Technology and Innovation Strategy (2007-2010) and the National Science, Technology and Innovation Strategy (2011-2016)" (Işık and Kılınç, 2012, p.187). In this context, the National Science, Technology and Innovation Strategy (2011-2016), one of the most up-to-date projects, is examined in detail.

The National Science, Technology and Innovation Strategy (2011-2016) is developed by the Supreme Council of Science and Technology (SCST). Because, SCST is the top governmental organization in Turkey led by the Prime Minister, who had the authority to decide nationwide science, innovation and technology policies (TUBITAK, 2011; Işık and Kılınç, 2012). The constituent parts that form the SCST are listed as follows in the Regulation on Duties, Working Procedures and Principles. The SCST is presided by the Prime Minister, it consists of "the relevant Minister of State, the Minister of National Defense, the Minister of Finance and Customs, the

Minister of National Education, the Minister of Health, the Minister of Agriculture, Forestry and Rural Affairs, the Minister of Industry and Trade, the Minister of Energy and Natural Resources, the President of Council of Higher Education, the Undersecretary of the State Planning Organization, the Undersecretary of Treasury and Foreign Trade, the President of the Scientific and Technological Research Council of Turkey and a deputy, the President of Turkish Atomic Energy Authority, the General Manager of Turkish Radio and Television Association, the President of the Union of Chambers and Commodity Exchanges of Turkey and a leading university related to the subject chosen by Council of Higher Education" (Supreme Council of Science and Technology Regulation, 1989). TUBITAK undertakes the secretariat services of the SCST. The main objectives of SCST are to ensure that science and technology policies are handled in a long-term manner by the state, to identify areas to be supported for R&D, to work on these areas, to establish the necessary legal framework, and to increase the interaction between the public and private sectors (Işık and Kılınç, 2012).

Before moving on to the most recent project of the Council, a brief look at its establishment and the policies it has developed in the field of innovation and technology in its history is useful for understanding the approach to these topics in Turkey. Elmacı (2015) evaluates the Turkish Science Policy, which was prepared for the years 1983-2003, document that in the document, all science and technology-related structures were examined and suggestions have been developed to eliminate the existing shortages in the systems. The purpose of these suggestions was also in line with Turkey's development goals. Policies have been built on "basic sciences, national defense, and science and research policies specific to sectors" (p.66). This science policy, in which existing problems and also potentials are well analyzed, has not been implemented. As Elmacı (2015) asserts, if the policy document was put into practice, it would be expected that Turkey would rank higher in the countries throughout the world in the sense of science and technology today. Although the Turkish Science Policy document was not put into practice, it is of great importance in that it led to the establishment of SCST and was the first official science policy of

Turkey (Türkcan, 2009, p.509). SCST convened in 1993 and prepared the Turkish Science and Technology Policy covering the years 1993 to 2003. Especially for the years 1996 and 1997, TUBITAK suggested state to develop immediate specialization and national innovation strategies (Canata, 2012). In addition to the Turkish Science and Technology Policy, the "Breakthrough in Science and Technology Project", which was implemented in 1997, was designed in line with the 7th 5-Year development plan. These efforts are considered to be the first to establish a national innovation system in Turkey. As a result of these developments, the National Science and Technology Policies document prepared by TUBITAK in 2004 covering the years 2003-2023 caused "innovation" concept to be included in Turkey's 2023 targets (Yiğit, 2018, p.138). According to Sat (2005), the SCST meeting in 1993 marked a turning point within the scope of the policies developed by Turkey in the fields of science and technology. While policies suggesting the establishment of IT infrastructure were being developed until then, policies aiming at the creation of "social welfare and added value" were started to be developed with this meeting (p.88).

According to Erdil and Pamukçu (2013), significant changes and developments in science and technology policies in Turkey since 2004 have led to various positive results. These can be named as the increase in the state supports to private sector R&D, diversification of supports according to initiatives with possible innovation potential, programming of grants according to national level priority technology areas and sectors (p.46). Improvements and developments in the fields of R&D and innovation envisaged in the National Science and Technology Policies Implementation Plan (2005-2010) made by SCST constituted the main motivation for the strategies and policies created in the following years (Erdil and Pamukçu, 2013).

In the National Science, Technology and Innovation Strategy (2011-2016), which will be examined in this section, a clearer national innovation strategy has been established compared to the National Innovation Strategy (2008-2010) made in partnership with SCST and TUBITAK. However, the importance of the National

Innovation Strategy in terms of using the international definition of innovation in Turkey and analyzing the current situation should not be disregarded (Yiğit, 2018).

The Industrial Strategy Document, prepared by the Ministry of Science, Industry, and Technology for the years 2011-2014, included both public and private sector representatives in the process in a participatory manner. A goal has been set for Turkey to be one of the leading countries in its geography in producing medium and high technology products (TUBITAK, 2012).

Figure 3.2. Diagram of functional dynamics of Main Actors of Turkey's National Innovation and Entrepreneurship System

The National Science, Technology and Innovation Strategy (2011-2016) covers the main vision, precedence and goals of the country in science, technology and innovation for a period of 6 years, accepted on 15 December 2010. A sustainable STI policy framework has been tried to be constructed for the 2023 targets for Turkey (TUBITAK, 2012). The strategic document has been prepared with the "functional dynamics approach" (Figure 3.2), which includes the basic dynamics and actors necessary for the effective functioning of R&D and innovation systems (TUBITAK, 2012, p.8). Different steps should be followed in order to realize the functional dynamic flow proposed for the national innovation and entrepreneurship system. These steps include promoting entrepreneurship, creation, and dissemination of knowledge, market formation. The actors and institutions identified as responsible for performing these steps are shown in Figure 3.3. These institutions and actors undertake different tasks according to their functions. These tasks are funding, policy-making, R&D, facilitating, and contributing to the market formation. As seen in the Figure 3.4 , it is observed that the public and private sectors are involved in R&D, while the investments are predominantly public and the policy-making is also publicly controlled. It can be said that facilitators are public and private, but the public again dominates the creation of the market.

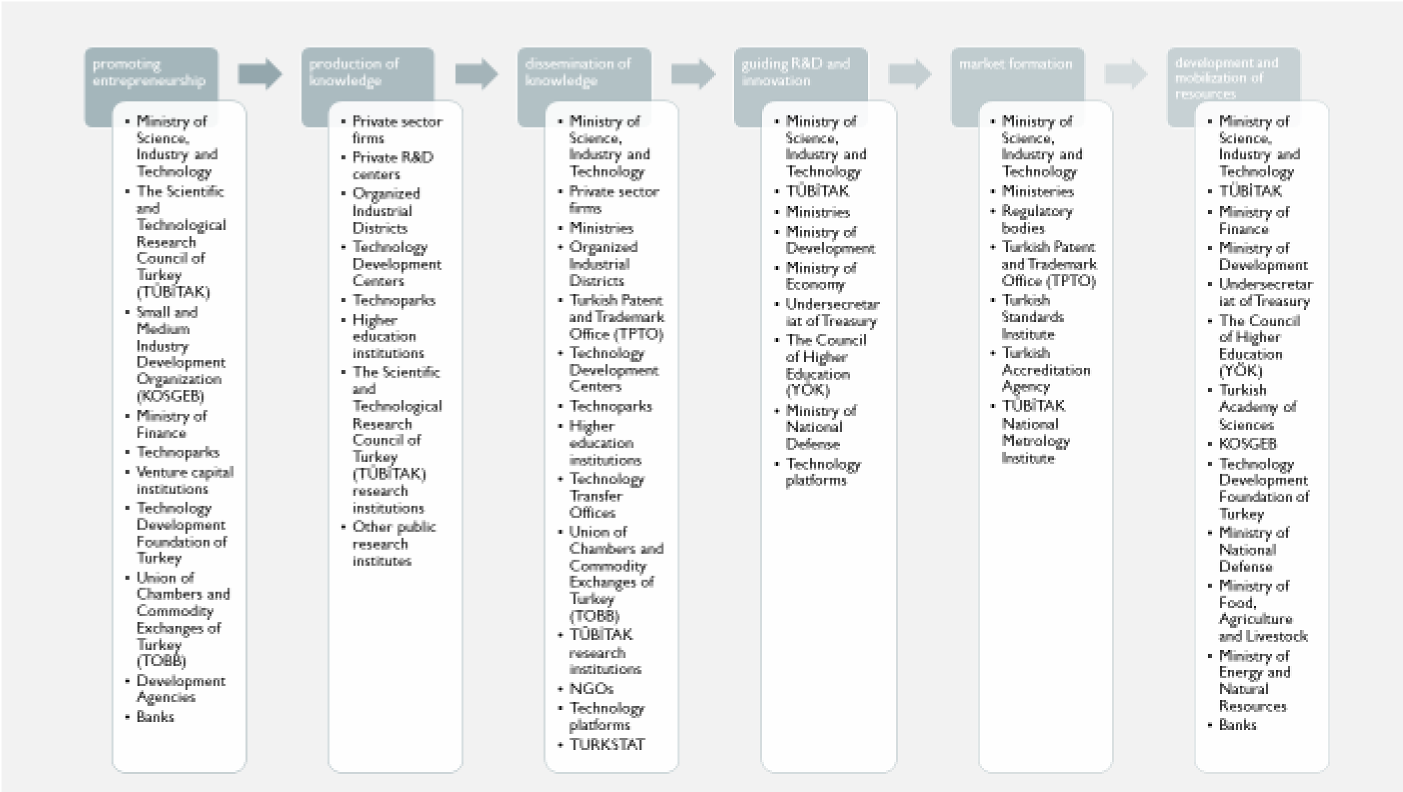

Figure 3.3. Institutions responsible for the stage specified in the national system

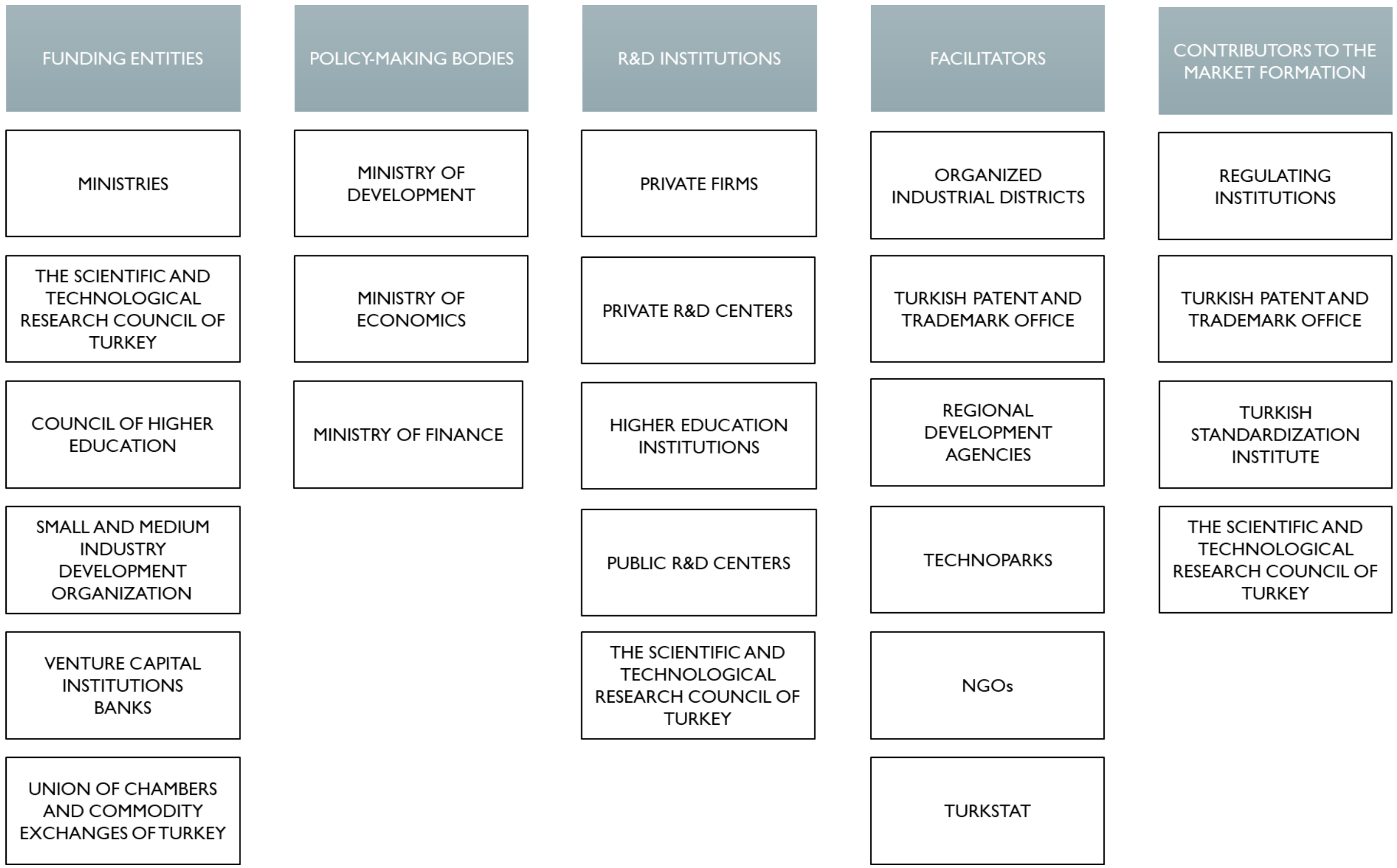

Figure 3.4. Main Actors of the National Innovation and Entrepreneurship System and their roles (TUBITAK, 2012)

Based on the results of the meetings held in 2011 and 2012 in addition to the national policies developed by SCST for the years of 2011-2016, Erdil and Pamukçu (2013) assert that Turkey's national R&D and innovation policies have evidently changed during the course of time. In their words, with these strategies developed in Turkey's R&D and innovation policies, a transition has been made from a "horizontal" perspective to a perspective focusing on "sectors" (p.4). Research and innovation have begun to take a more central place in national and regional policies, and in this context, strategic and integrated policy frameworks have begun to be drawn (Erdil and Pamukçu, 2013).

Investments in the field of R&D in Turkey have started to be made within the scope of the 7th 5-Year development plan (1996-2000) (Işık Maden and Kutgi, 2019). While SCST designs R&D policies in Turkey, its implementation is undertaken by TUBITAK, Small and Medium Enterprises Development Organization (KOSGEB), and Ministry of Industry and Technology (Belgin, 2019). In addition to these institutions, mechanisms that support R&D are classified as institutional and project-based. While institutional supports are provided by institutions for instance technology development zones and R&D centers; project-based supports are carried out in the form of different institutions and partnerships. These institutions are divided into private, public, and university sectors. While institutional supports are used as indirect grants, project-based supports are granted directly (Belgin, 2019). While it is aimed for priority sectors to benefit from support programs at the national level, Belgin (2019) observed that there is no such distinction at the regional level. It is aimed to increase the R&D capacity of the regions where technology development zones are located. As a result, Belgin (2019) explains in his study that there is no specialized R&D policy at the regional level in Turkey.

Specific attention should be paid to innovation in achieving the 2023 development and growth targets. It is expected that the changes made in the legal and management systems are expected to enrich the policy mix and implementations are to be made with new tools (Erdil and Pamukçu, 2013). In order to meet these expectations, it is necessary to update the technology and innovation policies that have been developed and are being developed on a regional scale and to take steps considering the targets and existing research and technology capacities of Turkey. In the following section, existing regional-scale policies are explained and scrutinized in the context of the thesis topic.

3.2 Local approach to innovation in Turkey

Policies and projects produced on a regional scale are examined in detail in this section. Definitions of regional scale in Turkey (NUTS 2 and NUTS 3), Turkey's situation in the computations of the European Regional Innovation Index, findings of academic studies in the field of regional innovation and institutional data produced, regional innovation system plans produced by regional development agencies, and their comparison with policies produced at the national level are examined in this section.

According to the Provincial Administration Law adopted in 1949, Turkey is divided into provinces, districts and sub-districts according to the geographical situation, economic conditions and the requirements of public services in terms of central administration. Some provinces formed, historically, even before Republic of Turkey is established (Ministry of Interior, 2018). As a result of this division, which is used for geographical and administrative purposes, 81 provinces have been formed. In 2002, Turkey started to use the regional statistical classification (Nomenclature of Units for Territorial Statistics - NUTS) used by the European Union countries. As a result of this classification, 12 NUTS 1, 26 NUTS 2, and 81 NUTS 3 regions were defined (Yıldırım et al., 2009). Over the years, with the changes in the legal frameworks (see for example Metropolitan Law No. 5216), there have been some changes in the definition and circumstances of provinces. With the Law No. 5449, 26 Regional Development Agencies were recognized for 26 NUTS 2 regions in 2006 in Turkey. Financial supports transferred by the state to regional development agencies are aimed to enhance the innovation and entrepreneurship capability of the regions, to ensure the development of the regions and to improve their competitiveness (Gömleksiz, 2012).

The Regional Innovation Scoreboard (RIS), which is the regional version of the innovation scoreboard calculated for European countries (EIS), is calculated by including a certain number of variables. RIS have indicators such as "population with tertiary education, employment medium and high tech manufacturing and knowledge-intensive services, scientific co-publications, sales of new-to-market and new-to-firm innovations, R&D expenditure public sector, public-private co-publications, innovative SMEs collaborating with others, innovation index, trademark applications, marketing or organizational innovators, design applications, non-R&D innovation expenditures, R&D expenditure business sector, product or process innovators, SMEs innovating in-house, most-cited publications, lifelong learning, and EPO patent applications" (European Commission, 2021).

In the calculation of the regional innovation index, the most recent calculation for 2021 is demonstrated for Turkey. Index calculations were not made at the regional level due to data limitations. Data is available for 30 out of 32 indicators for Turkey at national level in 2021. However, it is still beneficial to analyze Turkey at the national level in terms of the comparison with other countries and the variables used in the calculation of the index. The colors in the Figure 3.5 grouping mean: dark green "Innovation leader", light green "Strong innovator", yellow "Moderate innovator" and orange "Emerging innovator". The overall index of Turkey is 55.27 and Turkey is grouped as "Emerging innovator" as seen in Figure 3.5 (European Commission, 2021). Job-to-job mobility in Human Resources of Science and Technology, Government support for business R&D, and Broadband penetration variables are the forerunners in the calculation of the innovation score in 2021 for Turkey (see Figure 3.6). However, the decrease in innovation performance observed in 2021 in comparison to previous years is explained by the low number of initiatives providing ICT training, patent and design applications, and environment-related technologies (European Innovation Scoreboard, 2021).

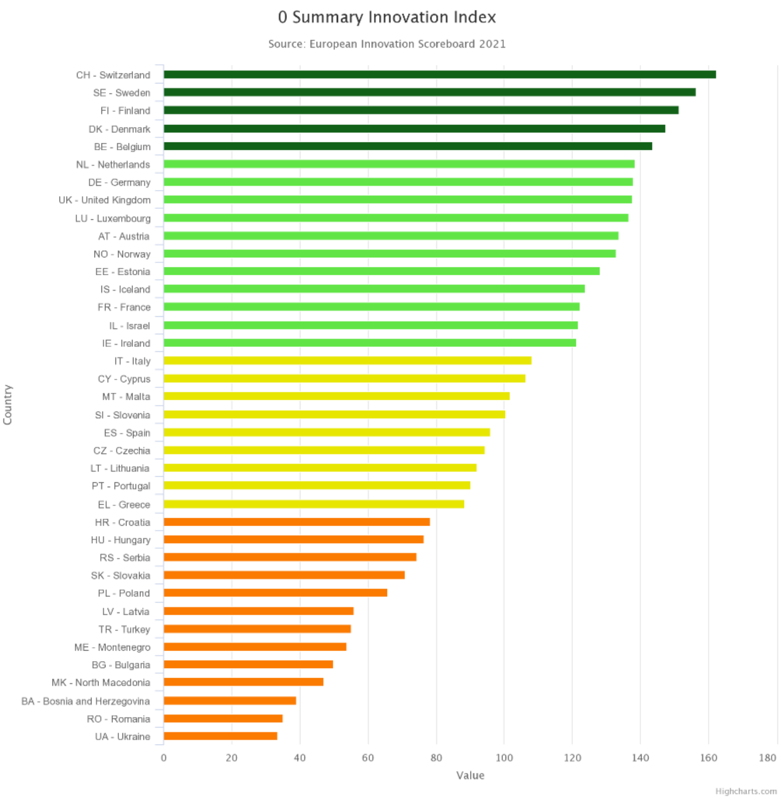

Figure 3.5. Summary innovation index for each country (European Innovation Scoreboard, 2021)

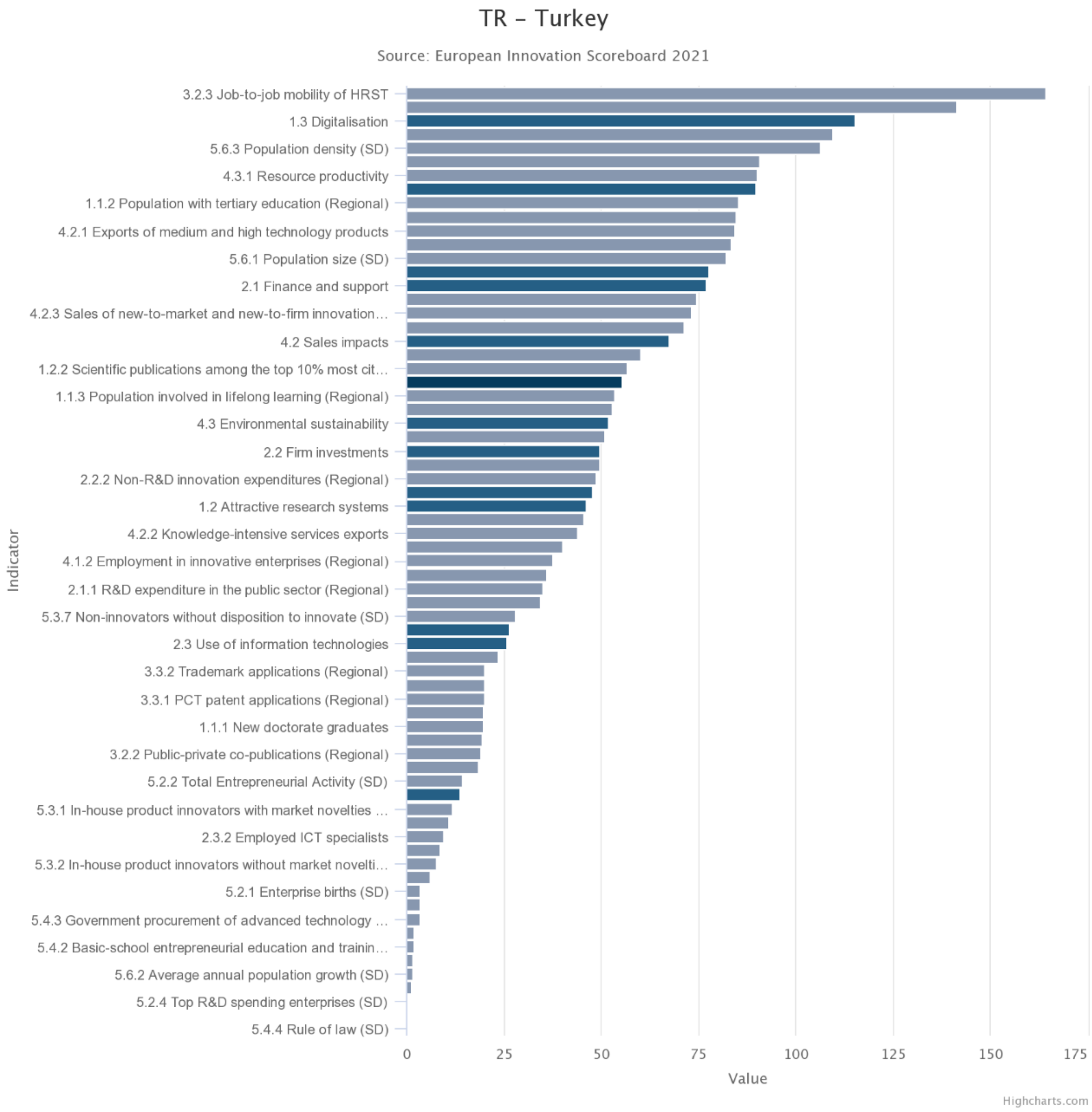

Figure 3.6. Specific index values for each variable in Turkey country profile (European Innovation Scoreboard, 2021)

In addition to the calculations that measure Turkey's innovation performance on a national scale, there is also research in the Turkish literature that tries to make sense of the relationship between innovation, technology and R&D at different scales. Research on innovation, technology, and R&D specific to Turkey are examined in detail. The Table 3.1 here is shown as an example of how the research in the literature is examined.

Table 3.1. Detailed description of innovation research in Turkey

Article	Primary explanatory mechanism	Regional division	Dependent variable	Modelling approach	Explanatory power of the models
(Akpınar et al., 2015) Innovative and Competitive Structure of Regional Economies in Turkey	Classification of regions based on technological revenues and create competitiveness and innovation index	NUTS-2 regions	Innovation and competitiveness index Biggest share= High- and medium-high-tech manufacturing revenues	Principal component analysis – innovation and competitiveness index	75.56% explained by PCA Eigenvalue= 7.55571
(Börü et al., 2020) The Effect of Technological and Scientific Knowledge on Economic Growth in Turkey (1980-2015)	Impact of science and technology on economic growth in Turkey for the period 1980 - 2015	Turkey	Gross domestic product (GDP) per capita in year t for Turkey	OLS regression Software R Autoregressive-distributed lag (ARDL) methodology	Regression results= formation of gross capital (0.17) and increase of total population (0.13) influence GDP growth rate in a positive way ARDL results= (long run) Human capital 0.83 positive impact (short run) Capital stock 0.29 and error term -0.78

Existing regional level research in Turkey offers valuable accumulation of knowledge that scrutinizes the spatial organization of industries (see Alkay and Hewings, 2012; Armatlı-Köroğlu et al., 2012; Gömleksiz, 2012; Karakayacı and Dinçer, 2012; Eraslan and Dönmez, 2017; Şahin et al., 2018; Sarı, 2018; Urhan and Sandal, 2019). Likewise, there is research in which the concept of innovation is discussed in various dimensions (see Pamukçu, 2003; Özçelik and Taymaz, 2004; Lenger, 2008; Varol et al., 2009; Karaçor and Duman, 2017; Şahin and Altuğ, 2017; Özelçi-Eceral and Çiftçi, 2018).

Nine studies from the literature (see Akpınar et al., 2015; Börü et al., 2020; Çelik et al., 2019; Çetin and Kalaycı, 2016; Gezici et al., 2017; Gezici et al., 2021; Kutgi and Işık Maden, 2020; Lenger, 2008; Şahin and Altuğ, 2017) contribute to the discussion in this thesis in examining how academic research approaches regional innovation in Turkey. Examining this research in more detail is expected to be useful in answering the research questions and understanding the analyzes done in the following chapters.

The research by Akpınar et al. (2015), which calculated the innovation and competitiveness index at the NUTS 2 level, reveals that the high and medium high technology manufacturing sectors have higher returns and contribute more to the index calculation. Innovation performance index, which is calculated for NUTS 2 regions by Kutgi and Işık Maden (2020), takes into account wide variety of determinants from human capital to scientific output. Another index research (Şahin and Altuğ, 2017) is on the calculation of the innovative specialization coefficient at the NUTS 3 level. As a result of these calculations, it has been concluded that the innovative specialization coefficients of İstanbul, Ankara, and İzmir are higher than the other provinces.

Reviewing another research, moving to the national level, the importance of technological and scientific knowledge in the increase of gross domestic product was investigated and as a result, it is revealed that the gross capital, the total change in the population, and human capital play an important role in this context for Turkey (Börü et al., 2020). Highpoint clusters of regions are defined in the research conducted at the NUTS 2 level in Turkey (Çelik et al., 2019), which takes into account the technology level and knowledge density. According to the results, high technology and medium high technology sectors in Turkey show a clustering tendency in the fields of “automotive, textile, health, and construction”. Industry in Turkey mostly consists of sectors that do not require high skills, knowledge, and development. It has been revealed that there are no regional competitive advantages due to the lack of technological development.

In NUTS 3 level research on R&D and the R&D spillover (Çetin and Kalaycı, 2016), which have an important place in the context of innovation, the location and proximity have an important impact on the R&D spillover. As a result of research (Gezici et al., 2017) examining the effect of technoparks on regional innovation, it has been concluded that the university and the technopark have a positive contribution. In reaching this conclusion, regions at the NUTS 3 level, namely provinces, were analyzed. It has been suggested that the manufacturing industry should be supported with more technology-intensive sectors for the underdeveloped regions as well as the existence of technoparks. Another research (Gezici et al., 2021) examining the clustering trends of sectors in different technologies found that credits and incentives at the NUTS 3 level positively affect the agglomeration of high and medium high technology sectors, while OIDs negatively affect them.

The research (Lenger, 2008), which examines regional innovation systems through the impact of state universities in Turkey, includes regions at NUTS 3 level, while also including legal and institutional structures. It also examines the patenting performance of regions through various factors in parallel with what this thesis explores. These elements are development zones, university-industry partnerships, and research centers.

Different institutions produce data to be used in research in the field in Turkey. At the same time, the datasets that these studies benefit from exist for a different time periods and at different levels of detail. An example of one of these datasets is Innovation Research (Yenilik Araştırması). In accordance with the Oslo Manual and Community Innovation Survey rules, TURKSTAT (2016) has been conducting an Innovation Research specific to enterprises since 1995. Since the statistical unit of the innovation research micro data set is an enterprise and does not contain province-level information, it was not included in the study. Although this data set cannot be used, it has been possible to reach different variables explaining regional innovation in accordance with the scope of the study. The types and the forms of data used in the analyses are explained in detail in the method section.

Before going into detailed explanations of the variables used in the measurement of regional innovation and the findings of empirical studies in the literature, it would be beneficial to look at the innovation strategies envisaged at the regional level in Turkey. Regional innovation strategies and plans prepared by 11 development agencies collaborating with several institutions are evaluated in terms of both their strategic and institutional dynamics and their relations with technology and innovation principles adopted at the national scale. The detailed information of the timeframe, main objectives, strategies, and the institutions expected to be involved in the process of each plan are shown in the Table 3.2.

Table 3.2. Detailed regional innovation systems plans and policies by RDAs

Policy Document	**Strategies and Institutions**
"Western Black Sea 2015-2025 Regional Innovation Strategy and Action Plan" (BAKKA)	<u>Strategies:</u> (Increase in) R&D share in regional income (%), share of private sector in R&D expenditures (%), Ratio of researchers in total employment in the region (full-time equivalent) (%), Annual domestic patent applications, Annual domestic utility model applications, Annual number of domestic industrial design applications, Number of newly established innovation-based enterprises in the Region (annual), Share of the Region in the country's exports (%). <u>Sectors:</u> Iron and Steel, Furniture, Machinery-Manufacturing-Engineering, Tourism. <u>Actors:</u> Regional Development Agency, Universities within Region, Chamber of Industry, Provincial Directorates of National Education.
"Eastern Black Sea Regional Innovation Strategy and Action Plan 2015-2017" (DOKA)	<u>Strategies:</u> Creating a Culture of Innovation, Strengthening the Regional Innovation System, Increasing Innovative Outputs. <u>Sectors:</u> Logistics, Agriculture and Food, Tourism. <u>Actors:</u> Various institutions (weak ties between stakeholders, underdeveloped awareness towards innovation).

Table 3.2. Detailed regional innovation systems plans and policies by RDAs (continued)

“South Aegean Regional Innovation and Entrepreneurship Strategy” (GEKA)	<u>Strategies:</u> South Aegean Region Innovation Capacity Development Program and Project Calls, Sustainable Innovative and Smart Region Project and Program Calls, Clusters’ calls for applications for issues that stand out in priority issues (Research, Technology Development and Innovation) for the Region, Calls to ensure the development of cooperation between clusters, Innovation Voucher Program, Innovation Cooperation Program. <u>Sectors:</u> Agriculture and Food, Textile, Tourism, Mining, Aquaculture. <u>Actors:</u> Universities, Regional Development Agency, Chamber of Commerce, Commodity Exchange, Unions.
“TRC1 Region Innovation Strategy 2017-2020” (İPEKYOLU)	<u>Strategies:</u> Developing innovation awareness, capacity and desire, Increasing accessibility to innovation support elements, Increasing cooperation among innovation ecosystem members. <u>Sectors:</u> Textiles, Machinery, Food and Agriculture. <u>Actors:</u> Local Universities, Technoparks, Technology Transfer Offices, Businessmen’s Organizations, Chambers of Commerce and Industry.
“İzmir Region Innovation Strategy” (İZKA)	<u>Strategies:</u> Stimulating research and innovation base, improving institutional composition and potential in the domain of science and technology, strengthening human sources in the realm of science and technology, promoting the patenting and advertisement of research

Table 3.2. Detailed regional innovation systems plans and policies by RDAs (continued)

	results, expediting access to finance, and developing the entrepreneurship and innovation environs. Sectors: Informatics, Biomedical Industry, Industrial Ventilation, Air Conditioning and Cooling Devices, Processed fruits and vegetables, Chemicals, Textiles, Renewable Energy and Environmental Technologies. Actors: Umbrella organizations consisting of chambers, commodity exchanges, associations, unions, federations, and OID administrations.
"East Marmara Region Innovation Strategy for Smart Specialization 2014-2018" (MARKA)	Strategies: Focusing on Priority Areas, Innovation Infrastructure, Innovation Infrastructure, Financing, Promotion and Dissemination. Sectors: Automotive and Automotive Supply Industry, Machinery, Electrical Machinery and Equipment. Actors: Universities, public institutes, technology development zones, private-sector research centers, TTO, Chambers of Commerce and Industry, Businessmen's associations, OID..
"Konya-Karaman Region Innovation Strategy Based on Smart Specialization (2014-2023)" (MEVKA)	Strategies: Developing R&D and Innovation Culture, Improving Infrastructure, Strengthening Human Capital, Strengthening Cooperation on the Basis of Smart Specialization, Increasing Access to Financial Resources. Sectors: Manufacture of food products, Manufacture of machinery and equipment n.e.c., Manufacture of motor vehicles, trailers and

Table 3.2. Detailed regional innovation systems plans and policies by RDAs (continued)

	semi-trailers, Basic metal industry, Manufacture of fabricated metal products (except for machinery and equipment), Plant and animal production and hunting and related service activities, Manufacture of chemicals and chemical products. Actors: Businesses, public institutes, NGOs and universities.
"Central Black Sea Regional Innovation Strategy (2013-2023)" (OKA)	Strategies: (Increase in) R&D expenditures' ratio in Regional GDP, Researchers' ratio in total employment in the Region (full-time equivalent), patent, utility model and industrial design application numbers (yearly), Doctoral student numbers studying science and technology in local universities, new innovation-based businesses and business enterprises (yearly), Regional income per capita (GVA), Regional total export amount, Regional unemployment rate. Sectors: Medical devices and tools, Machinery, equipment and household appliances, Agriculture and Food, Tourism, Stone and soil based industry. Actors: Innovation committees formed by stakeholders representing the private sector, public, universities and NGOs, clusters.
"Central Anatolian Development Agency TR72 Regional Innovation Strategy" (ORAN)	Strategies: Increasing the Rate of Benefiting from Supports, Facilitating Access to Finance and Improving Institutional Capacity, Increasing Cooperation between Institutions, Increasing the Level of Technology. Sectors: Furniture and other products n.e.c., Textile products, Machinery and equipment n.e.c., Electrical machinery and

Table 3.2. Detailed regional innovation systems plans and policies by RDAs (continued)

	equipment n.e.c., Metal goods industry (excluding machinery and equipment), Basic metal industry, Food products, and beverages. Actors: Interface organizations.
"TR21 Thrace Region Innovation Report" (TRAKYA)	Strategies: Developing entrepreneurship and innovation ecosystem, strengthening research and innovation infrastructure, supporting patenting and commercialization of research results. Actors: Universities, private sector, businesses.
"Zafer Development Agency TR33 Region Innovation Strategy" (ZAFER)	Strategies: Capacity building (short-term goals), Integration (medium-term goals), Innovative firm transfer (long-term goals). Actors: Universities, Ministry of Science, Industry, and Technology provincial directorate, Technology development zones, R&D centers, OID.

According to this Table 3.2, strategies, sectors and actors of the presented documents are analyzed. When each innovation policy is evaluated in the context of strategies, in general, strategies for innovation in regions aim to increase the share of the region in R&D expenditures and the number of researchers, and ultimately increase innovation output indicators such as patents and utility models. The creation of an innovation culture in the regions and the efforts to strengthen the relations between the stakeholders, which are thought to contribute to the innovation in the region, are among the remarkable elements in these policy documents. The separate utilization of grants and government supports to the region for projects that are expected to trigger innovation is among the main innovation strategies of some regions. Supporting start-ups and businesses in clustering is one of the strategies developed in the literature considering the innovation space relation in literature.

Sectors can be differentiated according to their technology intensities. When each innovation policy is evaluated in the context of sectors, the distribution of sectors targeted to be supported within the scope of innovation varies in terms of technology intensities. While it is observed that developed sectors have already been supported in different regions over the years, it is seen that the base for new sectors has been prepared. Sectoral distinction and setting support targets from different perspectives are among the strengths of these documents. However, it is also seen that most of the supported sectors are labor-intensive sectors. It is seen that the machinery manufacturing sector takes the lead among the supported sectors.

When each innovation policy is evaluated in the context of actors and stakeholders, although the envisaged plans are more detailed and region-specific in terms of strategies and sectors, the selection and functioning of the actors and institutions selected for the implementation of the strategies is not clear enough. Universities, businesses, chambers of commerce and industry, provincial directorates, and NGOs in the region are actors seen in almost all strategies. However, for example, in a certain region, associations assume a strong role in the creation of an innovation ecosystem, historically or later in the years, while in another region it might be lacking. In this respect, it is assumed to be beneficial to consider the stakeholders in each region in detail in terms of developing innovation in the region. In addition, while most documents recommend strengthening inter-institutional cooperation, few works develop detailed strategies on how to strengthen this cooperation.

A distribution in terms of functions of actors can be made and compared with national level technology policies such as Supreme Council of Science and Technology policies and national policies. While The National Science, Technology and Innovation Strategy (2011-2016) offers a perspective centered on the public, it is observed that the innovation strategies developed specifically for the regions involve the private sector and NGOs. As for conclusion, however, it is observed that public-oriented innovation strategies are not abandoned and strategies are not developed in sufficient detail in the establishment of inter-institutional relations.

After making these evaluations specific to Turkey, empirical studies on regional innovation determinants in the literature are provided in detail in the next section. Understanding the existing local capacity is beneficial in the development of place-based innovation policies.

CHAPTER 4

REGIONAL INNOVATION EMPIRICAL RESEARCH

This chapter includes the knowledge on empirical research done about regional innovation and related concepts both internationally and nationally. Mainly two subsections are included in this chapter. First of all, a detailed explanation of the regional innovation determinants are discussed under the first subsection. Then, second subsection exhibits the existing analysis methods and research models used in the literature based on the mentioned variables. In both sections, there are national and international research included. Finally, the factors included in the existing research in the literature and the important findings of these research are summarized and connected to this research. This section's aim is to examine the regional innovation literature in detail and to form the research model, which is built within the scope of the thesis, in terms of similarities and differences with the research in the literature.

Table 4.1. Empirical research variables in detail

Attributes	Level	Form of Measurement
Innovation	Input, output, capacity, success, specialization	Patent and Utility Model
Human capital	Education, employment	Tertiary education (%), HT, MHT and KIS labor (%)
Research and development	Input (expense, employment, scientific), output	R&D expenses, R&D employment, Academic personnel, publications, projects

Table 4.1. Empirical research variables in detail (continued)

Local structure	Economy, socio-economy, population, production, labor, openness	GDPPC, indeces, pop density, manufacturing employment, new enterprises (%), export, import
Externalities	Specialization, diversification, agglomeration, urbanization	Population density, Universities, OID
Spaces and institutions	Production, research and technology, bridging	OID, SMEs, Universities, RDC, TDZ, DC, NGOs

The variables examined and explained in this section are measured with different forms at different levels as shown in the Table 4.1. A general framework is drawn via including the forms of various variables related to regional innovation in the several analyses in this table. In the following sections, the variables are discussed in detail.

4.1 Regional innovation determinants

In this section, the descriptions about the regional innovation indicators (Appendix A) and analyses are included based on the mostly related scientific work. Regional innovation determinants are examined under six main sections as shown in Figure 4.1. These sections are innovation, human capital, research and development, local structure, externalities, and spaces and institutions. The innovation section describes the various dependent variables that are primarily used to measure innovation in multiple research. In the last section, variables which are used to control the rest of the variables are described.

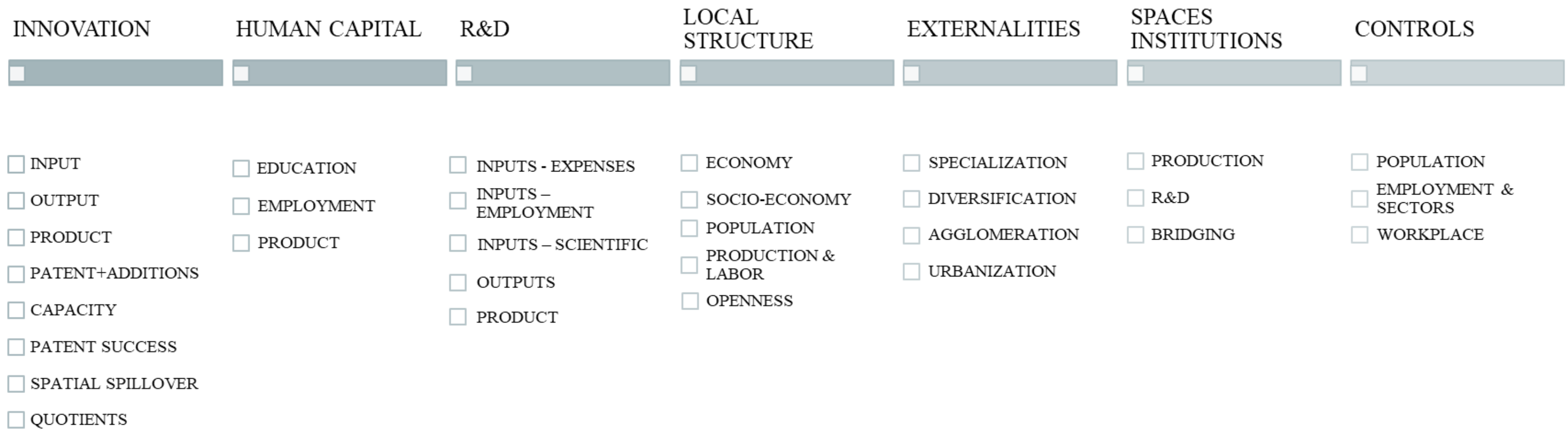

Figure 4.1. Regional innovation determinants titles and subtitles

4.1.1 Innovation

The variables used to measure innovation which the purpose of use, advantages, and disadvantages of the variables are explained in Section 2.1, are analyzed in detail in this section. In the light of the studies examined in the literature within the scope of this study, the variables are examined under eight different titles. These titles are innovation as input (patent application), as an output (patent registration), as combination of input and output, as patent and additional measurement attributes, as innovation capacity, as patent success, as spatial spillover and patent quotients.

Input as patent applications: The use of patent numbers in the measurement of innovation is a method that is generally applied in the literature. Patent applications have been transformed according to the number of people inhabiting in the region (Sternberg and Arndt, 2001; Hornych and Schwartz, 2009; Çelebioğlu, 2010; Hauser et al., 2018; Miguelez and Moreno, 2018; Gömleksiz and Özşahin, 2019; Ott and Rondé, 2019; Mewes and Broekel, 2020), the number of people employed in the region (Türkcan, 2015; Mewes and Broekel, 2020), or the economic development indicators in the region (Cabrer-Borras and Serrano-Domingo, 2007; Lopes et al., 2021) and included in the several research.

Output as patent registration: Patent registrations have been transformed according to the number of people inhabiting in the region (Furman et al., 2002; Moreno et al., 2005; Capello and Lenzi, 2013; Araújo and Garcia, 2019; Börü et al., 2020), or the technology shares of sectors (Pinto and Guerreiro, 2010) and included in the several research.

Combination of input and output: In some research, both application and registration data are used. For example, Kutgi and Işık Maden (2020) use "total number of patent and utility model application and registration per 1000 people" in order to measure innovation performance index calculation for NUTS 2 regions in Turkey.

Patent and additional measurement attributes: Besides patent applications and registrations, input such as trademark (Akpınar et al., 2015) and utility model (Gezici et al., 2021) data are used as a proxy for innovation.

Innovation capacity: Some of the methods used to measure innovation capacity can be diversified, such as including "previously registered patent numbers" (Thakur and Malecki, 2015) in the analysis or using "patent stocks" (Furman et al., 2002) owned by regions at certain time intervals.

Patent success: In one of the innovative research in the field, there is another variable called "patent success" (Çetin and Erdil, 2020), which can be explained as "the ratio of the number of patent registrations to the number of patent applications in measuring regional innovation".

Spatial spillover: The measurement of innovation under the title of spatial spillover is made by "the number of innovative firms in the functional regions" (Tavassoli and Karlsson, 2021) that are defined on "the basis of social and economic relations of spaces" or "the number of patents per capita in the neighboring regions" (Gonçalves and Almeida, 2009).

Patent quotients: Another method in measuring innovation is the calculation of innovation or technology specialization indeces. Whereas sectoral and regional ratios of the amount of patent applications are used in the calculation of "the innovation specialization index" (Şahin and Altuğ, 2017), "30 general-purpose technologies described in the international patent classification" are used in the calculation of "the technology specialization index" (Capello and Lenzi, 2013).

4.1.2 Human capital

Human capital is accounted as one of the foremost determinants of regional innovation. The different characteristics of human capital of individual regions have an impact on innovation outputs. Different aspects of human capital are discussed in

Chapter 2. Human capital determinants are scrutinized here in this section in more detail under three different titles: education, employment, and products.

Education: One of the main methods used to measure the association between the concept of human capital and innovation is education. The education variable has two dimensions: students and university associates. In terms of students, the numbers and percentages of the population living in the region and having completed their education at different levels, which are undergraduate and graduate levels, are included in the analysis; whereas the number of researchers and faculty members at university in terms of the university associates is included in the analysis. In the context of education, human capital characteristics are discussed with different variables such as "the percentage of people with tertiary education in the working population" (Sternberg and Arndt, 2001; Crescenzi et al., 2007; Gonçalves and Almeida, 2009; Capello and Lenzi, 2013; Hauser et al., 2018; Ott and Rondé, 2019; Capello and Lenzi, 2019; Gömleksiz and Özşahin, 2019; Börü et al., 2020; Kutgi and Işık Maden, 2020; Mewes and Broekel, 2020), "the number of people who have completed their graduate education" (Akpınar et al., 2015; Kutgi and Işık Maden, 2020; Ganau and Grandinetti, 2021), and "the number of people who have completed lifelong learning programs" (Oerlemans et al., 2001; Crescenzi et al., 2007; Ganau and Grandinetti, 2021). In addition to these, "the ratios of the number of faculty members and researchers working in the university" is also used to measure the human capital characteristics in the region (Gezici et al., 2017; Gezici et al., 2021).

Employment: The variables used to measure the human capital condition by examining the workforce characteristics in the region can be diversified as "the ratio of completion of undergraduate education among employees" (Cabrer-Borras and Serrano-Domingo, 2007; Crescenzi et al., 2007; Kutgi and Işık Maden, 2020; Grillitsch et al., 2021), "the ratio of employees in the fields of science and technology" (Furman et al., 2002; Capello and Lenzi, 2013; Miguelez and Moreno, 2018; Capello and Lenzi, 2019), and "the ratio of inventors" (Capello and Lenzi, 2013) among all employees.

Products: Some studies combine more than one variable in the calculation of human capital to form a product variable. For example, Ascani et al. (2020) evaluated human capital with a single variable by combining “the percentage of people who completed tertiary education, students’ regional net migration data and lifelong learning rates” with the Principal Component Analysis method.

4.1.3 Research and development

Research and development determinants are scrutinized under five different titles. These are inputs as expenses, people in form of manufacturing employment or in form of scientific employment (graduates), outputs and products.

Input – Expenses: The first group variable used to measure innovation in the framework of research and development is the expenditures used for the region as input. The most widely used research and development variable is “the share spent on R&D in regional gross domestic product” (Sternberg and Arndt, 2001; Moreno et al., 2005; Cabrer-Borras and Serrano-Domingo, 2007; Crescenzi et al., 2007; Capello and Lenzi, 2013; Malik, 2019; Ascani et al., 2020). There is research in which “R&D expenditures per capita” are used in addition to the regional share (Miguelez and Moreno, 2018). This variable is followed by “R&D expenditures for the private sector, public and higher education” (Furman et al., 2002; Hauser et al., 2018). Due to the lack of data at the relevant spatial levels, there is research using “per capita patent application” data as a proxy for R&D (Albahari et al., 2018).

Input – People and employment: Additional to R&D expenditures, “the number of R&D employees” (Pinto and Guerreiro, 2010; Fritsch and Slavtchev, 2011; Çetin and Kalaycı, 2016; Tavassoli and Karlsson, 2021) is also used in the measurement of regional innovation. “The number of people working in high and medium technology sectors in the manufacturing industry” (Hornych and Schwartz, 2009; Araújo and Garcia, 2019) is a variable that measures the R&D in the region.

Input – Scientific employment: One of the research capacity criteria for the scientific development of R&D outside of manufacturing is "the university associates in graduate programs" (Gonçalves and Almeida, 2009).

Output: Regional research and development can also be measured by looking at "scientific projects" (Kutgi and Işık Maden, 2020), "publications" (Lenger, 2008; Ott and Rondé, 2019; Börü et al., 2020) or "scientific citations" (Ganau and Grandinetti, 2021) as outputs.

Products: In the research of university R&D, there is a study in which "the number of university faculty members and graduate students" (Araújo and Garcia, 2019) is used by the method of computing variables.

4.1.4 Local structure

Local structure determinants are scrutinized under five different titles. These are economy, socio-economy, population, production and labor, and openness as including entrepreneurship, competition and innovation.

Economy: Variables such as "regional shares of gross domestic product" (Crescenzi et al., 2007), "per capita gross domestic product" (Alkay and Hewings, 2012; Albahari et al., 2018; Ganau and Grandinetti, 2021) and "gross capital formation" (Börü et al., 2020), which are generally used in evaluating the impact of local economic structure on regional innovation, are used.

Socio-economy: In addition to the local economic structure, existing indexes such as "Socio-Economic Development Index (SEGE)" (Gönül and Erkut, 2019) are also used to evaluate the social structure of the localities. In terms of innovative capacity, RYK10, RYK11 and RYK12 variables of socio-economic development index (SEGE, 2011) are in the same line with the other variables.

Population: Different perspectives of the population in the region are used to evaluate the relationship with regional innovation. These are "population density"

(Moreno et al., 2005; Fritsch and Slavtchev, 2011; Yıldırım et al., 2020; Mewes and Broekel, 2020; Grillitsch et al., 2021), "age characteristics of the population" (Crescenzi et al., 2007), "population growth rates" (Börü et al., 2020), and "regional size heterogeneity" (Ganau and Grandinetti, 2021) measured in terms of population, respectively.

Production and labor: In the discussion of the relationship between the local structure and innovation in the context of production and labor, variables such as "firm sizes" (Fritsch and Slavtchev, 2011; Gezici et al. 2021), "labor force ratios in the manufacturing industry" (Sternberg and Arndt, 2001; Miguelez and Moreno, 2018; Hauser et al., 2018; Mewes and Broekel, 2020; Grillitsch et al., 2021) and "unemployment rates" (Crescenzi et al., 2007; Gömleksiz and Özşahin, 2019; Ascani et al., 2020; Mewes and Broekel, 2020; Ganau and Grandinetti, 2021) are used.

Openness: The openness of a regional structure for entrepreneurship, competitiveness, and innovation are measured by "the opening ratios of new businesses" (Gezici et al. 2021), "the shares of exports" (Akpınar et al., 2015; Sakarya and İbişoğlu, 2015), and "the number of enterprises" (Kutgi and Işık Maden, 2020) and employees (Gezici et al., 2021; Grillitsch et al., 2021) in "high-tech manufacturing and knowledge-intensive services".

4.1.5 Externalities

Externalities determinants are scrutinized under three different titles. These are specialization and/or diversification, agglomeration and urbanization.

Specialization and/or diversification: Different types of local externalities have different effects on regional innovation. Marshall-Arrow-Romer and Jacobs externalities, which are discussed as specialization or diversification in the literature, are measured at the regional scale by using methods such as indexes. Examples of these indices are: "Krugman index, industrial specialization" (Hornych and Schwartz, 2009), "Herfindahl index" (Gonçalves and Almeida, 2009), "sectoral specialization” (Ersoy and Taylor, 2012), “regional sector specialization” (Ascani et al., 2020).

Agglomeration: Proxies are used to analyze the effects of agglomerations. There is research that looked at “the number of hospitals” (Gonçalves and Almeida, 2009) to determine the presence of agglomeration. In general, most studies include “population” (Capello and Lenzi, 2013; Hauser et al., 2018; Araújo and Garcia, 2019) and “labor density” (Ganau and Grandinetti, 2021) as proxies of agglomeration. There is some research in which “the regional GDP share” (Crescenzi et al., 2007) is used.

Urbanization: The variables used in the measurement of urbanization are “the number of universities” (Alkay and Hewings, 2012), “the ratio of the number of employees in the manufacturing and service sectors” (Fritsch and Slavtchev, 2011; Alkay and Hewings, 2012), and “the employment density” (Gonçalves and Almeida, 2009).

4.1.6 Spaces and institutions

Spaces and institutions determinants are scrutinized under three different titles. These are production, research and technology, and bridging institutions.

Production: The places where the production takes place and the institutionalization that enables the production are also defined as the variables used in the examination of regional innovation. The existence and number of spaces are used in the regional innovation literature such as “OIDs” (Gezici et al., 2017) where firms are clustered, and “SMEs” (Ganau and Grandinetti, 2021) employ less than 250 people.

Research and Technology: “The number of universities” (Oerlemans et al., 2001; Lenger, 2008; Çelebioğlu, 2010; Capello and Lenzi, 2013), “research labs” (Ersoy and Taylor, 2012), “R&D centers and departments” (Alkay and Hewings, 2012; Capello and Lenzi, 2013; Thakur and Malecki, 2015; Kutgi and Işık Maden, 2020), “technoparks”” (Gezici et al., 2021), “technology development centers and zones”

(Lenger, 2008; Kutgi and Işık Maden, 2020), "design centers" (Kutgi and Işık Maden, 2020) can be grouped as spaces and institutions that contribute to regional innovation within the scope of R&D.

Bridging institutions: In addition to production and "R&D spaces and institutions, innovation centers, private consultancy institutions, business associations" (Oerlemans et al., 2001), NGOs (Ersoy and Taylor, 2012), institutions that support science, innovation and technological developments such as "TUBITAK and KOSGEB" (Lenger, 2008) act as bridging institutions in the formation of regional innovation.

4.1.7 Controls

Since regions and provinces have different features, aforementioned variables are controlled by a number of determinants. The control variables are referred to the numbers of population, employment and sectors, and work places.

Population: Province population numbers are used in the normalization of selected variables. The reason for this is that the population ratios of metropolitan cities such as İstanbul, Ankara and İzmir are quite high. Population numbers are used as control variables so that the dependent and independent variables give statistically accurate results.

Employment and sectors: The number of workforce in technology and knowledge-intensive manufacturing and service sectors, which define the innovation used by Eurostat and OECD (Ersoy and Taylor, 2012; Akpınar et al., 2015; Gezici et al., 2017; Miguelez and Moreno, 2018; Çelik et al., 2019; Ganau and Grandinetti, 2021; Tavassoli and Karlsson, 2021; Lopes et al., 2021), is used as a control variable. In detail, Eurostat classifies sectors in the manufacturing industry as high, medium-high, medium-low and low technology-intensive, according to NACE Rev.2 2-digit economic activity divisions (see Appendix E).

Work places: The number of workplaces is included both the whole workplaces in the province and the amount of workplaces in selected sectors in the province as a control variable.

4.2 Regional innovation analyses and findings

In this section, the key findings and some recommendations of empirical studies from both the general literature and the Turkish discourse on regional innovation are discussed in detail. First, a general outline is drawn. The important topics in this general outline have been explained. More detailed explanations of the various research used for reaching the key findings and recommendations are presented in the following paragraphs in sequential order.

The Table 4.2 shows what type of inferences are made in the literature worldwide in a general outline form. It also includes the results of the research carried out in Turkey.

Table 4.2. Key topics in empirical studies

GENERAL	TURKEY
The existence and extend of innovation infrastructure (S&T policies, R&D efforts – industrial and higher education, R&D institutions, higher education supporting mechanisms, technological knowledge capacity, local university, research centers)	Unevenness between western and eastern provinces “East-West dichotomy” Eastern provinces: Low social variables, inequal technology and R&D investments, low R&D and innovation performance, low life quality and development levels
Employment characteristics (manufacturing sector employment,	Low-skilled employment characteristics

Table 4.2. Key topics in empirical studies (continued)

public and private R&D employment, labor market thickness)	
The importance of human capital	The impact of social variables and environment on human capital mobility, relation of human capital and increase in gross domestic product
The role of knowledge (certain level of knowledge, dissemination between neighboring regions, innovation enclaves)	The importance of regionally produced knowledge (universities, Technology development regions also known as Technoparks) and knowledge externalities resulting in innovative outcomes
Institutional capacity and quality (regional structural circumstances – local institutional quality, culture, institutional structural change)	Publicly funded R&D Positive impact of credits and incentives
Local dynamics (forms of production – specialization and/or diversification, urbanization, population density, industry clusters)	Special attention for specialization and innovation in Turkey Negative impact of overspecialization on regional development Existing regional specialization based on sectors without high skill and knowledge Agglomerations and clustering of sectors due to international forces and financial capital availability
Social and economic development (education, high education, life-long learning, economic development,	Economic development (The existence and support of the SMEs, local institutions and access to markets)

Table 4.2. Key topics in empirical studies (continued)

wealthy regions, gross domestic product per capita, sectoral composition, unemployment rate, demographic features)	Difficulties in transforming patents to marketable products in Turkey
Recommendations in general effective and qualified interaction between RIS actors Innovative labor allocation	Recommendations for Turkey Need for generating province-level variables and data Analysis of existing knowledge base and industrial strengths and create place-based regional industrial policies Need for better understanding of less developed regions – possible proposals of more diversified production Need for enhanced education and training for employment, university industry cooperation

Important findings of empirical research for regional innovation in general is that well developed innovation infrastructure contributes to the sustainability of regional innovation. Both the existence and extend of innovation infrastructure comprised of science and technology policies, R&D efforts from both industry and higher education, R&D institutions, higher education supporting mechanisms, technological knowledge capacity, local university and research centers paves the way for regional innovation. R&D efforts vary from employment to expenses that both are substantial for innovation generation. From employment characteristics perspective, conditions such as the amount of manufacturing sector employment, public and private R&D employment, and the thickness of labor market, have positive impact on the regional innovation. The input of human capital to innovation from different perspectives is generally addressed in the literature. In the formation of regional innovation, issues as places having a certain level of knowledge, their interactions with neighborhood units, and places functioning as innovation enclaves in some empirical research are discussed in terms of knowledge. The structural conditions of the region, the local institutional culture and the interaction between local stakeholders constitute the institutional capacity and quality of the region. While this local institutional dynamics fundamentally affect regional innovation, one of the first things that is necessary for the development of a place in terms of innovation is the change and development of the institutional structure. On the other hand, local dynamics are also formed fundamentally by the forms of production for instance specialization and/or diversification, and urbanization. Another implication from literature stresses that social and economic development determined by high education, life-long learning, regional wealth, gross domestic product per capita, sectoral composition, unemployment rate and demographic features is highly decisive in the regional innovation. In the latter part, some suggestions aimed to guide the research in the related literature are presented. It is recommended to carry out the necessary research to establish an effective and qualified interaction between the actors that contribute to regional innovation. This causes the concepts such as institutions, institutionalization, the interaction between institutions and other stakeholders in the literature to be handled from different perspectives. On the other hand, it is argued that innovative labor allocation is expected to contribute to regional innovation.

As for the important findings for Turkey as a result of the analysis of empirical academic research, the most basic result refers to the unevenness between east and west provinces. Eastern provinces have low social variables, inequal share of technology and R&D investments, low R&D and innovation performance, low life quality and development levels. In the light of the results of research examining general forms of production, it is seen that low-skilled employment is more common in Turkey. The existing clusters of economic activities do not require high skills, knowledge and development. While the positive effect of human capital on regional economic development is not disregarded, it is observed that social facility differences between provinces of Turkey lead to human capital mobility. The prominent units in the creation of regional knowledge and in the utilization of knowledge externalities, which is also directly related to human capital, are listed in some studies as local universities, technology development zones, also known as, techno-parks and SMEs. R&D expenditures in Turkey are funded principally by the public, and additional loans and incentives allocated to some regions aim to increase regional economic development and innovation. In the context of forms of production, it is argued that over-specialization in Turkish provinces has a negative impact on regional development. As there is no requirement to have high skills and knowledge for the existing specialized sectors, the outputs take shape correspondingly. There are some difficulties mentioned in transforming patents to marketable products in Turkey. This is a point that needs to be emphasized on the transformation of innovation outputs into economic gains. Some suggestions aimed to guide the research in the Turkey are presented. It is recommended to generate province-level variables and data, in order to analyze the existing knowledge base and industrial strengths and thereafter create place-based regional industrial policies. For sure, there is a grand need for better understanding of less developed regions. Diversified production, improved education and training opportunities for employment, and encouraged interaction of different institutions in regions, especially industrial agencies, and universities, are a few of the topics suggested by the research in the literature for the regions of Turkey.

Innovation is considered as an outcome of multiple components within regions. The difference between the distribution of innovation input factors and the different shares of these factors on the outcome are analyzed. Profound debates have been taken place in the literature about the quantification of innovative activity. The following part until the end of this chapter contains more comprehensive knowledge about the research on which the inferences from Table 4.2 are made.

Sternberg and Arndt (2001) scrutinize innovation behavior of firms from the perspectives of inside and outside of the firm. Not only the internal dynamics of the firm affect the firm's innovation capacity. In addition, externalities such as intraregional and extra-regional, also have an impact. Innovation behavior is measured by the number of patents, via regional level determinants such as population with university degree, percentage of the manufacturing employment, patent applications (European Patent Office) per one million inhabitants, total R&D expenses in % of regional GDP, and the EU-Index of peripherality. These regional determinants have impact on the innovative product, process and turnovers. While percentage of the manufacturing employment has positive and statistically significant impact on all three innovative outcomes (product, process and turnovers), rest of the regional determinants have significant and positive impact only on product innovation.

Furman et al. (2002) suggested that the national innovation system has three basic components. The first of these components is the innovation infrastructure of the country. The second main component is industry clusters. The third and last component is the institutions and the institutionalization capacity that establish the link between the first two components. The strength of the innovation infrastructure is measured by the science and technology policies, R&D and higher education supporting mechanisms and technological knowledge capacity of countries for developing and commodifying novel ideas. Corresponding to the Porter (1990), Furman et al. (2002) highlights the importance of microeconomic environment where decisions of investments and competitions take turns. The microeconomic environment incorporates the clustering of industries in varying fields. Additionally, the presence of local universities or support for new initiatives, for instance, establishes the link between innovation infrastructure and clusters, revealing the contribution of the third component, institutionalization, to the national innovation system. From the overall perspective of these three components, it can be concluded that local dynamics have a vital role in the formation of the national innovation system.

In the research of Crescenzi et al. (2007), both USA and EU regions (Metropolitan statistical areas and Combined statistical areas in USA, NUTS 1 and NUTS 2 regions in EU) are analyzed in terms of innovation outputs and the role of geography on these inputs. Regression models are proposed for a number of geographical variables. Additional to the regression models, spatial autocorrelation and neighboring impact on the innovation inputs are calculated. Emphasizing the socio-economic factors of local areas, “social filter” variables are included in the analysis which make a region “more innovation prone” (p.12). These variables are education, life-long learning, composition of sectors, unemployment rates and demographic characteristics. In both continents, these variables show statistically significant and positive signs. Regions with such structural features host successful regional innovation systems and have enhanced innovative performances compared to rest of the regions. One of the most important input to the innovation output is the knowledge production. This research empirically proves that both continents have different geographical approach and processes in the knowledge production and innovation output. While USA regions are “self-contained, relying on inner R&D efforts and having favorable local socio-economic environments which attract skilled people”; for EU regions “suitable local conditions, proximity to innovative areas, generating capacity to utilize knowledge dissemination from inter-regions” are much more linked to the innovation (p.29). Geographical settings have a significant place in knowledge and innovation generation, which is common to both continents.

In the research of “Innovation and R&D spillover effects in Spanish regions: A spatial approach”, Cabrer-Borras and Serrano-Domingo (2007) develops a spatio-temporal perspective for the Spanish NUTS 2 regions with regards to the innovation and R&D spillovers. The research particularly focuses on innovation activities’ determinants and the function geographical space serves on the technological knowledge distribution. Beyond looking at the spatial proximity of regions to each other, the researchers provide new perspective for dissemination of innovation and R&D with the example of Spanish regions between the years of 1989 towards 2000.

Inventions, R&D efforts and innovations are represented by different indicators as patents, patent applications, utility models or scientific publications in the literature. Referring to the research of Moreno-Serrano et al. (2005), Cabrer-Borras and Serrano-Domingo (2007) use patent applications to approximate output for regional innovation due to the fact that the process of patent application is a costly and novel process itself. They developed research models for spatial dependence and did spatial autocorrelation tests.

The results show that there is positive evidence for the spatial dependence for innovation activity among Spanish regions. When analyzing the spatial relations of innovative contiguity between productive sectors and inter-regional imports and trades, commercial proximity, in other words trade or imports between regions, is stronger compared to spatial proximity. Whereas the positive contribution of the proximity of the regions in the sharing and dissemination of knowledge is admitted, it is proved that the number of patent applications treated in the context of innovation is more correlated between the regions where commercial partnerships and supply relations are established compared to the regions with geographical neighboring (Cabrer-Borras and Serrano-Domingo, 2007). On the other hand, knowledge dissemination between regions have statistically significant and positive influence on local innovation. Public R&D efforts including high education and government, promote regional innovation. Remarkably, the impact of R&D exertions of regional trade associates on innovation have impact twice as much of endogenous regional innovative activity. A minimum level of development is a requirement for different levels of R&D utilization in the regions. In other words, economically more developed regions are more likely to benefit directly from the pile of local R&D (Cabrer-Borras and Serrano-Domingo, 2007).

As for conclusion, innovation and R&D spillovers are affected by human capital, R&D efforts within and among regions, specialization and concentration of forms of production during the years given in the research for Spain. Findings show that socio-economic development level of a region is relevant for its innovative capacity. In addition to general policies for industry, science and technology, specific policies should be created such as improving education levels, technological capacity of related industries, linking scientific research to related technological necessities. In short, for regional innovation enhancements, combinations of general and region-specific measures should be created and combined for creating innovation prone environments.

In “Regional innovation systems and the role of state: Institutional design and state universities in Turkey”, Lenger (2008) unravels the part of state in regional innovation practices with the help of state universities, laws related to regional innovation and general institutional structure in Turkey. Two main models generated by incorporating regions or centers for technology development, joint research centers of university and industry, and public universities. The research criticizes the deficiency of the established regional policy so far in Turkey. The impact of institutional structure and universities on Regional Innovation Systems (RIS) is debated. Lenger (2008) quantitatively analyzes innovation performance in Turkish regions. He puts emphasis on the existence and collaborations of public universities in the creation of regional innovation. First of all, Lenger (2008) examines the association between the number of public universities and patent numbers in regions. The correlation coefficient (0.71) result reveals a positive relationship between universities to patent numbers. Research output in this research is measure by the numbers of internationally indexed publications from medicine, science, engineering, agriculture and other disciplines. Therefore, Lenger (2008) assumes that regionally produced knowledge by universities contributes to the regional innovation. Later, he does econometric analysis to measure the quantitative effect of variables such as the number of technology development institutions and public universities, and the publications made by the public universities. Econometric analysis shows the limited positive impact of universities on patenting performance of regions. The most effective variable on patenting performance is the technology development regions, in other words, the techno parks. In following, university–industry joint research centers have less and the technology development centers have the least impact. Lenger (2008) proposes policy recommendations for the regional structures included in this research. The universities, the technology development centers and regions are forces to enable local productive dynamics to join in regional innovation systems. Therefore, regional innovation systems in Turkey could benefit from the development of such regional structures.

Çelebioğlu's (2010) research shows the spatial disparities and clusters of multiple variables for NUTS 3 regions of Turkey. Çelebioğlu (2010) presents visualizations of analysis with the help of Geographic Data Analysis Program (GeoDA). According to the previous findings from Çelebioglu and Dall'erba (2010) which is stating the significance of public investments and human capital on the regional growth in Turkish regions, Çelebioğlu (2010) builds a wider model including additional variables to inquire disparities and clusters. This inquiry utilizes spatial statistical tools to show spatial dependence in Turkish regions. The variables used in this research are public investments, patent applications, entrepreneurship numbers, electricity consumption, exports, imports per capita, and cars per thousand people, rates of net migration, unemployment, and literacy, also university degrees, and the number of hospital beds. First part of the analysis includes distributions of these variables on the provinces map of Turkey. One of the main interpretations from the distributions is that there is east-west dichotomy in Turkey based on GDP per capita, patent applications, car ownership, migration patterns, unemployment rates, literacy and education ratios. For the second part of the research, Çelebioğlu (2010) scrutinizes the random or clustered distributions of these variables on provinces in Turkey. There are randomly distributed variables such as public investments and exports per capita. The rest of the variables show clustered patterns. The data that can provide input from this research within the scope of the thesis is the data about patent applications. Patent applications in Turkish NUTS 3 regions are highly clustered nearby the "big western cities such as İstanbul, Kocaeli, Sakarya, and Bursa" (p.6), while eastern provinces show low clustered pattern. As for policy implications, Çelebioğlu (2010) suggests improved education and training opportunities for lagging provinces in order to tackle with the regional imbalances.

Fritsch and Slavtchev (2011) develop a perspective on the analysis of efficiency of regional innovation systems in 93 planning regions of Germany. They used knowledge production function and spatial distribution models for the analysis. Regional innovative output is defined by regional patent applications as a proxy. Foremost, the relation between R&D and innovative output is examined. Other explanatory variables are technological proximity, population density, service sector employment, firm size and employment shares from various engineering departments. Results show that private sector R&D employment have positive impact on the efficiency of regional innovation. Population density also have positive impact since denser population is a sign of urbanization economies in terms of increased interaction between actors. On the other hand, higher the service sector employment in a region lower the innovative output there is. Service sector have lower potential for patenting compared to manufacturing. Additionally, the firm size variable also shows similar negative relation to regional innovation. Efficiency of patenting decreases with the increase in firm sizes and higher share of large establishments. In conclusion, knowledge dissemination between public and private R&D bodies has positive influence on the regional innovation efficacy. Especially, existence of universities and research institutions enable private sector interaction in cases of similar technological research fields. Most important finding of the Fritsch and Slavtchev (2011)'s research is that what is needed to increase regional innovation efficiency is the effective and qualified interaction between the RIS elements and the explicit allocation of innovative labor.

In "The determinants of agglomeration for the manufacturing sector in the Istanbul metropolitan area", Alkay and Hewings (2012) scrutinizes the reasons of clustering by checking the forms of economies of urbanization and localization for industrial production in Istanbul metropolitan area (IMA). The case study of İstanbul is chosen due to the features of being the most inhabited cosmopolitan area in the whole nation and having the maximum surplus value city in the Turkish economy. For this research first Ellison-Glaeser index is calculated. Afterwards, a set of independent variables are chosen for explaining the variance on EGI values for industries in IMA as dependent variable. Regression models are decided based on geographical location (European or Asian side of Istanbul Metropolitan Area), sector, employee numbers, establishment year, and establishment size. Two-stage least-squares regression is employed. EGI values for European side is 0.187 and Asian side is 0.062. The closer the EGI value to one, the more concentrated the industry is.

Whereas urbanization in total IMA has more impact, localization in individually both European and Asian sides of IMA have more impact on agglomeration. Consequently, research suggests that above other determinants density, and potential for market area and labor market have the most impact on urbanization and accordingly on agglomeration for IMA case. On the other hand, labor market pooling and inputs for manufacturing have strong influence on localization in IMA. Researchers suggest that the lack of data on the measurement and analysis of knowledge spillover needs more elaboration.

In "Modelling Local and Regional Economic Development in Turkey: A 'Curate's Egg'", Ersoy and Taylor (2012) discuss the regional economic growth dynamics in Turkey by utilizing an econometric modelling approach. Ordinary Least Squares (OLS) regression analysis is conducted in order to find out the impact of several explanatory variables derived on theory on regional economic growth. Dependent variables in this analysis are employment and change of unemployment between the years of 2004 to 2008 in all Turkish provinces. Low unemployment rates show better economic regional performance according to this research. Based on the econometric analysis results, contrary to the general assumptions from the theoretical background, knowledge creation and access to information variables have negative impact on the economic growth at province level. This result needs further analysis. The existence and support of the SMEs, human capital, local institutions and access to markets are main determinants having positive impact on provincial economic growth in Turkey. Ersoy and Taylor (2012) argue that the theoretical framework underlying their analysis does not adequately explain the growth at the province level in Turkey, and suggest that researchers in the related fields develop models that focus on more local characteristics. They underline the need to analyze the development at the province level by generating variables specific to Turkey.

In "Regional determinants of research and development institutions in India", Thakur and Malecki (2015) sets up 5 different models to analyze R&D and innovation dynamics of regions in India. They utilize Statgraphics software for building Multiple Regression Models. Dependent variables are R&D expenditures, institutions and filed patents. Explanatory variables are urban population density, literacy rates, state domestic product per capita, science and technology expenditures, location, higher education institutions, and banks (p.533). One of the research issues they raise is that the determinants for regional distribution of patents. Fourth and fifth regression models are used to explain determinants impact on filed patents. For the case of Indian regions, patent distribution is greater in economically wealthy regions where R&D establishments and expenditures are higher compared to the rest. Fourth model analyzes the impact of explanatory variables on the filed patents in 1989. Amount of R&D institutions, population intensity and state domestic product per capita have positive and significant impact on the number of filed patents. Region dummy is created as value of “1” for regions located in Northwest, West, or South, while “0” for regions located in North, Central, East, and North East. The location of region has a negative impact on the patents since Northwest, West, or South parts of India is more advanced in terms of R&D intensity than North, Central, East, and North East parts. In fifth model, the impact of determinants on the filed patent during 1998 towards 1999 are examined. Like in the fourth model, number of R&D institutions have positive impact. Additionally, the higher number of filed patents in earlier years show positive impact on the patent numbers of the current years. On the other hand, corporate sector diffusion decreases the number of filed patents. Thakur and Malecki (2015) conclude that in order to maintain the technological change and innovation of the regions, more domestic product and banking opportunities in terms of economy, and the creation of higher quality educational institutions in terms of education are the reasons for encouraging investment in R&D institutions. Correspondingly, innovative activity within a region is indicated by the amount of filed patents. Based on findings, R&D promotes patents in highly populated regions and knowledge dissemination between regions. Fifth model shows signs of path-dependency of regional innovation since explanatory variables of filed patents in earlier years have positive impact on current filed patents. According to the results of this research, it can be deduced that the distribution of R&D is open to differ on the basis of size and location of places.

According to the research of Sakarya and İbişoğlu (2015), the variables that constitute socio-economic development and the explanation rates of this development index differ geographically. They conduct a geographically weighted regression model in order to reach this calculation. They find that the economic variables that explain socio-economic development at a higher rate, these disclosure rates are higher in developed provinces, and the social variables that explain development at a lower rate are higher in less developed provinces (p.235).

Türkcan (2015) analyzes the impact of knowledge externalities formed by medium-high and high-technology industries on regional total factor productivity in NUTS 2 regions in Turkey between the years of 1989 to 2008. The main assumptions of this study are the high potential of innovative outcomes from high technology industries via creating knowledge externalities, and enhanced regional economic growth produced by these externalities in the form of total factor productivity. The spatial behavior of these industries in NUTS 2 regions in Turkey is subject to this research by looking into the different type of knowledge externalities. The dependent variable is the total factor productivity (TFP) of each NUTS 2 region. TFP model is used to measure production function shifts. Within the scope of this study, regional TFP is assumed to reflect "economic progress and growth of a region" (p.6716). The explanatory variables are lined up as MAR (Marshall-Arrow-Romer), Porter, Jacobs knowledge externalities and additionally innovation density, spatial clustering. Importantly, this research adds to the discourse in two main ways. First, additionally to the existing research on the knowledge externalities in Turkish regions, this research extends the inspected time periods towards more current ones. Secondly, by including 4-digit industry codes in the research, Türkcan (2015) finds an opportunity to make more comprehensive analysis. Innovative density, one of the explanatory variables in the research, provides useful input about the regions of Turkey within the scope of this thesis. Innovative density is a estimated by "the ratio of regional patent applications to the regional employment level" multiplied by 100 (p.6717). For medium-high and high-technology industries which taken into account in this research, innovative density has positive and statistically significant impact.

Nevertheless, some industries are negatively affected by the innovative density in terms of TFP according to current and lagged values of the innovation density. For current values industries of Manufacture of paints, varnishes and lacquers, for one-year lagged values industries of Manufacture of fertilizers and pesticides and Manufacture of metal and wood working machinery show different results. For two-year lagged values, innovative density shows positive relation to all industries. As for conclusion, based on the findings, “overspecialization should be avoided in Turkey” due to the fact that specialized knowledge externalities negatively impact regional TFP (p.6726). Innovative density is one of the main determinants for regional total factor productivity, and activities that lead to patent generation should be supported in Turkey.

In their research of “Innovative and competitive structure of regional economies in Turkey”, Akpınar et al. (2015) firstly categorizes NUTS 2 level regions in Turkey for technology development levels based on returns gained from the high- and medium-high-tech manufacturing activities. Secondly, they create an innovation and competitiveness index. Principal component analysis (PCA) method is used in order to find out the weights of each variable that included in the calculation of innovation and competitiveness index scores. The variables are given with their automatically calculated weights via PCA shown in the brackets. The shares of high- and medium-high-tech manufacturing companies (35.61%) and employment (35.38%) are used to indicate technological level of industries. Banking credit ratio (35.18%) is the sign of regional economic vitality. The numbers of patent (34.85%) and trademark (34.33%) applications are the innovation indicators. Total export per capita in US dollars (34.21%) is the indicator of regional competitiveness. Masters and PhD degree ratio within 15+ age population (28.15%) is used to indicate human capital resources. Additional variables used in the research are broadband penetration ratio – ADSL per household (32.08%), urbanization rate (26.99%) and GSM subscription ratio per head (11.39%).

The scores are categorized into 7 groups for Turkish NUTS 2 regions namely “globally competitive innovation centers, regional knowledge clusters, regional competitive innovation centers, emerging innovation centers, take-off regions, promising regions, and lagging regions" (p.345). Unsurprisingly, İstanbul metropolitan region is the sole "globally competitive innovation center" in Turkey. Ankara (TR51) region is identified as "regional knowledge cluster" with the assets of R&D activities, technology development zones (TDZs), scientific publications and human capital. Following group, regional competitive innovation centers, is comprised of regions as İzmir, Bursa and Kocaeli with several industries as automotive, chemical, and shipbuilding industries. For the lagging regions, state has strategies as government incentives and the establishment of new universities with the aim of creating innovative capacity and competitiveness for these regions.

In "Spatial Econometric Analysis of R&D Spillovers in Turkey", Çetin and Kalaycı (2016) explore the impacts of R&D spillovers at province and firm level in Turkey. Knowledge and knowledge spillovers are measured by patent numbers and R&D expenditure in literature. Based on their analysis, Çetin and Kalaycı (2016, p.56) use R&D expenditures as a proxy for "knowledge stock". Researchers contribute to the literature by using spatial econometric methods for R&D spillover effects in the neighboring industrial provinces in the case of Turkey. Analysis method of spatial autocorrelation is used because only using OLS regressions might lead "insufficient and biased results" (Anselin, 1988 as cited in Çetin and Kalaycı, 2016, p.58). Variables used for the research are R&D expenditures, R&D employees, employees, foreign share, R&D subsidy amount, Pavitt sector dummies (supplier dominated, scale-intensive, specialized supplier, science based sector), seaside provinces, provinces on border, and number of airports. They take science based firms, based on the taxonomy of Pavitt (1984), as a reference class in the analysis of R&D spillover. Two generally used spatial econometric estimation models are implemented namely Spatial Autoregressive Model (SAM) and Spatial Error Model (SEM). Preliminary tests for spatial dependence such as Moran's I and Geary's C test are implemented. According to the results of these tests, R&D expenditure is found spatially autocorrelated dependent variable. As for conclusion, Çetin and Kalaycı (2016, p.66) demonstrates that "distance matters" in R&D spillovers in

Turkey. Spatial effect, measured by spatial lag model, encompasses one third of total effects on R&D spillover.

Şahin and Altuğ (2017) analyze the relation between sectoral specialization and innovative specialization. They normalize the patent application numbers by population of 10.000 people in Turkey. In order to calculate the innovative specialization, they use Hildebrand and Mace's approach. It is the ratio of patent applications of a sector in a region to the total country patent applications in that specific industry. They conduct their research for the three cities in Turkey namely İstanbul, Ankara and İzmir. Based on their findings, there are some similarities between specializations of sectors and innovation. Nevertheless, more comprehensive research is necessary in order to interpret whether there are any causalities between these specializations.

In their work of "Regional and structural analysis of the manufacturing industry in Turkey", Gezici et al. (2017) make analysis on the agglomeration of manufacturing in Turkish NUTS 3 regions (81 provinces) by their technological levels. They create both statistical and geographical models. The concentration pattern of manufacturing in 2012 is explored in the entire Turkey. They calculate a concentration index that mainly shows the 40% of total manufacturing employment concentration is in the three metropolitan regions namely İstanbul, Ankara and İzmir. These regions are geographically close to Europe continent which is advantageous for exports and market reach. By the help of Location Quotient (LQ) calculations, Gezici et al. (2017, p.214) depict the concentration tendency of neighboring provinces of metropolitan areas via "de-concentration of manufacturing". They use the Geographically Weighted Regression method in their research in order to tackle the problem of misdetection that caused by stationary ordinary regression models. A location-specific approach is implemented for Turkish provinces. Mainly two models investigate globally and locally the concentrations of aggregate, and high- and medium-high-tech manufacturing. Export, import and total bank credits have positive impact on the concentration of aggregate manufacturing employment. On the other hand, credits and incentives have positive impact on the concentration of high- and medium-high-tech manufacturing concentration. Remarkably, Organized Industrial Districts (OID) have no statistically significant impact on the high- and medium-high-tech manufacturing concentration. Location models, check for locality of variables, supports the significant impact of export, import and total bank credits for aggregate manufacturing concentration; whereas, only credits are significant for high- and medium-high-tech manufacturing concentration in Turkey. Analysis proves the spatial impact on the manufacturing concentrations and additionally highlights that "the factors of manufacturing agglomerations are dominated by neo-liberal forces (international trade and availability of financial capital)" (p.226). Although Turkey prioritize to support the increase in high-tech industry in the last decade, the share is still relatively low. Furthermore, the "well-known east–west dualism of Turkey" is present due to the different spatial dynamics of east and west provinces (p.224, 227). The current industrial activity in the west part of Turkey attract high- and medium-high-technology manufacturing, and the main motives for the emergence of new activities stem from agglomerations located in the west part. Gezici et al. (2017, p.227) suggests for further studies to look more into the "micro-foundations of a neoliberal economic system" for Turkey. By these micro-foundations, they mean the impact of international trade and financial markets on the local dynamics of manufacturing concentration in Turkey.

As mentioned before in the Regional Innovation section with a focus on actors of regional innovation, the work of Albahari et al. (2018) is important to review. They analyze the contribution of Science and Technology Parks (STPs) on the innovative performance of firms. Albahari et al. (2018) analyzes a number of variables' impact on the result of firm innovation. Firm innovation is measured by the "sales from new to the market products" (p.261). Based on the final results of this research, age of STPs influences innovation in U-shape; whereas size and management organization of STPs influence positively. The consultancy services provided by STPs have negative impact on the innovation. Interestingly, the development levels of provinces have negative impact on innovation. Closer inspection to this issue, what is important from this research that can be an input to this dissertation is that the impact of location of Science and Technology Parks (STPs) on innovation. Based on their results, STPs perform better in the less technologically developed regions that they locate. Increase in “the patent applications per million inhabitants” which reflects one of the location characteristics of STPs, results in decrease of new product sales that reflects the firm innovation. This result contradicts to the general belief in the discourse where STPs have positive role in regional development; therefore, this can be interpreted as “indirect evidence” for policy making for less technologically developed regions by STPs (p.269). According to Siegel et al. (2003 as cited in Albahari et al., 2018, p.274), STPs might have capacity to create “innovation enclaves” in such regions and tackle lack of innovation inputs. The results are still valuable addition for the development of the discourse which investigates the impacts of different regional actors on regional development and innovation.

The research of Hauser et al. (2018) analyses the relation between driving forces for innovation and innovation indicators derived from indices and related research. Existing scholarly work offers three main measurement approaches for “regional innovation intensity”. The first mostly used approach includes single indicator in order to quantify innovation. Statistics about patent and patent related data e.g. citations are used mainly in this first approach. The second approach involves multiple number of indicators to analyze regional innovation. Classifications are generated based on these indicators for countries or regions. This second approach provides identification of different systems and typologies of processes of innovation for such places. The third approach utilizes multiple indicators in the scope of generating composite indices. European, American and World innovation indices are produced according to this approach. Aim for this approach is to provide a base for policy makers to track existing innovation capacity together with potentials for future innovation (Hauser et al., 2018, p.43-4).

According to Hauser et al. (2018, p.45), solely focusing on one innovation index or innovation indicators from ranking founded methods cause information loss on innovation. They aim to provide “a qualitative impression” about this information loss. Their analysis has shown that concentrating on a sole indicator prevents a healthy estimate of the impacts of a distinguished innovation policy. The innovation indicators are goods, service, process, new-to-firm, new-to-market innovators and patent applications. On the other hand, innovation drivers are research and development, human and social capital, values, quality of governance, agglomeration dynamisms and additional RIS variables. In the analysis, all drivers and indicators of innovation are aggregated to regional level which is the interested level by the researchers. A spatial error model is used because OLS models presented significant spatial autocorrelation. Additionally, Principal Component Analysis (PCA) with Varimax rotation is utilized (p.48-49). Findings show that innovations addressed "weak" as service and process innovations are more challenging to describe by hard indicators like "patents" (p.49). In addition, there are different drivers for soft innovations and innovations in goods. One index approach shows importance of individual drivers of innovation but not necessarily the aspects for innovation. Looking all innovation indicators concurrently proves this outcome. The interpretations on the innovation should be based on both different importance and aspects of innovation drivers on innovation indicators.

Considering a large number of indicators separately helps in making a comprehensive analysis of the concept of multidimensional innovation. A single demonstration can be used to analyze innovation at a certain level. However, it would be more appropriate to consider more than one indicator in order to understand the drivers of innovation performance of a region (Hauser et al., 2018). All in all, Hauser et al. (2018) discuss the different impacts of innovation drivers on the different innovation indicators. For future research, they propose besides the stimulation of generally used innovation indices for the research interest for innovation, from technical perspective of creating innovation policies and programs, more diverse set of innovation indicators should be proposed.

In the research "An assessment of the technology level and knowledge intensity of regions in Turkey", Çelik et al. (2019) have two main aims. They want to observe the cluster patterns at national level in Turkey at first; and secondly to analyze the composition of technology and knowledge in the prominent regional clusters.

The researchers utilize the most recent input-output table dates to 2012 in order to explore the pattern of relations between industries in Turkey. The table enables researchers to interpret inter-industry linkages and to identify models of industry clusters. By identifying of these models and looking at sectoral compositions, clusters are classified according to their levels of technology and intensity of knowledge. The results of the analyses show the spatial distribution of prominent clusters in Turkey. Prominent industrial clusters are textile, automotive, food and agriculture, logistics, energy and tourism sectors in Turkey according to the research.

From the technological point of view, the study shows that high- and medium-high-tech sectors in Turkey are automotive, textile, health and construction sectoral clusters. The only high-tech sectors are in health and automotive, which are also identified as the most equipped for digital conversion through all other sectors in Turkey. Rest of the sectors include medium-low- and low-tech sectors. From the intensity of knowledge use point of view, knowledge-intensive-services sectors are energy, health, services, media, logistics, food and agriculture and tourism sectors. Energy, media, services and health sectors are identified as both high-tech and knowledge-intensive-services sectors. From the sectoral composition point of view, the most clustered regions do not have high-tech and/or knowledge-intensive-services sectors as primary sectors. This shows that "regional specialization in Turkey is largely based on industries whose technologies do not demand high skills, knowledge and sophistication" (p.968). For creating regional competitive advantage, based on this research, Turkish regions have some disadvantages. Researchers recommend some policies in order to tackle the disadvantages. Human capital development through education and the increase in support of cooperation and communications between university and industry are to be good motivations for the technological output increase in industries. Improved focus on R&D activities and collaborations between regional actors are required. For the less developed regions, according to Çelik et al. (2019), a special attention is needed to unravel the existing knowledge base and industrial strengths, and to create place-based regional industrial policies.

In their research, "Why Do Skilled People Migrate to Cities? A Spatial Econometric Analysis for Understanding the Impact of the Social Environment on the Attraction of Human Capital to Cities in Turkey", Gönül and Erkut (2019) focuses on the social mechanisms in urban areas which are responsible for attracting human capital. Mainly theories of relocation of human capital and attraction of urban areas are scrutinized. Gönül and Erkut (2019) finds that relocating human capital, which are composed of undergraduate and post-graduate people, keep social environments forefront. They find a gap in the literature about developing a spatial approach; therefore, they focus on the neighboring impact of social mechanisms on the human capital migration. Human capital migration is analyzed by a number of independent variables which are socio-economic development index, cultural diversity, population growth pace, citizen's participation in social, cultural and art events. OLS regression model shows the positive impact of socio-economic development index and participation to fairs on human capital migration. Following spatial autocorrelation model results show the spatial dependency of human capital migration up to 72%. Researchers explain that the lambda and coefficient values, are withdrew from the spatial model, show "province choices of human capital are affected by the level of social environment variables in the neighboring locations" (p.145). As conclusion, researchers suggests policy makers to develop "regional and relational approach" when creating regional policies by taking into account the neighboring regions (p.145).

Belgin and Apaydın Avşar (2019) measure R&D and innovation performance of Turkey at 3 different NUTS levels namely 1, 2 and 3. They utilize Grey Relational Analysis, that is a multi-criteria decision-making method, in order to reach performance results for each spatial level. These performance results deliver the existing R&D and innovation potentials and help for supporting the future development. For their analysis, Belgin and Apaydın Avşar (2019) have 5 main categories namely human capital, R&D and innovation substructure, scientific research efficiency, R&D competence and public university industry collaboration, and commercialization. For R&D and innovation substructure, they use variables as

R&D centers, TDZs, R&D employees that work in R&D centers and TDZs, and R&D expenditure. Analysis results show for all categories west part of Turkey take the lead. By little differences cities as İstanbul, Ankara, İzmir, Bursa and Kocaeli dominate the analysis by their R&D and innovation performances. Eastern and Southeastern provinces show low performance in R&D and innovation.

Araújo and Garcia (2019) aim to provide empirical evidence for innovation and geography relation in specific to Brazilian regions within the context of developing countries. They focus on the elements and spatial dependency of regional innovation in Brazil. The existing studies about Brazil show regional innovation concentration in "South and Southeast regions" (p.379). These regions have higher numbers of people, GDP per capita and educated work force compared to other regions in Brazil. In order to measure the regional innovation, patent numbers are used as a proxy deriving from literature. Explanatory variables as knowledge accumulation, local R&D capacity, geographical proximity, spillovers, specialization, diversification dynamics are subjected to their models. Additional to the generally used knowledge production function, Araújo and Garcia (2019, p.383) added spatial dependency models to the analysis. They performed a Spatial Tobit Model in order to tackle with "high proportion of zero-patent regions", which distort the analysis results. According to their results, local R&D efforts that both from industrial and higher educational perspectives are vital for local actors to produce patents. In other words, academic research enhances patent generation. Diversified regions have more innovative performances compared to specialized ones. In addition, densely populated regions are more innovative based on the first model results. The results of the models that produced for spatial dependency of regional innovation show the positive and significant relation between adjacent regions. For additional control variables within the models, besides level of agglomerations in regions all other variables show relation to the regional innovation. Nevertheless, agglomeration interacts with diversification of a region. Results show that when a region shows high diversification and density at the same time, this combination reflects positively on the innovation generation in that region. In brief, knowledge, an important driver for regional innovation, disseminates to adjacent regions in Brazil and diversified local industries are advantageous for regional innovation. From policy-making perspective, this research suggests the withdrawal from universal policy approaches to innovation. As an alternative, local characteristics of regions are supposed to be appreciated in order to foster regional innovation. Policies should take measures to strengthen the existing local capacity. As a result of this policy approach, firms can benefit the geographical concentration of inputs that lead to innovation. As from the developing country perspective, in this case of Brazilian regions, R&D expenses are weaker compared to developed countries. Consequently, utilization of local innovation efforts is possible with place-based policy making approach.

In their work of "Global networks, local specialisation and regional patterns of innovation", Ascani et al. (2020, p.2) scrutinizes the different or complementary impacts of "internal specialization" and involvement in the "external subsidiaries" on the regional innovation process. They investigate the advantageous or disadvantageous conditions that produced by the external networks and local industrial specialization, in terms of local innovative outcomes. According to Ascani et al. (2020), innovation is a complicated process that both local knowledge and outside knowledge are involved and combined in different extents. In the context of their research, outside knowledge is incorporated into local economy by international establishments named as "knowledge gatekeepers" (p.5). These establishments are capable of utilizing global networks for reaching locally unavailable and expensive knowledge. Contrariwise to the discourse of "anti-globalization" for local economies, this research's findings support the regional policies of "regional openness and internationalization support" in order to reach successful regional innovations especially for high level specialized regions (p. 2-3). In the case of Italian regions, analysis results support the stream of literature where local knowledge is considered fundamental for innovation capacity. Even the network intensity variable has shown positive impact on the increase of innovative output, absolute specialization and R&D variables, namely two of the main internal knowledge sources, have shown way more positive impact compared to network intensity variable as a measure of involvement of external subsidiaries. As for remarkable results, Ascani et al. (2020, p.14) classified regional specialization according to percentiles, then they reached the conclusion that different levels of specialization in the regions have impact on the taking benefit of networks that are created by local firms. For regions with “lower levels of specialization up until 50th percentile” based on the classification, the returns from the engagement in external networks are negative and not significant. These findings show that certain degree of local knowledge is necessary for regions to benefit from external networks. Regions with “higher levels of specialization” (more than 50th percentile) can use outside knowledge via external networks and transform it for creating innovation. The outside knowledge is complementary for the existing local knowledge instead of being substitute for local knowledge entirely. The important thing to remember is that local knowledge is the precondition for regional innovation. This research based on the Italian NUTS 2 regions between the years of 2007-2012 show that internal specialization and involvement of the external subsidiaries are complementary to each other rather than substituting. In conclusion, regional innovation is a complex and interactive process that involves respected knowledge resources not only generated by local dynamics but also combined with external contributions.

In their research of “R&D investments and quality of life in Turkey”, Erdin and Özkaya (2020) intend to conduct an analysis on Turkish cities in terms of R&D, Technology Development Zones (TDZs) and quality of life. The differences between cities are examined according to the technological investments and life quality. Researchers assert that mainly public resources are used for the R&D expenditure in Turkey. Government supports defense, automotive and IT sectors forefront. What surprises Erdin and Özkaya (2020) is the low share of government incentives to pharmaceutical sector in Turkey, contrariwise to the situation in worldwide. The proposed methods for this research are FAHP (fuzzy analytic hierarchy process) and TOPSIS (Technique for Order Preference by similarity to ideal solution). Based on the relevant determinants of quality of life, weights are produced via FAHP. In the following step, TOPSIS analysis produced individual results for each city. Relative closeness of each city to the ideal quality of life, R&D and TDZs is calculated. Based on the classification Erdin and Özkaya (2020, p.7) make, cities located in the east part of Turkey are not governed "fairly" with regards to technology and R&D investments. Even though the distribution of universities is proper also in East and Southeast parts; life quality, developmental levels are still not adequate. There is a lack of R&D centers and TDZs. Suitability for R&D and research investments are ranked from Marmara region towards Eastern Anatolia (Marmara, Central Anatolia, Aegean, Mediterranean, Black Sea, Southeast Anatolia and Eastern Anatolia (p.8)). Erdin & Özkaya (2020) recommend the policy makers to tackle existing socio-economic situation and living standards of Eastern part of Turkey in order to economic growth in terms of R&D and technology.

In their research named "The Effect of Technological and Scientific Knowledge on Economic Growth in Turkey (1980-2015)", Börü et al. (2020) scrutinize the relation between economic growth and growth of knowledge by detecting significant determinants for Turkey. This study aims to provide input for policy making of economic growth for Turkey as a developing country. Knowledge is categorized as technological and scientific. Two models of analyses have been conducted. Börü et al. (2020, p.113) analyze the relationship via "linear regression and time series" approaches. Economic growth is measured by the variable of GDP. Knowledge is measured by the scientific articles and technological patents. Both approaches provide diverse findings. Based on the first linear regression approach, the findings show no statistically significant relation between economic growth and knowledge. Nevertheless, capital formation and population increase variables have positive impact on economic growth. Since the first method was insufficient to define the short- and long-term impact of the variables, a second method is used. Based on the findings of second approach, patents from knowledge variables have weak impact on the GDP in the long-run, while scientific articles have no statistically significant impact neither in the short- nor in the long-term. In conclusion, the weak relation between the GDP and patent in the long-run might demonstrate the difficulties of the transformation of patents to marketable products. The non-existent relationship between scientific publications and economic growth of productive sectors reveals the necessity for increased university and industry cooperation on R&D activities in Turkey.

Tavassoli and Karlsson (2021), in their work of "The role of location on complexity of firms' innovation outcome", investigate the effect of location on the complexity of innovation outcomes of firms in Sweden. They categorized dependent variable as simple, low complex, medium complex and high complex innovation outcomes. Innovation outcome types are according to the Schumpeterian innovations as product, process, marketing and organizational. They conduct multinomial logit analysis in order to reveal the relationships of innovation determinants. They propose three main groups of independent variables including regional characteristics. These are, in order, the labor market thickness, specialized supplier thickness and knowledge spillover extent. According to the findings, high complex innovation is affected most by the three groups of regional characteristics. Increase in labor market thickness results in highly complex innovation in Swedish firms. Interestingly they find that regional characteristics have higher impact on the most complex innovation outcomes among all Schumpeterian innovation types combined. Contrary to the general belief, R&D investments within and from outside of the region are associated positively to non-innovative or simple innovation outcomes. Specialized supplier thickness and extent of knowledge spillover have also similar impact on the innovation outcome as the labor market thickness. The two of the independent variables mutually affect each other meaning that agglomeration externalities positively impact interregional knowledge dissemination. For policy implications, Tavassoli and Karlsson (2021) recommend to keep in mind the complexity level of the innovation outcomes within a region and to propose distinctive regional innovation policies based on this complexity for each region. All in all, location is significant for firms' innovation outcomes as many times confirmed in the literature. Particular to this research, Tavassoli and Karlsson (2021) find the relation of location to the complexity of innovation outcomes. According to the researchers, "regional environments and regional innovation policies" can be shaped according to the findings of this research (p.12). It is recommended to develop a regional innovation policy according to the innovation complexity diversity in the region.

Ganau and Grandinetti (2021) aim to analyze empirically impact of "institutional quality" that activate and stimulate various innovation inputs in regions (p.7). EU regions are subject to this empirical analysis according to the input and output perspectives for innovation activity. Researchers aim to unravel the specific role different innovation inputs has in total innovation output, additionally including heterogeneous institutional settings across different regions. Institutional quality, within the scope of this research, is comprised of three main pillars. These pillars are "the dimensions of quality, impartiality, and corruption of the local institutional environment" (Ganau and Grandinetti, 2021, p.11). Regions are characterized based on the synthesis of this pillars. According to this characterization, regions with different quality of institutions have different reliance on innovation inputs. In other words, formal and informal innovation inputs described in the literature are predicated regarding the high- and low-quality of institutions in the region. The quality of local institutions, also known as regional structural circumstances, is significant in the different input utilization preferences.

Analysis results show the positive association between institutional quality and total regional productivity. Improvements in the institutional quality relatively have impact on the "higher productivity of public R&D expenditure, business R&D expenditure, SMEs collaborating for innovation, and labor force in mid- and high-tech manufacturing (MHTM) and knowledge-intensive services (KIS) sectors" (p.19). Secondly, regional innovation performance is correlated significantly to the less formal inputs contrary to the general opinion. These less formal inputs are "SMEs' non-R&D expenditure for innovation, SMEs' collaborating for innovation, a region's endowment of labor force in MHTM and KIS sectors, and the production of scientific publication" while the formal ones are namely "human capital and public R&D expenditure" (Ganau and Grandinetti, 2021, p.20).

From theoretical perspective, indexes generated in the literature for regional innovation are not enough to comprehend innovation systems particular to regions. From policy-making perspective, effective regional innovation systems and maximized innovation capability are reached through tailor-made and region-specific policies. Place-neutral (Barca et al., 2012) or one-size-fits-all type of regional policies have tendency to overlook the regional features for innovation input and output. The necessity of creating a structure different from the generally used "synthetic indexes" via innovation input and outputs for relative innovation capacity of regions, motivated the researchers to go into detail the institutional characteristics of regions and its relation on innovation output (Ganau and Grandinetti, 2021, p.15). Based on Ganau and Grandinetti (2021)'s results, highly formal inputs do not result in regional innovation in regions where the quality of institutionalization is low. In other words, formal inputs necessitate corresponding institutional setting. Regional policies should aim to change the regional institutional structures if they aim to create regional innovation.

CHAPTER 5

RESEARCH METHOD

Afterwards the theoretical framework is drawn and regional innovation is examined in detail through the examples of Turkey and the world in the literature, the details of the analysis are explained in this method section. This section includes subsections explaining such as the reasons for using this specific type of analysis method, the characteristics of the data included in the analysis, the data corresponding to the variables used in the regional innovation measurement, the reasons for the necessary changes made on the data, the specification of the research models and the expression of the limitations.

Corresponding to the existing research methodologies and models in this research global and local statistical approaches are adopted. This research has three main questions.

Research Question 1: What are the key components contributing to province level innovation output in Turkey?

Research Question 2: What is the relationship between innovation output encouraging key components and space at the province level in Turkey?

Research Question 3: Which key components show spatial dependency differences at Turkish NUTS 3 regions in explaining the innovation output?

While deciding on the method to be used to answer these research questions, the most effective method is tried to be found in the light of the studies in the literature. In order to find the key variables of regional innovation in Turkey, it is necessary to define the region and to list the variables that affect the innovation output within these regions and subject them to a regression analysis. Many studies in the literature make use of general (global) models on these issues. Based on the results obtained from this model, an answer is sought for the second research question. Among these key components, methods such as spatial dependency tests and geographically weighted regression (GWR) are used to examine the relationship between the ones that affect the regional innovation output and the space. There are frequently used methods to measure the effect of space on innovation which is explained in detail in this section in order. The methods used to answer the third research question focus on spatial dependence and where this dependence differs on the geographical sphere. While trying to answer this question, it is expected that reasons behind the differences would come forward and new discussion platforms to emerge.

The methods used to answer the research questions are mentioned in detail, respectively. The Ordinary Least Squares (OLS) regression model is employed for the model that had to be constructed to response the first research question. OLS, which is defined as a global model, reveals the relationship between the modeled variable and each explanatory variable with a single equation. The basic supposition of the OLS model is that the relationships between the variables are "static and consistent" in the whole field of study (Scott and Janikas, 2010, p.36). In other words, considering the assumption that the relations between variables might be diverse in various parts of the field of study, the effect of the global model tends to decrease (Scott and Janikas, 2010). On the other hand, Geographical Weighted Regression (GWR) models are called local models. These local models generate separate equations for each feature in the model. Each of these equations is adjusted using the modeled variable and its neighbors. That is, proximate features have an upper weight in standardization than distant features. This means that the association between the modeled variable and the descriptive variables might show altered results in different parts of the field of study. The essence of the GWR model is that it includes space variations (Scott and Janikas, 2010). The Table 5.1 shows the dissimilarities between global and local models in general (Fotheringham et al., 2002).

Table 5.1. Dissimilarities amongst global and local statistical approaches

Global	Local
Summarize data for the whole region	Local disaggregations of global statistics
Single-valued statistic	Multi-valued statistic
Non-mappable	Mappable
GIS – unfriendly	GIS – friendly
Aspatial or spatially limited	Spatial
Emphasise similarities across space	Emphasise differences across space
Search for regularities or 'laws'	Search for exceptions or local 'hot-spots'
Example: Classic Regression	Example: Geographically Weighted Regression (GWR)

There are features where global and local statistical models differ from each other. Global models include a measure of the mean, standard deviation, and spatial autocorrelation of residuals in the data set. Local models, on the other hand, include multiple values. It is observed that the values associated with location and proximity change at different spaces (Fotheringham et al., 2002).

Global models and statistics cannot be mapped as they are used for single-value measurement. On the contrary, local models can be examined and mapped in more detail using software programs such as Geographic Information Systems (GIS). For example, local models are preferred to examine the spatial impacts of explanatory variables on the modeled variable. The reason for this is that many variables are included in the model and it is necessary to map them in order to reach significant results. As a result, global models are "aspatial or spatially limited" models, while local models are spatial statistical approaches (Fotheringham et al., 2002, p.7).

Another important difference between global and local models is the tendency of global models to find similarities and local models to find differences in the datasets due to their nature. While constructing global models, there is an assumption that all parts of the area subject to the study can be represented by a single value. On the other hand, local models reject this assumption and are constructed to show what really happens in different parts of the field of study. That is, local models are preferred to search for “outliers or hot-spots” in the field of study (Fotheringham et al., 2002, p.7).

Since social processes and issues are not static, it is important when and where the research models and analyses are made. Therefore, the global models used while investigating these phenomena might lead to insufficient information. Global models might not be as powerful as local models in capturing and explaining local differences. In the light of the results of global models, some confusion might arise about local variables. For this reason, it would be useful to examine the effects of space on the relations between variables in some research problems. In some other research, if there is no assumption that the space has a differing effect in the research models, it might not be necessary to adopt a local statistical approach (Fotheringham et al., 2002, p.9).

Geographical Weighted Regression (GWR) was proposed by Fotheringham et al. (1995) as a local version of the OLS model. The purpose of its use is the spatial nonuniformity of variables in classical regression and the ability of the local model to explicitly model the variance. Regression estimation is made using weight matrices for each location. The focus of the method is to estimate the variance of the variables (Getis, 2010 in Fischer and Getis, 2010). As mentioned in Section 2.2, weight matrices are used in spatial dependence and spatial regression models. For example, contiguity weight matrices take the values of 1 when the spaces share borders, and 0 when they do not.

GWR results can be described as a mapping that includes “parameter space”. High values in this mapping show that the relationship between dependent and independent variables tends to be strong. However, it should be noted that these parameters do not indicate direct spatial autocorrelation (Getis, 2010, p.271-2 in

Fischer and Getis, 2010). In this case, it becomes necessary to apply other methods in the analysis of spatial autocorrelation.

Another series of methods to be used in order to answer research questions is the methods used to measure spatial dependence. These methods are called global and local Moran's I.

Spatial dependence connotes that a feature in a location is affected by features in its close locations. A global perspective on spatial association was developed by Getis and Ord (1992). A local alternative of this global perspective has also been developed to depict the trends of values around a location. The local spatial association statistics method proves that space has a role in different trends in the distribution of a variable. With this statistical approach, differences such as clustering of values and mixtures of high and low values could be revealed in some parts of the study. Such differences cannot be accessed by calculations of global models, as mentioned earlier (Fotheringham et al., 2002). Local Moran's I is one of the classical spatial autocorrelation methods used to measure spatial dependence. It is seen that there is a positive spatial autocorrelation when the high and low values are distributed close to similar values in the field of study. In the case of negative spatial autocorrelation, it is observed that the high and low values are close to each other. Local Moran's I method is used to reveal these differences and similarities (Fotheringham et al., 2002, p.14-5; Çubukçu, 2015, p.284).

One of the reasons why local models are favored over global models is that analysis can be done with strong visualizations created using programs such as GIS and the like. The development and better understanding of the structure of spatial relations is another reason why local models are favored. They act as a "microscope" as they allow more details to be revealed (Fotheringham et al., 2002, p.25).

5.1 Data

In order to answer the questions of this research, data obtained from the statistical databases of formal institutions are used. The institutions are Council of Higher Education (YÖK), Ministry of Customs and Trade, Ministry of Industry and Technology, Ministry of Interior, Ministry of Trade, Social Security Institution (SGK), Technology Transfer Platform (TPTO), The Union of Chambers and Commodity Exchanges of Turkey (TOBB), Turkish General Directorate of Foundations, Turkish Statistical Institute (TURKSTAT), TPTO. On February 4, 2020, all patent and utility model registration data between 2010-2019 are obtained from TPTO institution at provincial level. The patent and utility model registration data between 2010 to 2019 originally has 10,055 entry. There are 84 different economic activities addressed in the forms of NACE Rev.2 division, group and class forms (Figure 5.1) in the data. According to the definition of Eurostat (2018), NACE (Nomenclature statistique des activités économiques dans la Communauté européenne) is a form of classification that hierarchically includes economic activities with guidelines and explanations. In this hierarchy (see Figure 5.1), the first level includes "section" consisting of alphabetic codes, the second level "division" consisting of a two-digit code, the third level "group" consisting of a three-digit code, and the last level "classes" consisting of a four-digit numerical code (Eurostat, 2008, p.15). For example, "Manufacture of watches and clocks" is coded as "C26.52". Number 26 shows the division, 26.5 shows the group and 26.52 shows the class. Since this economic activity is related to manufacturing, it is included under the section C. Original data is arranged by NACE Rev.2 divisions. The purpose of this is to ensure concordance since sectoral research is carried out with other datasets. The full names of the economic activities (sectors) in the dataset and the NACE Rev.2 codes can be accessed from the Appendix B. In short, the NACE divisions of the economic activities in the data set and used within the scope of the research are 26 sectors which are 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 42, 43 and 62. Patent and utility model registrations used within the scope of the research are registered only in Turkey. Due to the fact that the number of inventions registered by the European Patent Office, the Japanese Patent Office and the American Patent and Trademark Office (OECD, 2021), which is called the triadic patent family, is low in Turkey and the detailed data of these registrations are not stored by the TPTO, national data is used.

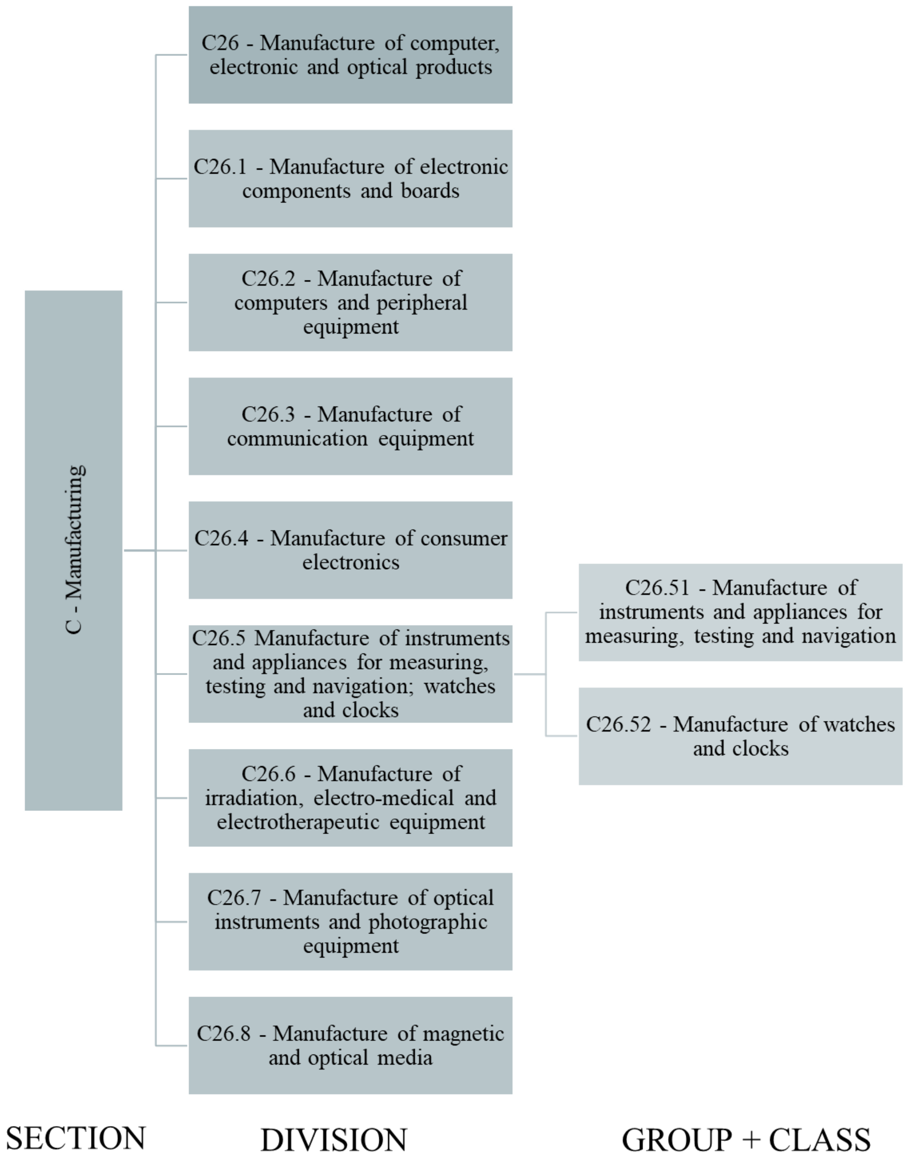

Figure 5.1. Example of NACE Rev.2 hierarchical structure

The variables included in the original registration data obtained from TPTO, the description of the variables and the information on which the variable is divided into categories are shown in detail in the Table 5.2.

Table 5.2. Content of registration data obtained from TPTO

Variable name	Description	Category
NACE2_TR	Statistical Classification of Economic Activities in the European Community, Rev. 2 (in digits)	Section, division, group, class e.g. Manufacture of batteries and accumulators (C 27.20)
TESCIL YILI	Year of registration	2010 to 2019 (10 years)
KORUMA_TIPI	Protection type of innovation	Patent or utility model
IL	Province name	81 provinces (NUTS 3 regions) of Turkey
SAYI	Total number of registrations	Numeric (1 to 268)

A few examples are presented in the Table 5.3 for a better understanding of the original data. These examples (see Table 5.3) were randomly selected to show the listing patterns of the variables in the original data set.

International Patent Classification represents the hierarchical classification and search of patent documents according to the technical fields they belong to. This classification and regulation makes it easier to follow innovations in certain economic activity areas. The IPC consists of eight divisions (A to H) and approximately 70,000 subdivisions. Each subdivision has its own symbols consisting of numbers and letters (WIPO, 2021). There are transformation methods that connect IPC to economic activity (NACE). Economic activity classification is as follows: ISIC Rev3 and NACE were dated back to 1989. NACE Rev. 1 dated back to 1990, afterward Rev 1.1 was in 2002. 1 January 2008 onwards EU (Eurostat) uses the economic classification of NACE Rev. 2 (formed in 2006). From IPC to NACE conversion done by TPTO. The conversion table can be accessed from the Appendix

C. NACE codes codification is necessary in order to match the employment data from Social Security Institution (SGK) for innovative sectoral employment.

Table 5.3. Example table showing the details of original patent and utility model registration data

2010-2019 PATENT/UTILITY MODEL REGISTRATIONS				
NACE2_TR	**TESCIL YILI**	**KORUMA_TIPI**	**IL**	**SAYI**
Manufacture of batteries and accumulators	2010	patent	Ankara	1
Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	2010	patent	İstanbul	2
Manufacture of other special-purpose machinery n.e.c.	2013	patent	Bursa	22
Manufacture of electric lighting equipment	2014	patent	Sakarya	1
Specialized construction activities	2015	patent	Isparta	1
Manufacture of motor vehicles, trailers and semi-trailers	2010	utility model	Osmaniye	1
Manufacture of other special-purpose machinery n.e.c.	2014	utility model	Giresun	4
Wholesale of wood, construction materials and sanitary equipment	2015	utility model	Kütahya	1
Manufacture of optical instruments and photographic equipment	2016	utility model	Denizli	1
Manufacture of plastics and rubber machinery	2019	utility model	Aydın	1

Table 5.4. Descriptives on Total Patent And Utility Model Data in 2019

Descriptive Statistics						
	N	Minimum	Maximum	Sum	Mean	Std. Deviation
TOTREG19	81	0	1898	3767	46.51	216.720

The total number of patent and utility model registrations in 2019 (referred as TOTREG19) is used as a dependent variable in the thesis. The total number of patents and utility models registered in Turkey in 2019 in numbers is 3,767 (see Table 5.4). Patent and utility model registrations by province are shown in the Table 5.5. İstanbul, Ankara, Bursa, İzmir, Kocaeli and Konya are the provinces with the highest number of patents and utility models in 2019.

Table 5.5. Provinces with the highest total number of patents and utility models (more than 100)

PROVINCE	**TOTREG19**
İstanbul	1898
Ankara	399
Bursa	265
İzmir	182
Kocaeli	158
Konya	108

Considering the number of patents and utility models in 2019 in terms of economic activities, it is observed that the highest number of registrations were received from manufacturing industry sectors such as Machinery and Equipment Manufacturing, Computer, Electronics and Optical Production and Electrical Equipment Production (see Table 5.6). While Machinery and Equipment Manufacturing and Electrical Equipment production have medium-high R&D density; Computer, Electronics, and Optical production have high R&D density among the manufacturing industry sectors. For more information on the dependent variable, please check Appendix F.

Table 5.6. The sectors with the highest number of patent and utility model registrations in 2019 and their percentage distribution

NACE	DIVISION	TOTREG19	PERCENTAGE
28	Manufacture of machinery and equipment n.e.c.	807	21.95
26	Manufacture of computer, electronic and optical products	565	15.37
27	Manufacture of electrical equipment	417	11.34
32	Other manufacturing	394	10.72
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	386	10.50

As seen in Table 5.7, economic sectors are grouped by OECD and Eurostat according to their R&D and technology intensities (see Appendix D and Appendix E). This grouping is taken as a reference for the innovative sectors grouped within the scope of the thesis.

Table 5.7. Economic sectors based on R&D and technology intensity

INTENSITY (R&D, Technology)	OECD and EUROSTAT
HIGH (manufacturing)	21, 26
HIGH (non-manufacturing, knowledge-intensive services)	58, 59, 60, 61, 62, 63, 72
MEDIUM HIGH (manufacturing)	20, 27, 28, 29, 30

This map (Figure 5.2) shows the sectors with the highest number of registrations in each province where in some cases the sector with the highest registration number among all sectors with registrations or another provinces an only sector is registered. The colors on this map show the high-tech sectors in red, the medium-high-tech sectors in blue, and the medium, medium-low, and low-tech sectors in black. Provinces in white color are those that do not have registration for 2019. For example, the sector with the highest number of registrations in 30 cities is the machinery and equipment industry with 28 NACE Rev.2 code. The high-tech and R&D-intensive sectors of pharmaceutics and computer, electronics and optical production in all 10 cities for example İstanbul (645), Ankara (103), Gaziantep (16), Nevşehir (5), Düzce (3), Adıyaman (1), Elazığ (1), Edirne (1), Uşak (1), and Tunceli (1).

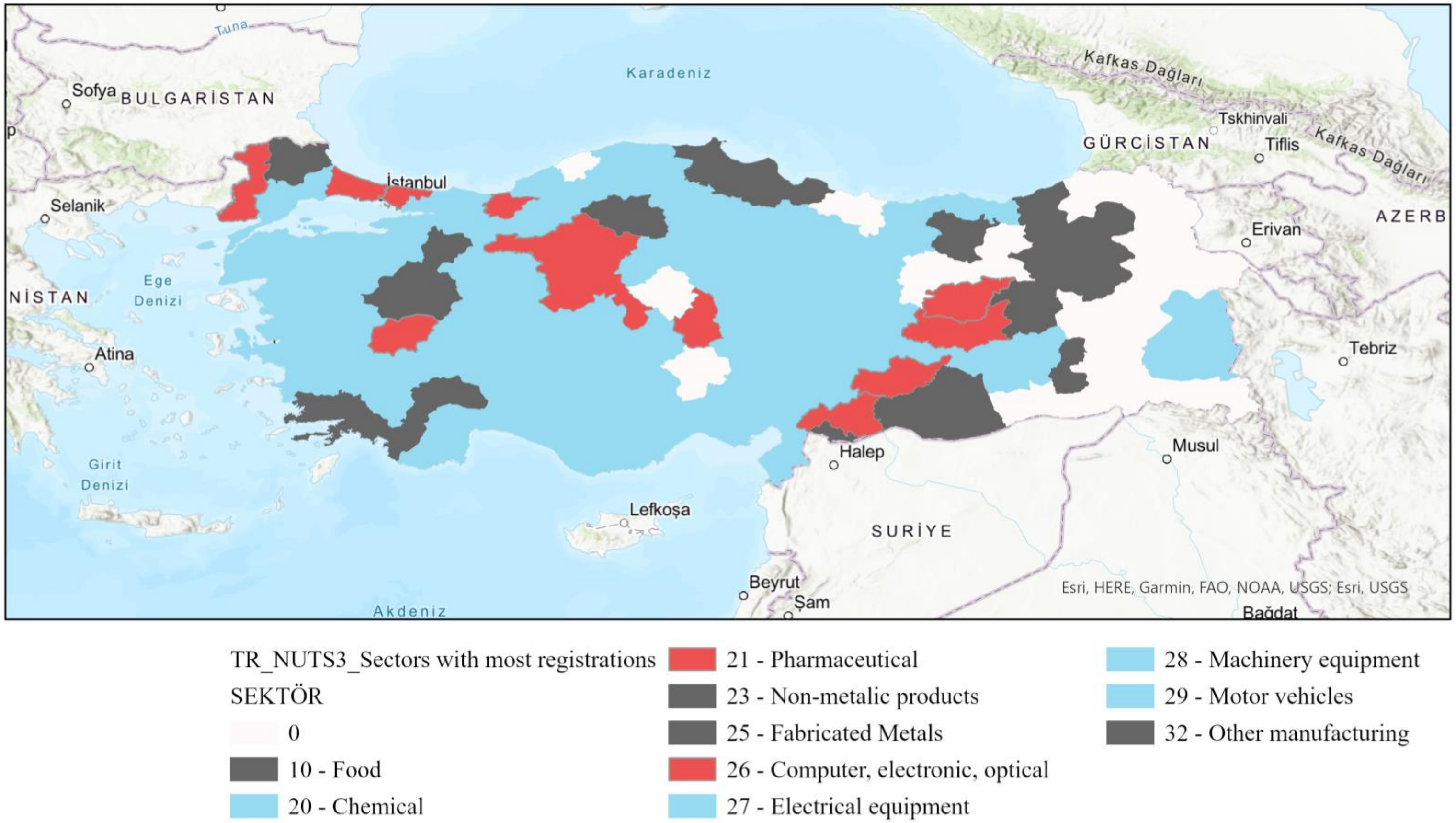

Figure 5.2. Sectors with most registrations

5.2 All variables

The variables included in the analysis are grouped and shown in detail in this section in order to both answer the research questions and include the variables used by similar research in the literature.

The dependent variable was determined as the number of patent and utility model registrations to define the innovation output of the regions. The reason for obtaining the registration numbers is that the application was accepted in Turkey as a novelty. The reason for including utility models in the analysis in addition to patent numbers is that utility models protect "the novel and industrially applicable inventions" as mentioned by TPTO (2017). Since the utility model application process is more convenient than the patent application in terms of time and expenses, it is seen that institutions such as SMEs and research centers prefer the utility model. Protection of inventions via utility models made by these institutions at different scales benefits them among competing institutions (TPTO, 2017). For these reasons, the number of utility models has been added to the number of patents.

Independent variables are examined in separate sections as they relate to the innovation output of regions in different aspects. Apart from these sections, the following sections explain how they are included in research models in detail.

Detailed information about the NUTS 3 regions map of Turkey, which is used as a base in spatial analyzes and visualizations, is given in Section 1.3 (Method of the research).

5.2.1 Innovation

Within the scope of this research, the dependent variable is the number of patent and utility model registrations showing innovation outputs.

TOTREG19_pop: The ratio of the total number of patent and utility model registrations in 2019 according to the population in the province (the number of patents and utility model registrations per 10000 people in the province in 2019)

Table 5.8. Descriptive statistics for innovation variable

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std.Deviation
TOTREG19_pop	81	.00	1.22	.1675	.22936

5.2.2 Human capital

Innovative employment plays a vital role in the calculation of the human capital variable. In this research, two reference classifications are used to identify innovative economic activities. These references are "Taxonomy of Economic Activities Based on R&D Intensity" prepared by OECD (Galindo-Rueda and Verger, 2016) and "Indicators on High-tech industry and Knowledge-intensive services" prepared by Eurostat (Table 5.7. Economic sectors based on R&D and technology intensity). In the OECD classification, manufacturing and non-manufacturing economic activities are divided into five different R&D intensity groups as high, medium-high, medium, medium-low and low. On the other hand, Eurostat divides economic activities into manufacturing and knowledge-intensive services. After this division, Eurostat divides industries into four main groups as high, medium-high, medium-low, and low based on technological intensity.

According to Eurostat classification, high-technology manufacturing industries are accepted as NACE Rev.2 codes as 21 (Manufacture of basic pharmaceutical products and pharmaceutical preparations) and 26 (Manufacture of computer, electronic and optical products). Medium-high-technology manufacturing industries' NACE Rev.2 codes are 20 (Manufacture of chemicals and chemical products), 27 (Manufacture of electrical equipment), 28 (Manufacture of machinery and equipment n.e.c.), 29 (Manufacture of motor vehicles, trailers and equipment and semi-trailers) and 30

(Manufacture of other transport equipment). High-tech knowledge-intensive services in the Eurostat classification are NACE Rev.2 codes 59 (Motion picture, video and television program production, sound recording and music publishing activities), 60 (Programming and broadcasting activities), 61 (Telecommunications), 62 (Computer programming, consultancy and related activities), 63 (Information service activities) and 72 (Scientific research and development).

NACE Rev.2 divisions of manufacturing industries requiring high R&D intensity in OECD (Galindo-Rueda and Verger, 2016) classification are 21 (Manufacture of basic pharmaceutical products and pharmaceutical preparations) and 26 (Manufacture of computer, electronic and optical products); while non-manufacturing sector division is 72 (Scientific research and development). Medium-high R&D intensity manufacturing industries NACE Rev.2 divisions are 20 (Manufacture of chemicals and chemical products), 27 (Manufacture of electrical equipment), 28 (Manufacture of machinery and equipment n.e.c.), 29 (Manufacture of motor vehicles, trailers and semi-trailers), 30 (Manufacture of other transport equipment); while non-manufacturing sectors' are 58 (Publishing activities), 59 (Motion picture, video and television program production, sound recording and music publishing activities) and 63 (Information service activities).

Table 5.9. Description of selected innovative economic activities

NACE Rev.2 Code	Economic Activity	Reference source
C20	Manufacture of chemicals and chemical products	OECD Medium-high R&D intensity manufacturing; Eurostat Medium-high-tech manufacturing
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	OECD High R&D intensity manufacturing; Eurostat High-tech manufacturing
C26	Manufacture of computer, electronic and optical products	OECD High R&D intensity manufacturing;

Table 5.9. Description of selected innovative economic activities (continued)

		Eurostat High-tech manufacturing
C27	Manufacture of electrical equipment	OECD Medium-high R&D intensity manufacturing; Eurostat Medium-high-tech manufacturing
C28	Manufacture of machinery and equipment n.e.c.	OECD Medium-high R&D intensity manufacturing; Eurostat Medium-high-tech manufacturing
C29	Manufacture of motor vehicles, trailers and semi-trailers	OECD Medium-high R&D intensity manufacturing; Eurostat Medium-high-tech manufacturing
C30	Manufacture of other transport equipment	OECD Medium-high R&D intensity manufacturing; Eurostat Medium-high-tech manufacturing
J58	Publishing activities	OECD High R&D intensity non-manufacturing; Eurostat High-tech knowledge intensive services
J59	Motion picture, video and television programme production, sound recording and music publishing activities	Eurostat High-tech knowledge intensive services
J60	Programming and broadcasting activities	Eurostat High-tech knowledge intensive services
J61	Telecommunications	Eurostat High-tech knowledge intensive services

Table 5.9. Description of selected innovative economic activities (continued)

J62	Computer programming, consultancy and related activities	OECD High R&D intensity non-manufacturing; Eurostat High-tech knowledge intensive services
J63	Information service activities	OECD High R&D intensity non-manufacturing; Eurostat High-tech knowledge intensive services
M72	Scientific research and development	OECD High R&D intensity non-manufacturing; Eurostat High-tech knowledge intensive services

According to NACE Rev.2 classification of economic activities, section C stands for manufacturing while section J signifies information and communication, and finally, section M stands for professional, scientific, and technical activities.

INOEMP1_1: Total number of employment in high- and medium-high-tech manufacturing and knowledge intensive services based on OECD and Eurostat classifications (NACE Rev.2: 20, 21, 26, 27, 28, 29, 30, 58, 59, 60, 61, 62, 63, 72).

INOEMP2_1: Percentage of INOEMP1_1 in total workforce (INOEMP1_1/TOTEMP).

HCAP1: Number of people between the ages of 20 to 64 having bachelor and higher education (TURKSTAT, 2019)

HCAP2: The ratio of the number of people between the ages of 20 to 64 with undergraduate and higher education to the entire province population (HCAP1/POP)

LLL1: Lifelong learning Non-formal education courses (TURKSTAT, 2017)

LLL2: Lifelong learning Non-formal education course graduates (TURKSTAT, 2017)

LLL3: Proportion of lifelong learning non-formal education course graduates to the entire provincial population (LLL2/POP)

ACADEMIC_P: Total academician numbers in state universities each province in 2019 (TURKSTAT, 2019)

STU19: The total number of students studying at public universities in the 2018-2019 period in primary education (TURKSTAT, 2019).

Academic_p_perstudent: Number of academicians per student in province (ACADEMIC_P/STU19).

Table 5.10. Descriptive statistics for human capital variables

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
INOEMP1_1	81	39	278942	12055.41	36391.552
INOEMP2_1	81	.0021	.3435	.040859	.0515599
HCAP1	81	7912	2269619	120620.52	280808.496
HCAP2	81	.05	.18	.1018	.02410
LLL1	81	87	25257	1099.53	2998.845
LLL2	81	4560	1411230	64647.38	185893.405
LLL3	81	.02	.16	.0471	.02553
ACADEMIC_P	81	277	17729	1746.44	2612.251
STU19	81	1901	284736	31228.28	40955.576
academic_p_perstudent	81	.03	.16	.0571	.01686

5.2.3 Research and development

RDWORK1: R&D personnel headcount weighted by total employment from NUTS2 level data (TURKSTAT, 2019).

RDWORK1_log: The logarithmic transformation of the RDWORK1.

RDEXP1: R&D expenditure (TL) weighted by GDP per capita share of the region from NUTS2 level data (TÜİK, 2018-2019).

RDEXP1_log: The logarithmic transformation of RDEXP1.

Table 5.11. Descriptive statistics for research and development variables

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
RDWORK1	81	154	87166	3775.44	11583.379
RDWORK1_log	81	2.19	4.94	3.1118	.51309
RDEXP1	81	14660242.23	14528650579.00	567329519.7037	2081437541.74509
RDEXP1_log	81	7.17	10.16	8.1619	.57062

5.2.4 Local structure

GDPPC19: GDP per capita for each province in 2019 (TURKSTAT, 2019).

POP_log (for agglomeration): The logarithmic transformation of population of each province in 2019.

ENT1_1: Total number of new enterprises in high- and medium-high-tech manufacturing and knowledge intensive services based on OECD and Eurostat classifications (NACE Rev.2: 20, 21, 26, 27, 28, 29, 30, 58, 59, 60, 61, 62, 63, 72).

ENT2_1 (for openness): Percentage of innovating new enterprises in total new enterprises (ENT1/TOTENT).

EXP1: NUTS3 level annual export value TL (TURKSTAT, 2019).

EXP1_log: The logarithmic transformation of EXP1.

Table 5.12. Descriptive statistics for local structure variables

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
GDPPC19	81	16727	86798	39595.53	13645.464
POP_log	81	4.93	7.19	5.7649	.41765
ENT1_1	81	24	38268	1182.35	4411.302
ENT2_1	81	.006965	.040497	.01447192	.006494905
EXP1	81	228.59	88827639.70	2232502.4763	10048269.52517
EXP1_log	81	2.36	7.95	5.2726	1.05350

5.2.5 Externalities

At the provincial level, the employment data of the innovative sectors are already examined under the title of R&D and the industry specialization and/or diversification quotients have not been calculated to avoid possible overlaps (i.e. multi-collinearity) on the data.

POPDENSE_19: Population density is calculated by TURKSTAT every year at the province level as the number of people per square kilometer (TURKSTAT, 2019).

POPDENSE19_LOG: The logarithmic transformation of POPDENSE_19.

UNI: Total number of public and private universities in the province (Council of Higher Education, 2019).

OID: The total number of Organized Industrial Districts in province (Ministry of Industry and Technology).

Table 5.13. Descriptive statistics for externalities variables

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std.Deviation
POPDENSE_19	81	11	2987	132.20	333.349
POPDENSE19_log	81	1.04	3.48	1.8712	.37645

Table 5.13. Descriptive statistics for externalities variables (continued)

UNI	81	1	58	2.53	6.770
OID	81	1	17	4.00	3.380

5.2.6 Spaces and institutions

OID: The total number of Organized Industrial Districts in province (Ministry of Industry and Technology).

SME1: The number of newly established SMEs (250- employees) (TURKSTAT, 2019).

SME1_log: The logarithmic transformation of SME1.

RDC: The number of research and development center in the province (Ministry of Industry and Technology).

DC: The number of design centers in the province (Ministry of Industry and Technology).

TDZ (techno parks): The number of technology development zones in the province (Ministry of Industry and Technology).

NGO: The total number of chambers in the province (Turkey Tradesmen and Artisans Confederation, 2021).

Table 5.14. Descriptive statistics for spaces and institutions variables

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
OID	81	1	17	4.00	3.380
SME1	81	3091	942710	48538.73	111248.336
SME1_log	81	3.49	5.97	4.3693	.46213
RDC	81	0	422	15.33	52.644
DC	81	0	166	4.56	19.584

Table 5.14. Descriptive statistics for spaces and institutions variables (continued)

TDZ	81	0	9	.89	1.466
NGO	81	3	157	37.02	30.139

5.2.7 Control variables

POP: Population of each province in 2019 (TURKSTAT).

POP_ACT: Number of actively employed population aged 15 to 64 in 2019 (TURKSTAT).

TOTEMP: Total number of employment in all NACE Rev.2 sectors (NACE Rev.2 1 to 99) (SSI, 2019).

TOTENT: Total number of new enterprises (TURKSTAT, 2019).

Table 5.15. Descriptive statistics for control variables.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std.Deviation
POP	81	84660	15519267	1026604.90	1873902.836
POP_ACT	81	58638	11077045	696196.60	1330257.722
TOTEMP	81	8106	4130578	176719.91	481283.219
TOTENT	81	3091	944954	48823.43	111446.327

5.3 Transformed variables

Some variables included in the analysis are subject to change for various reasons. The different reasons for these changes are explained in detail in this section. Variables have undergone transformations. For example, these are ratio to population (TOTREG19_pop, HCAP2, LLL3); ratio to the number of workers in all sectors (INOEMP2_1, RDWORK1); ratio to the number of workplaces (ENT2_1); ratio to the number of students (Academic_p_perstudent); ratio to GDP (RDEXP1);

and logarithmic transformation (RDWORK1_log, RDEXP1_log, POP_log, EXP1_log, POPDENSE19_log, SME1_log).

The dependent variable (TOTREG19_pop) was obtained by multiplying the total number of patents and utility model registrations per person by 10000 [(Total number of patents and utility models / economically active working population aged 15 to 64) * 10.000]. This is because the registration numbers are year-based, hence they are low in number and convert decimal numbers to include them in the analysis. The transformations of other variables made according to the population were made by proportioning. For example, in the calculation of the HCAP2 variable, the ratio of the population defined as the human capital in a province to the whole population was calculated.

Another transformation was made by calculating the shares of the innovative employment (INOEMP2_1) and R&D employment (RDWORK1) in the total number of employees in all NACE Rev.2 sectors. The share of new initiatives in all initiatives (ENT2_1) also shows that the number of workplaces is used in the transformations. The number of academics per student (Academic_p_perstudent) and the R&D expenditures (RDEXP1) received by the province according to the GDP ratio in the region are the variables obtained as a result of the transformations made with the proportioning method.

Finally, the logaritmic transformation is a transformation that replaces a variable x with log (x), and its aim is to decrease or eliminate the skewness of the original data (Changyong et al., 2014). The aforementioned variables (RDWORK1_log, RDEXP1_log, POP_log, EXP1_log, POPDENSE19_LOG, SME1_log) were subjected to log transformation.

5.4 Description of variables

Before moving on to the research models and analyses, the characteristics of all the variables included in the research are shown in the Table 5.16 in detail. Variable names, descriptions, measurement levels, data sources, and descriptive statistical information can be accessed from this table.

Table 5.16. Detailed information on all variables included in the analyses

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
ID	ID number for each province	For 81 provinces 1 to 81 numbers	-	81	-	-	-	-
NUTS3	3-digit-code for provinces	For 81 provinces from TR100 to TRC34	-	81	-	-	-	-
PRVNC	Name of the provinces	Each individual name for provinces	-	81	-	-	-	-
TOTREG19	Patent and utility model registration	Total number of patent and utility model registration in 2019	TPTO	81	0	1898	46.51	216.720

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
TOTREG19_pop	The ratio of the total number of patent and utility model registrations in 2019 according to the population in the province	The number of patents and utility model registrations per 10000 people in the province in 2019	Own calculation	81	.00	1.22	.1675	.22936
INOEMP1_1	Innovative employment	Employment in medium-high/high tech manufacturing and knowledge-	Social Security Institution (SGK)	81	39	278942	12055.41	36391.552

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
		intensive services (NACE Rev.2 sectors: 20, 21, 26, 27, 28, 29, 30, 58, 59, 60, 61, 62, 63, 72) (2019)						
INOEMP2_1	Innovative employment ratio	Percentage of INOEMP1_1 in total workforce (INOEMP1_1/TOTEMP)	Own calculation	81	.0021	.3435	.040859	.0515599
HCAP1	Human capital	Number of people between the ages of 20 to 64 having	Turkish Statistical	81	7912	2269619	120620.52	280808.496

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
		bachelor and higher education (TURKSTAT, 2019)	Institute (TURKSTAT)					
HCAP2	Human capital ratio	The ratio of the number of people between the ages of 20 to 64 with undergraduate and higher education to the entire province population (HCAP1/POP)	Own calculation	81	.05	.18	.1018	.02410

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
LLL1	Lifelong learning	Lifelong learning Non-formal education courses (2019)	Turkish Statistical Institute (TURKSTAT)	81	87	25257	1099.53	2998.845
LLL2	Lifelong learning	Lifelong learning Non-formal education course graduates (2019)	Turkish Statistical Institute (TURKSTAT)	81	4560	1411230	64647.38	185893.405
LLL3	Lifelong learning ratio	Proportion of lifelong learning non-formal education course graduates to the entire provincial	Own calculation	81	.02	.16	.0471	.02553

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
		population (LLL2/POP)						
ACADEMIC_P	Academicians	Total academician numbers in state universities each province in 2019	Turkish Statistical Institute (TURKSTAT)	81	277	17729	1746.44	2612.251
STU19	University students	The total number of students studying at public universities in the 2018-2019 period in primary education	Turkish Statistical Institute (TURKSTAT)	81	1901	284736	31228.28	40955.576

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
academic_p_perstudent	Academicians per university student	Number of academicians per student in province (ACADEMIC_P/STU19)	Own calculation	81	.03	.16	.0571	.01686
RDWORK1	R&D employment	R&D personnel headcount weighted by total employment from NUTS2 level data (2019)	Turkish Statistical Institute (TURKSTAT)	81	154	87166	3775.44	11583.379
RDWORK1_log	R&D employment (log)	The logarithmic transformation of the RDWORK1	Own calculation	81	2.19	4.94	3.1118	.51309

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
RDEXP1	R&D expense	R&D expenditure (TL) weighted by GDP per capita share of the region from NUTS2 level data (2019)	Turkish Statistical Institute (TURKSTAT)	81	1466024 2.23	14528650579 .00	567329519.7 037	2081437541.74 509
RDEXP1_log	R&D expense (log)	The logarithmic transformation of RDEXP1	Own calculation	81	7.17	10.16	8.1619	.57062
GDPPC19	GDP	GDP per capita for each province in 2019	Turkish Statistical Institute (TURKSTAT)	81	16727	86798	39595.53	13645.464

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	**Description**	**Level of measurement**	**Source**	**N**	**Min**	**Max**	**Mean**	**SD**
POP_log	Population (log)	The logarithmic transformation of population of each province in 2019	Own calculation	81	4.93	7.19	5.7649	.41765
ENT1_1	Entrepreneurship	Number of new enterprises based on most innovating NACE Rev.2 sectors (NACE Rev.2 sectors: 20, 21, 26, 27, 28, 29, 30, 58, 59, 60, 61, 62, 63, 72) (2019)	Turkish Statistical Institute (TURKSTAT)	81	24	38268	1182.35	4411.302

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
ENT2_1	Enterprises	Percentage of most innovating new enterprises in total new enterprises (ENT1/TOTENT)	Own calculation	81	.006965	.040497	.01447192	.006494905
EXP1	Export	NUTS3 level annual export value TL 2019	Turkish Statistical Institute (TURKSTAT)	81	228.59	88827639.70	2232502.476 3	10048269.5251 7
EXP1_log	Export (log)	The logarithmic transformation of EXP1	Own calculation	81	2.36	7.95	5.2726	1.05350

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
POPDENSE_19	Population density	The number of people per square kilometer in province 2019	Turkish Statistical Institute (TURKSTAT)	81	11	2987	132.20	333.349
POPDENSE19_log	Population density (log)	The logarithmic transformation of POPDENSE_19	Own calculation	81	1.04	3.48	1.8712	.37645
UNI	University	Number of Universities (public and private) for each province (2018-2019)	Council of Higher Education (YÖK)	81	1	58	2.53	6.770

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
OID	Organized Industrial District	Number of Organized Industrial Districts for each province	Ministry of Industry and Technology	81	1	17	4.00	3.380
SME1	Small and medium enterprises	The number of newly established SMEs (250-employees) (2019)	Turkish Statistical Institute (TURKSTAT)	81	3091	942710	48538.73	111248.336
SME1_log	Small and medium enterprises (log)	The logarithmic transformation of SME1	Own calculation	81	3.49	5.97	4.3693	.46213

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
RDC	Research and Development Center	Number of Research and Development Centers for each province	Ministry of Industry and Technology	81	0	422	15.33	52.644
DC	Design Center	Number of Design Centers for each province	Ministry of Industry and Technology	81	0	166	4.56	19.584
TDZ	Technology Development Zone	Number of Technology Development Zones for each province	Ministry of Industry and Technology	81	0	9	.89	1.466

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
NGO	Non-governmental organization	The total number of chambers in the province (2021)	Turkey Tradesmen and Artisans Confederation	81	3	157	37.02	30.139
POP	Population	Population of provinces (2019)	Turkish Statistical Institute (TURKSTAT)	81	84660	15519267	1026604.90	1873902.836
POP_ACT	Active population	Number of actively employed population aged 15 to 64 (2019)	Turkish Statistical Institute (TURKSTAT)	81	58638	11077045	696196.60	1330257.722

Table 5.16. Detailed information on all variables included in the analyses (continued)

Variable	Description	Level of measurement	Source	N	Min	Max	Mean	SD
TOTEMP	Total employment	Total number of employment in all NACE Rev.2 sectors (2019)	Social Security Institution (SGK)	81	8106	4130578	176719.91	481283.219
TOTENT	Enterprises	Total number of new enterprises (2019)	Turkish Statistical Institute (TURKSTAT)	81	3091	944954	48823.43	111446.327

5.5 Research models and key findings

In literature, structural requirements for the formation of innovation outputs are on the clustering of economic activities and modeling of innovation activities such as R&D and human capital that affect competitiveness (Grillitsch et al., 2021). For these reasons, as summarized in the theoretical background section, the structural requirements for the innovation outputs of the provinces in Turkey are examined with research models. In this subsection, the construction of the global regression models (OLS), the control of errors of and residuals from the models, spatial autocorrelation tests, and local regression models (GWR) are discussed in detail in order.

While global observations give average values for all parts of the field of study, separate averages are calculated for local observations. For global observations to provide reliable information about the field of study, local observations must differ slightly from each other. For study fields where spatial diversity increases, the reliability of global observations decreases (Fotheringham et al., 2002).

Considering the differences between global and local models, the structure of the models and their results are evaluated. The construct of the global models, which is explained in detail in the introduction of this section, are explained onwards. Statistical models are made and conducted in SPSS and ArcGIS Pro programs. Global models are constructed with multiple linear regression methods.

Multiple linear regression is the extension of simple linear regression that includes more than one explanatory variable. It is used to estimate relationships between response and explanatory variables for a specific sample (Tranmer et al., 2020). In global models, the r-squared value, i.e. “coefficient of determination”, shows the rate of variance of observed data explained by the model. The local r-squared version shows how well the model can replicate data recorded near the regression point (Fotheringham et al., 2002, p.215). In order to explain the r-squared values more, multiple r-squared and adjusted r-squared values are from 0 to 1. As the value gets closer to 1, the statistical explanatory power of the model increases (Pimpler, 2017).

As mentioned in the previous sections, there is a possibility that global models might fail to explain the examined phenomena. Various methods are used to examine this possibility. Mapping residual values from conventional global regression models is one of the traditional methods used to investigate model errors (Fotheringham et al., 2002). One of the other employed methods is the comparison of certain statistical values of the models. Another method is to check the spatial autocorrelation of the residual values.

In spatial analysis, the variable values of the observed point data are examined. The spatial autocorrelation phenomenon arises once the values at adjacent locations are dependent to each other (Tobler, 1970; Getis, 2010). Spatial autocorrelation, with its simplest definition, reveals the relationship between observations in an environment where each spatial observation or point is expressed with a variable value (Çubukçu, 2015). Spatial autocorrelation measurements are divided into two at local and global scales. While all items are taken into account and a single value is reached in global measurements, the spatial autocorrelation value is reached for each item in local ones (Getis, 2010).

In the spatial analyzes made in the ArcGIS Pro program, choices are made according to the nature of the variables and the research. The preferences in spatial autocorrelation analyzes are as follows, respectively. Since the provinces are the subject of this research, "contiguity edges corners" is chosen. In order to explain "contiguity edges corners", this option includes polygons share a boundary, a node, or have overlapping features that affect calculations. For distance method, Euclidian distance which means straight distance between points, is used. For standardization, Row standardization is used as generally recommended in order to count in the possible model biases.

In addition to global models, local models are also constructed within the scope of this research. Geographical Weighted Regression is used for these local models. The preferences in local regression analyzes are as follows, respectively. The selection of bandwidth (neighborhood) is significant when visualizing data distributions. Choosing either the "Number of Neighbors" or "Distance Band" options are required when constructing the model. When "Distance Band" is selected, the Kernel Type for GWR is decided after the selection of the variables. Kernel Type options are called "Fixed (Gaussian)" or "Adaptive (Bi-square)". "Cross-validation (CV)" or "Akaike Information Criterion (AIC)" minimization methods are used to determine the kernel width (Fotheringham et al., 2002). When "Number of neighbors" is selected, the minimum and the maximum number of neighbors must be selected for GWR. The size of the number of neighbors can vary by choosing small in places where the characteristics of the variables are intense, and by choosing large in places where the features are sparse (Anselin, 1995). In this research, "Number of neighbors" is chosen because neighboring provinces are investigated. After choosing this distance method, the "Golden search" option is used. The purpose of golden search is to calculate AIC at minimum and maximum distances. The distances and numbers of neighbors with low AICs are automatically determined and shown in the analysis (Fotheringham et al., 2002).

The Akaike Information Criterion (AIC), created by Akaike (1973), suggests that an accurate model may exist. However, the model may not directly validate the research. Still, it is useful in estimating the model closest to the accuracy among the constructed models. By showing this closeness, AIC reveals the most accurate and best model among the models. AIC is not just a degree of "goodness of fit". At the same time, the complexity of the model is taken into account in its calculation (Fotheringham et al., 2002, p.87). AIC values used in the comparison of models, it is accepted that the model with the smallest AIC value is the most suitable model for the research among the compared models. The decrease in the AIC values encountered in the comparison of the AIC values of the global and local models shows that the local models are more successful than the global ones in explaining the research (Fotheringham et al., 2002).

Table 5.17. An overview of the research models

Purpose	Variables	Details and Results
Model 1 **Human Agency**	Dependent Variable TOTREG19_pop Explanatory Variables INOEMP2_1; HCAP2; LLL3; RDWORK1_log	**Model 1** (Adj r^2: 0.598068; AICc: -74.479718) INOEMP2_1 (β: +1.05093; $p < 0.01$) RDWORK1_log (β: +0.26056 ; $p < 0.01$)
Model 2 **Research Capacity**	Dependent Variable TOTREG19_pop Explanatory Variables ACADEMIC_P; STU19; academic_p_perstudent; RDEXP1_log; UNI; RDC	**Model 2** (Adj r^2: 0.772705; AICc: -117.947650) RDEXP1_log (β: +0.69999; $p < 0.01$)
Model 3 **Spaces and Institutions**	Dependent Variable TOTREG19_pop Explanatory Variables UNI; OID; SME1_log; RDC;DC; TDZ; NGO	**Model 3** (Adj r^2: +0.750607; AICc: -108.999376) OID (β: +0.015649; $p < 0.01$)
Model 4 **Existing conditions**	Dependent Variable TOTREG19_pop Explanatory Variables GDPPC19; EXP1_log; POPDENSE19_log	**Model 4** (Adj r^2: +0.643882; AICc: -85.558625) GDPPC19 (β: +0.000009; $p < 0.01$) POPDENSE19_log (β: +0.159423; $p < 0.01$)
Model 5 **Innovation variables**	Dependent Variable TOTREG19_pop Explanatory Variables INOEMP2_1; RDEXP1_log;	**Model 5** (Adj r^2: 0.793589; AICc: -124.321375) GDPPC19 (β: +0.000005; $p < 0.01$)

Table 5.17. An overview of the research models (continued)

	GDPPC19; ENT2_1; OID; RDC; NGO	ENT2_1 (β: +7.060971; $p < 0.01$) OID (β: +0.015158; $p < 0.01$) RDC (β: +0.001545; $p < 0.01$)

Table 5.17 summarizes the main purposes for the research models designed to answer this research's questions, the variables included in the model, and the analysis details and results, based on the data set created at the province level in Turkey.

Analyzes and models specific to the research questions are described, respectively. First of all, the global models established to answer the research questions are explained in detail. Inserting all available independent data into the regression models in order and modeling together essential variables that are assumed to explain different aspects of the research lead to presenting results free of preliminary problematic issues of statistical analysis. Multiple linear regression models are constructed to answer the first research question which is "What are the key components contributing to province level innovation output in Turkey?" as shown schematically in Figure 5.3.

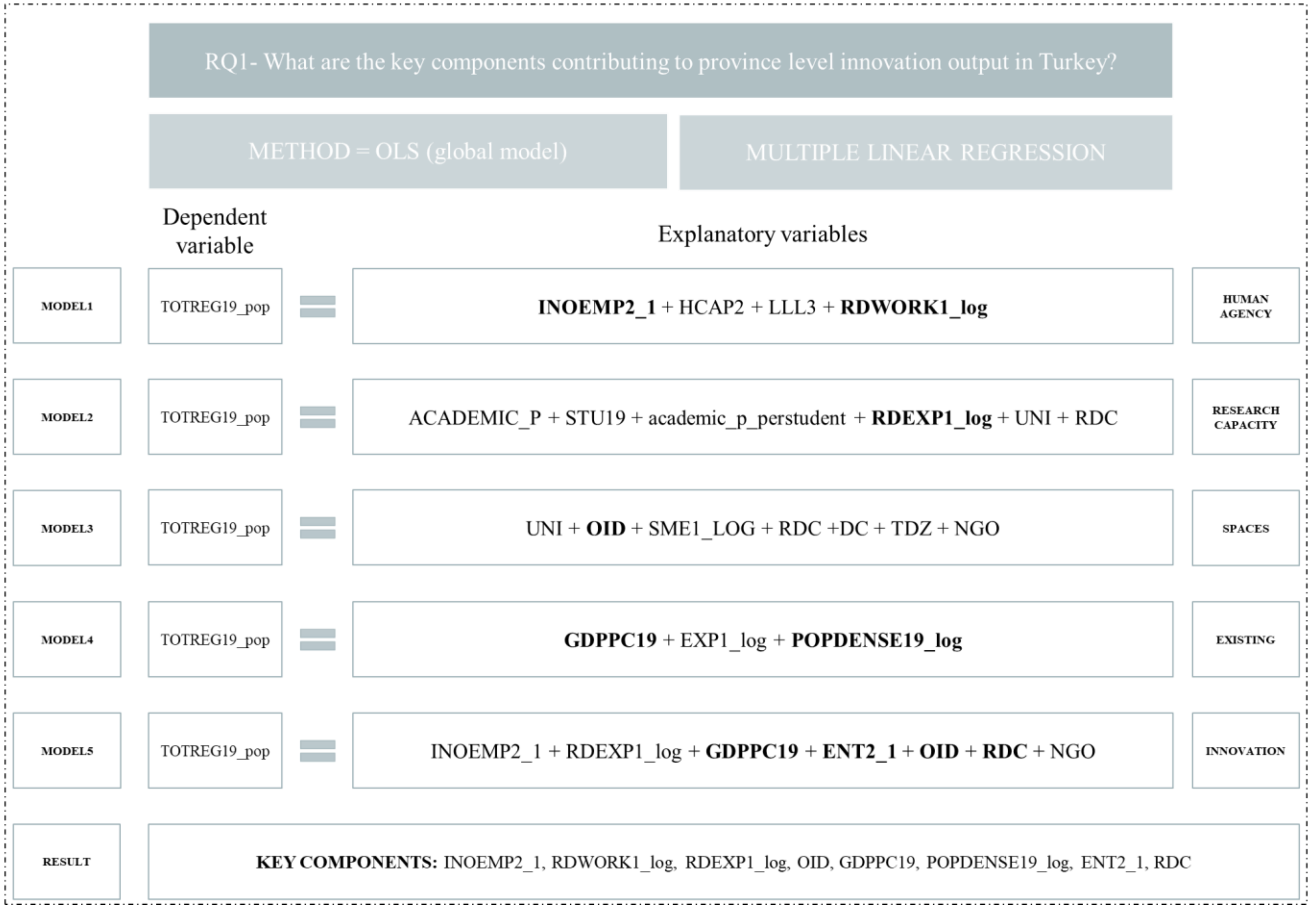

Figure 5.3. Conceptual scheme for OLS regression models

General explanation

In general terms, these constructed models show that the first research question was addressed in different dimensions. Multiple linear regression was used to assess the ability of explanatory variables to predict the dependent variable. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Additionally, the Global Moran's I test, which is one of the spatial autocorrelation tests, is used to analyze the spatial distribution of residual values. The Global Moran's I tool computes a single summary value, a z-score, describing the degree of spatial concentration or dispersion for the measured variable (Scott and Janikas, 2010). Global Moran's I has a value from -1 to 1. However, while other coefficients measure perfect correlation to no correlation, Moran's is slightly different by providing results while -1 is perfect clustering of dissimilar values, 0 is no autocorrelation and +1 indicates perfect clustering of similar values.

Model 1

Model 1 for analyzing innovation output in terms of human agency is constructed to answer the first research question which is "What are the key components contributing to province level innovation output in Turkey?" as shown schematically in Figure 5.3.

Multiple linear regression was used to assess the ability of four control measures (INOEMP2_1, HCAP2, LLL3, RDWORK1_log) to predict the dependent variable (TOTREG19_pop). Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Among four variables two control variables are statistically significant which are the INOEMP2_1 (β: +1.05093; $p<0.01$) and RDWORK1_log (β: +0.26056 ; $p<0.01$). The adjusted r-squared value which is consulted with smaller samples, is 0.59. Hence, the total variance explained by the model as a whole is 59%. This means percentage of innovative employment in total workforce and R&D personnel have statistically positive impact on the patent and utility model registration in 2019. As a result of this analysis, which aims to measure the impact of human capital on province-level innovation, it is concluded that the percentage of people working in innovative sectors among total workforce and the number of people working in R&D departments are more decisive in the context of innovation outputs of provinces compared to variables related to education.

Model 2

Model 2 for analyzing innovation output in terms of existing research capacity is constructed to answer the first research question which is “What are the key components contributing to province level innovation output in Turkey?” as shown schematically in Figure 5.3.

Multiple linear regression was used to assess the ability of six control measures (ACADEMIC_P, STU19, academic_p_perstudent, RDEXP1_log, UNI, RDC) to predict the dependent variable (TOTREG19_pop). Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Among six variables one of the control variables is statistically significant which is the RDEXP1_log (β: +0.69999; $p<0.01$). The adjusted r-squared value which is consulted with smaller samples, is 0.77. Hence, the total variance explained by the model as a whole is 77%. As a result of this analysis, which aims to measure the effect of research capacity on innovation, it is concluded that the R&D expenditures are more determinant in the context of innovation outputs of the provinces among the other research-related variables, which are the number of universities, academicians, students, and R&D centers.

Model 3

Model 3 for analyzing innovation output in terms of spaces and institutions is constructed to answer the first research question which is “What are the key components contributing to province level innovation output in Turkey?” as shown schematically in Figure 5.3.

Multiple linear regression was used to assess the ability of seven control measures (UNI, OID, SME1_log, RDC, DC, TDZ, NGO) to predict the dependent variable (TOTREG19_pop). Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Among seven variables one of the control variables are statistically significant which is the OID (β: +0.015649; $p<0.01$). The adjusted r-squared value which is consulted with smaller samples, is 0.75. Hence, the total variance explained by the model as a whole is 75%. As a result of this analysis, which aims to measure the effect of spaces on innovation, Organized Industrial Districts is more determinant in the context of innovation outputs of the provinces among the other space-related variables, which are universities, SMEs, R&D centers, design centers, technology development zones and NGOs.

Model 4

Model 4 for analyzing innovation output in terms of existing regional conditions is constructed to answer the first research question which is "What are the key components contributing to province level innovation output in Turkey?" as shown schematically in Figure 5.3.

Multiple linear regression was used to assess the ability of three control measures (GDPPC19, EXP1_log, POPDENSE19_log) to predict the dependent variable (TOTREG19_pop). Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Among three variables one of the control variables are statistically significant which are the GDPPC19 (β: +0.000009; $p<0.01$) and POPDENSE19_log (β: +0.159423; $p<0.01$). The adjusted r-squared value which is consulted with smaller samples, is 0.64. Hence, the total variance explained by the model as a whole is 64%. As a result of this analysis, which aims to measure the effect of existing regional conditions on innovation, economic development level and population density are more determinant in the context of innovation outputs of the provinces.

Model 5

Model 5 for analyzing innovation output in terms of all statistically significant variables contributing to regional innovation is constructed to answer the first research question which is "What are the key components contributing to province level innovation output in Turkey?" as shown schematically in Figure 5.3.

Multiple linear regression was used to assess the ability of seven control measures (INOEMP2_1, RDEXP1_log, GDPPC19, ENT2_1, OID, RDC, NGO) to predict the dependent variable (TOTREG19_pop). Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Among seven variables four of the control variables are statistically significant which are the GDPPC19 (β: +0.000005; $p<0.01$), ENT2_1 (β: +7.060971; $p<0.01$), OID (β: +0.015158; $p<0.01$) and RDC (β: +0.001545; $p<0.01$). The adjusted r-squared value which is consulted with smaller samples, is 0.79. Hence, the total variance explained by the model as a whole is 79%. As a result of this analysis, which aims to measure the effect of overall contributing variables on innovation, economic development level, newly established innovative enterprises, Organized Industrial Districts and R&D centers are more determinant in the context of innovation outputs of the provinces.

As a result of global models, the key variables affecting the innovation output at the province level are listed as employees in innovative sectors and R&D departments, R&D expenditures, OIDs, R&D centers, economic development level, population density and newly opened innovative enterprises.

The results of these five different OLS global models show the diversity of values affecting innovation in the context of Turkish provinces and the need for developing local models. Local models, differing from the global OLS models such as GWR models, generate a calculation for every feature/polygon in the dataset, adjusting each one using the target feature and its neighbors. Geographically weighted regression models are constructed to answer the second research question of "What is the relationship between innovation output encouraging key components and space at the province level in Turkey?".

First, the spatial autocorrelation of the dependent variable, which is the indicator of the innovation output in the analyses, was examined. According to the global Moran's index, the probability that the clustering of the dependent variable is the result of random chance is less than 1% with a z-score of 5.968926. Global Moran's I value for dependent variable is total registration of patent and utility model by population in 2019 is 0.40 (Table 5.18 and Figure 5.4). Moran's I value is in the 99 percent confidence level. Hence, the dependent variable TOTREG19_pop tends to cluster similar values with a Moran's index of 0.40.

Table 5.18. Global Moran's Index for dependent variable (TOTREG19_pop)

Moran's Index	0.401047
Expected Index	-0.012500
Variance	0.004800
z-score	5.968926
p-value	0.000000

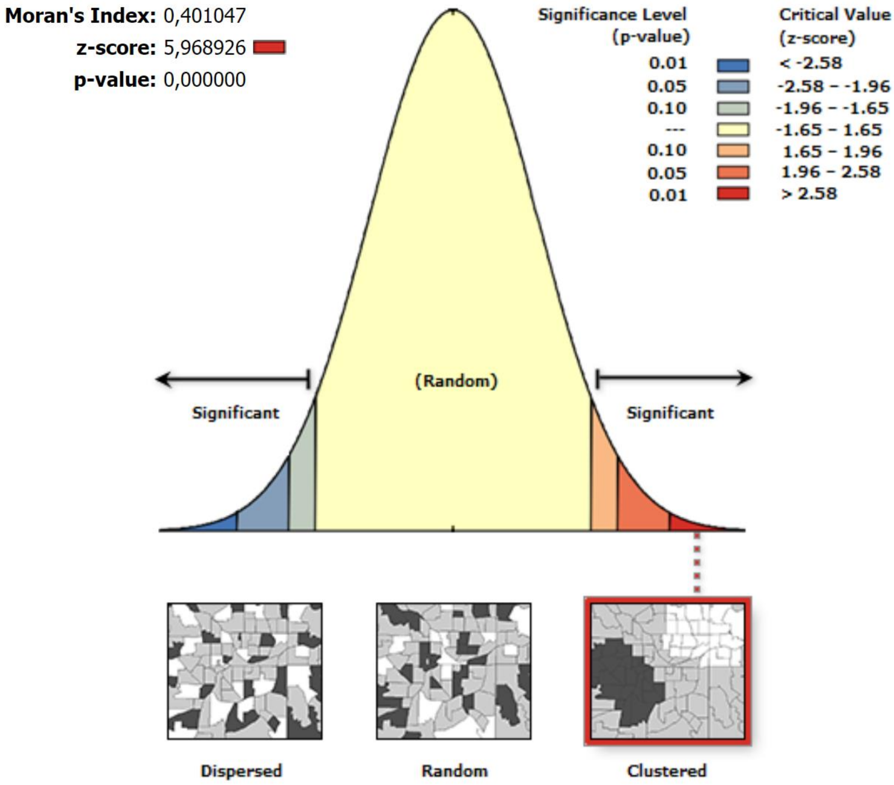

Figure 5.4. Spatial autocorrelation report for dependent variable (TOTREG19_pop)

GWR

After measuring the spatial autocorrelation of the dependent variable, a regression model with key variables contributing to the province-level innovation was built in ArcGIS Pro program as GWR. Local r-squared values take a value between 0 and 1, showing how well the local regression model fits the observed y values. High values indicate that the local model performs well. The locations of the good or bad predictions of the GWR model can be visualized by mapping and providing an idea about the variables that are likely to be missing in the whole model (Fotheringham et al., 2002).

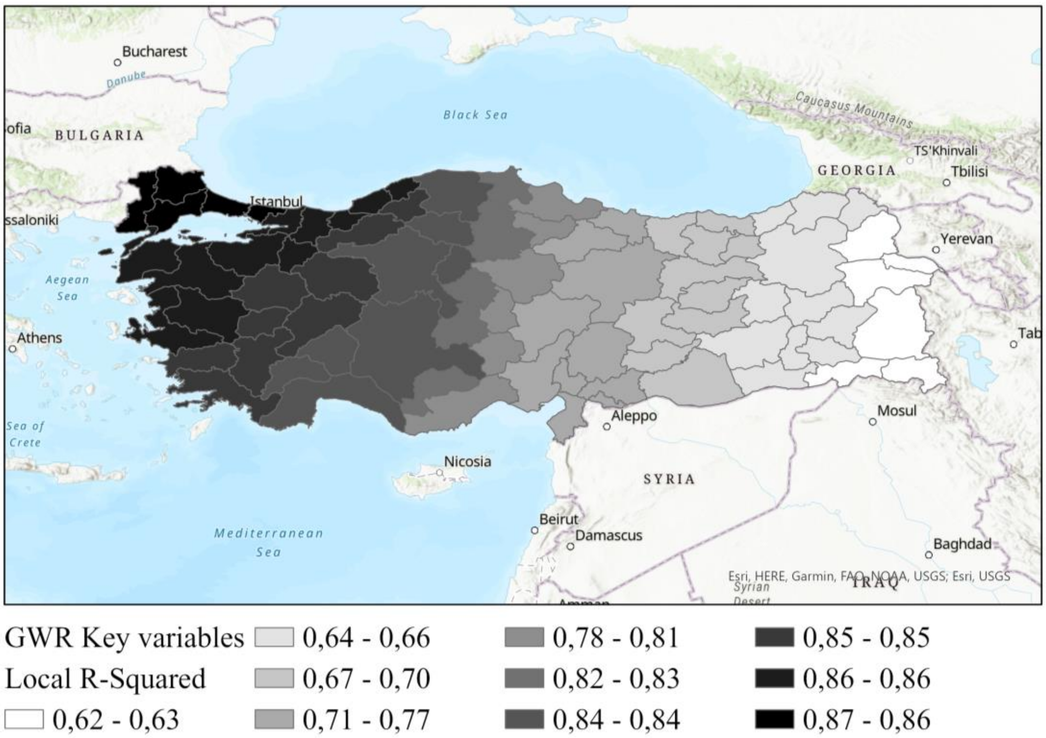

Figure 5.5. GWR model map of local r-squared values

As seen in the Figure 5.5, the geographically weighted regression shows that local r-squared values explain up to 85% of the total variance on the surrounding area of İstanbul, in other words North-Western part of Turkey. This explanation rate decreases towards 62% towards the eastern provinces.

Afterward, the effect of each of the variables used in the definition of regional innovation on innovative output is examined using the geographically weighted regression via creating coefficient raster surfaces (Figure 5.6), total for the model and individually for the key variables. The geographically weighted effects of all variables on innovative output, from the percentage of the innovative workforce in the province to R&D expenditures, from the number of OID and RDC to the number of new innovative enterprises, were examined. The explanatory value of the effect of each of the variables on the innovative output varies according to the location of the provinces. Looking at the coefficient raster surfaces and local r-squared values, it is seen that the variables examined mainly tend to explain the innovative outputs in the West and North West provinces more compared to the rest. For sure, there are limitations on the interpretation of r-squared values that are discussed in the next section.

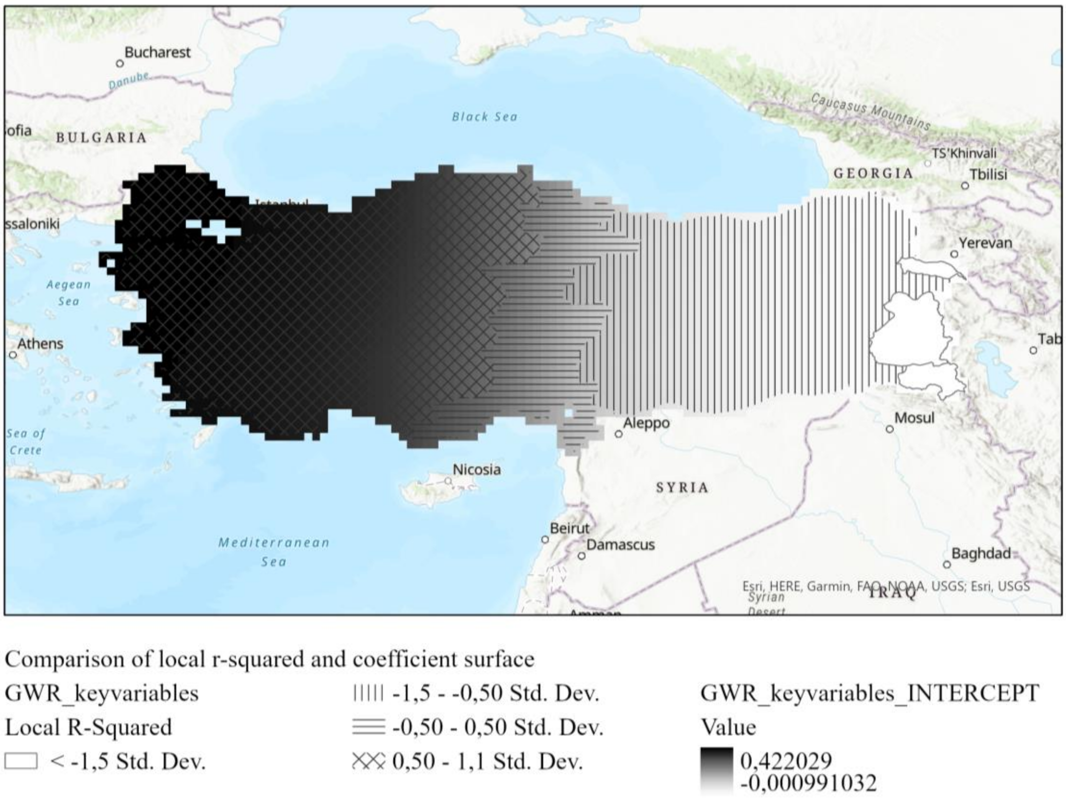

Figure 5.6. Comparison of local r-squared values and coefficient surfaces

This map (Figure 5.6), which was created to compare local r-squared values and intersecting coefficient surfaces, shows that the created local model has differences in the geographical context in affecting the innovation output. This difference is seen by grouping the local squared values by standard deviation and overlapping the created coefficient raster surfaces. Local r-squared values shown with scans on the map are divided into 4 groups. Areas with no scans are below -1.5 standard deviations, while vertically scanned areas are areas with local r-squared values between -1.5 and -0.5 standard deviations. Horizontal scans show areas with values between -0.5 and +0.5, while crosshatch fill scans indicate areas with local r-squared values between +0.5 and +1.1 standard deviations. Local r-squared values of the

GWR model increase from non-scan areas to crosshatch-filled areas, and the explanatory power of the variables included in the model also increases. On the other hand, the change from black to white colors shown on the map shows the differences in the intercepting coefficient raster surface. When the values shown with colors and scans are overlapped, it is observed that the surfaces formed by the variables vary in geographical context, even outside the provincial borders. It is vital to interpret these changes, geographical location in Turkey is important in models constructed with variables that affect regional innovation.

Additionally, the R&D employees (RDWORK1_log), the percentage of innovative enterprises in new enterprises (ENT2_1), SMEs (SME1_log), RDC, and NGOs as the chambers of commerce and trade (NGO) show high values in terms of local r-squared values in explaining local models.

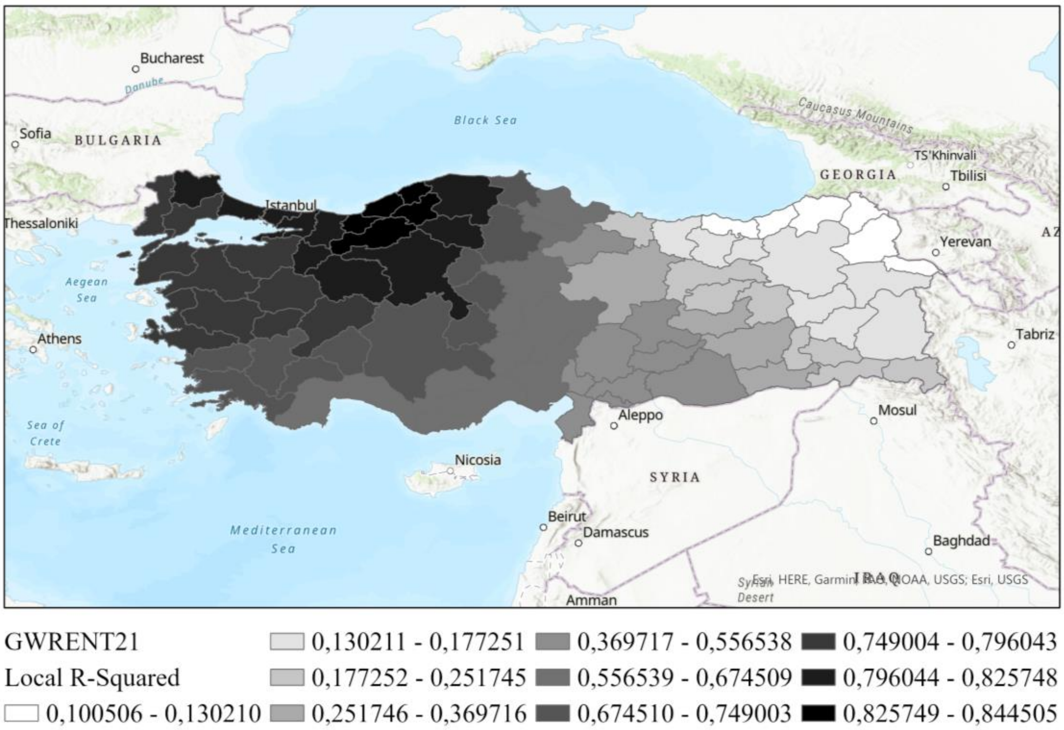

Figure 5.7. GWR local r-squared values map of ENT2_1 variable

For example as seen in Figure 5.7, the transitions from dark to light colors on the map show the spatial variation of the innovative new enterprise percentage variable on innovative output. The percentage of innovative new enterprises in the darkest-colored provinces, taken into consideration individually, explains innovative output by 82% towards 84%.

Local Moran's I

Anselin Local Moran's Indexes are constructed to answer the third research question. Research Question 3 is "Which key components show spatial dependency differences at Turkish NUTS 3 regions in explaining the innovation output?".

Anselin local Moran's I values are calculated in order to find out clusters and/or outliers in terms of regional innovation in provinces. The map (Figure 5.8) shows provinces with p-values and z-scores calculated automatically. The ones with p-value is lower than 0.05 (95 percent confidence level) are classified as clusters. The rest is not significant due to high p-values which means that not statistically significant. The cluster/outlier type field, calculated in attribute table, distinguishes between a statistically significant cluster of high values (HH- high high), cluster of low values (LL- low low) on the one hand; on the other hand, outlier in which a high value is surrounded primarily by low values (HL- high low), and outlier in which a low value is surrounded primarily by high values (LH- low high).

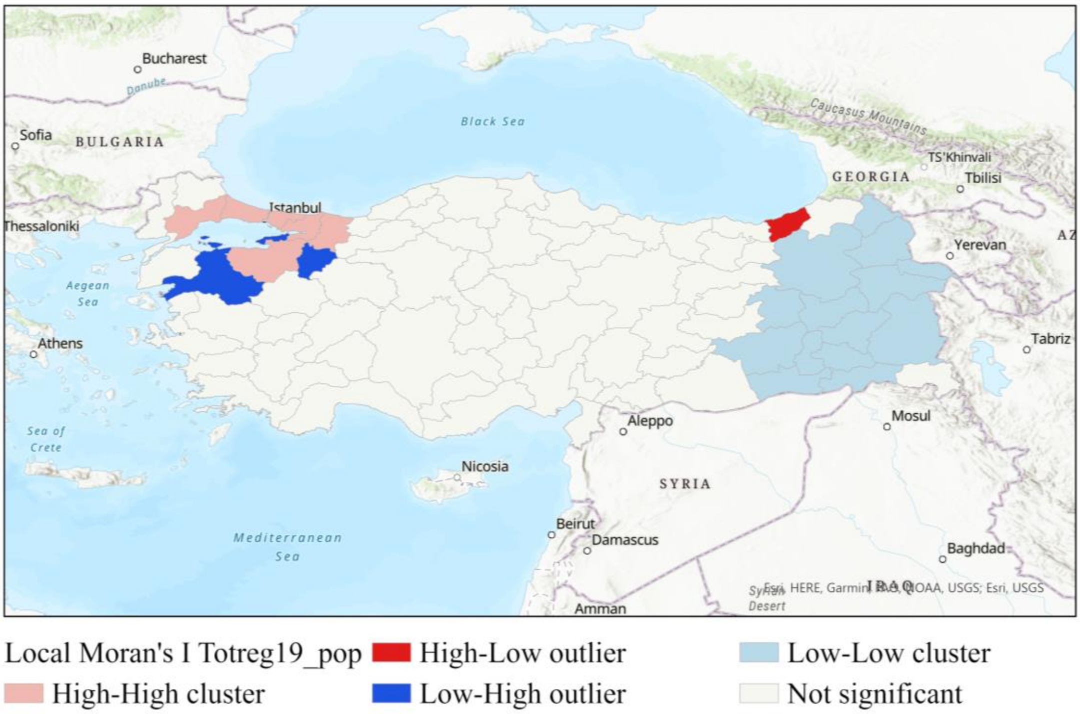

Figure 5.8. Cluster and Outlier Analysis (Anselin Local Moran's I) for dependent variable (TOTREG19_pop)

In order to interpret the results of Figure 5.8, Tekirdağ, İstanbul, Kocaeli, Sakarya and Bursa form high innovation cluster while Eastern provinces are clustered in a low innovation manner. Nevertheless, there are outliers such as Balıkesir, Yalova, Bilecik forming Low-high outliers in other words low values are surrounded primarily by high values. Rize is a high-low outlier which means a high value of innovation that surrounded primarily by low values in its surrounding area. The fact Rize is a high-low outlier that the province has a total of 16 patent and utility model registrations in 2019 and is the large difference among the surrounding provinces. These 16 registrations are listed based on sectors as two in machinery, four in other manufacturing, and 10 in food products. On the other hand, Ardahan, Erzurum, Kars, Iğdır, Ağrı, Van, Bingöl, Muş, Bitlis, Siirt, Diyarbakır, Mardin, Şırnak and Batman show significant clustering of low values. This map shows the patent and utility model registrations in 2019, which is also the dependent variable of the analyses.

For a more comprehensive idea, since the number of patent and utility model registrations in the data set covers 10-year span, the change of clusters and outliers in this 10-year span has been examined.

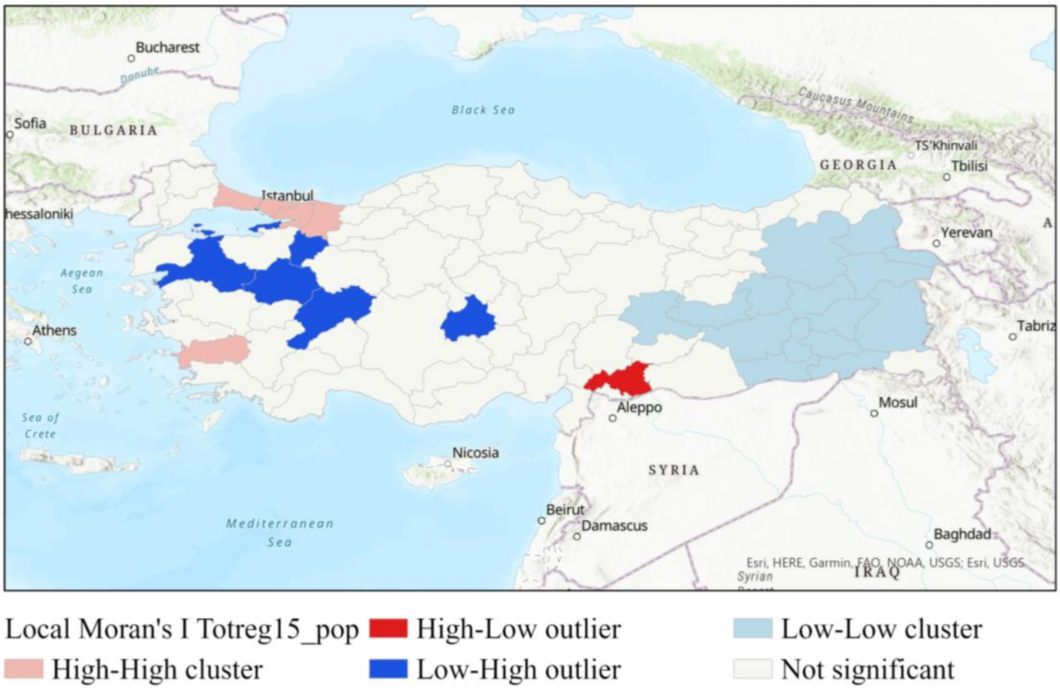

Figure 5.9. Cluster and Outlier Analysis for total patent and utility model registrations according to population in 2015

For example, in the analysis of 2015 (Figure 5.9), it is observed that the provinces with high values are clustered around İstanbul, while the provinces with low values are the ones in the east of Turkey. It is also observed that Aydın has a high value. The provinces surrounded by these high values but with low outliers are Balıkesir, Yalova, Kütahya, Afyonkarahisar and Aksaray. The province with the highest outlier value compared to the surrounding provinces in the southeast is Gaziantep.

In order to talk about the prominent provinces in the 10-year span, it is observed that clusters with high values continue to exist in and around İstanbul. In addition to this group, Aydın stands out in some years. It is seen that Eskişehir, Afyonkarahisar, and Balıkesir provinces are also added to the cluster with high values in 2017. Clustering of low values has been observed in eastern Turkey over the past 10 years. Gaziantep and Rize come to the fore among the provinces with higher outliers compared to the surrounding provinces. The reason for this is that they have more patent and utility model registrations in certain years than the neighboring provinces. Another important finding is that the provinces of Yalova, Balıkesir, Kütahya, Bilecik, Aksaray, and Afyonkarahisar, which are adjacent to high-value clusters, are outliers with low values.

When the spatial dependencies of the key variables from the global model that have an impact on the innovation output in Turkish provinces are examined, provinces with clustered and outlier values are observed. Cluster and outlier analyzes were carried out using the most recent data of 2019 since data from different years are not available for other variables.

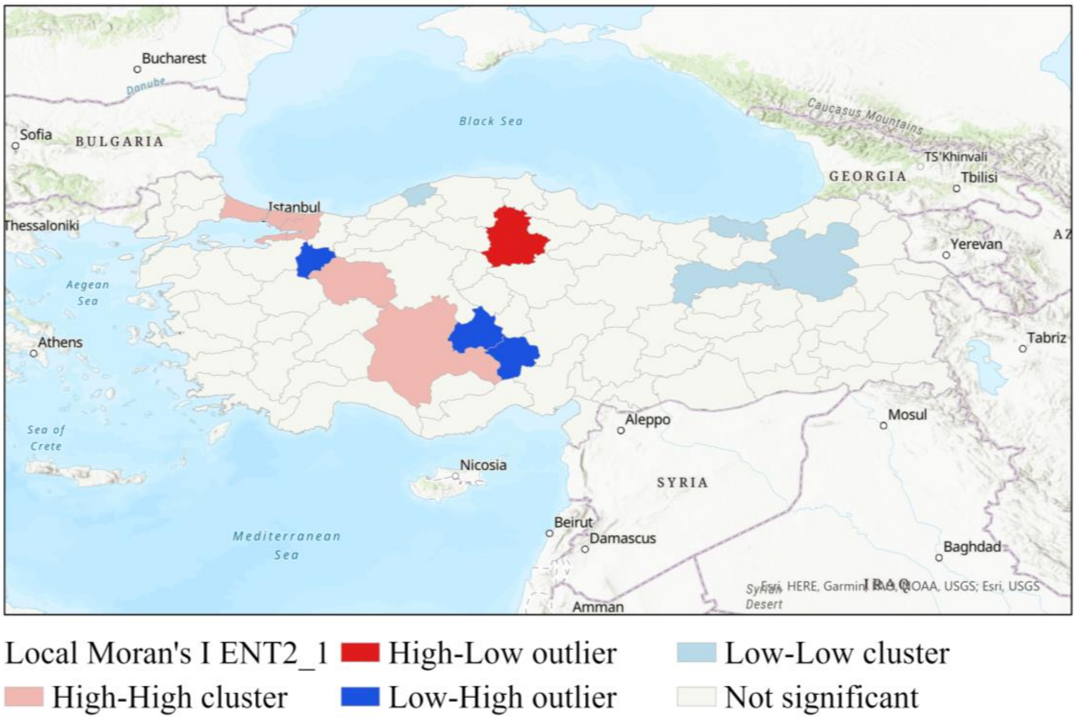

Figure 5.10. Local Moran’s I values for ENT2_1 variable

In the context of spatial autocorrelation, the variable of percentage of new innovative enterprises (Figure 5.10) shows a high clustering tendency in İstanbul, Kocaeli, Yalova, Eskişehir, and Konya provinces, while low clustering in Bartın, Trabzon, Erzincan, and Erzurum provinces. Çorum, which is an outlier, is expressed with a high-low value since it has a relatively higher value than the surrounding provinces for this variable.

The following variable of the number of OIDs shows a high clustering tendency in Kırklareli, İstanbul, Kocaeli, Sakarya, Yalova, Bolu, Bilecik, Bursa, Eskişehir, Balıkesir, Denizli, Ordu and Gaziantep provinces; while low clustering in Erzincan, Tunceli, Elazığ, Bingöl, Erzurum, Muş, Kars, Iğdır, Ağrı, Bitlis, Van, Batman, Siirt and Şırnak provinces (Figure 5.11). Çanakkale and Eskişehir, which are outliers, are expressed with a low-high value since they have relatively lower values than the surrounding provinces for this variable. Kastamonu, Trabzon, Yozgat, Sivas, Kahramanmaraş and Adana, which are other outliers, are expressed with a low-high value since they have relatively higher values than the surrounding provinces for this variable.

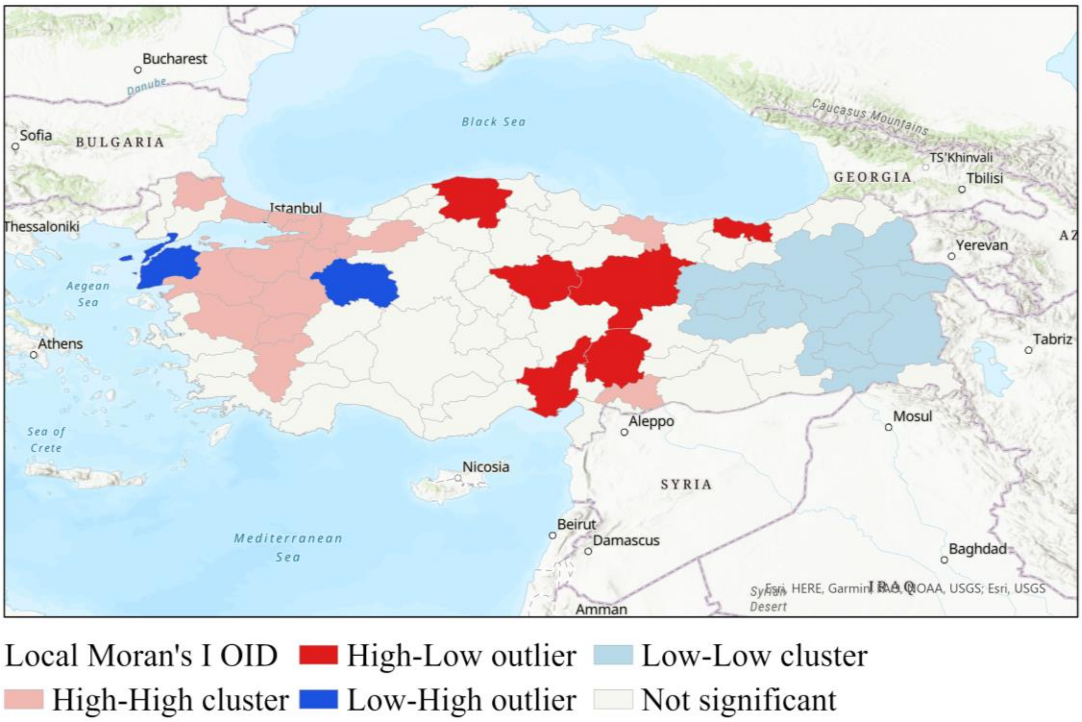

Figure 5.11. Local Moran’s I values for OID variable

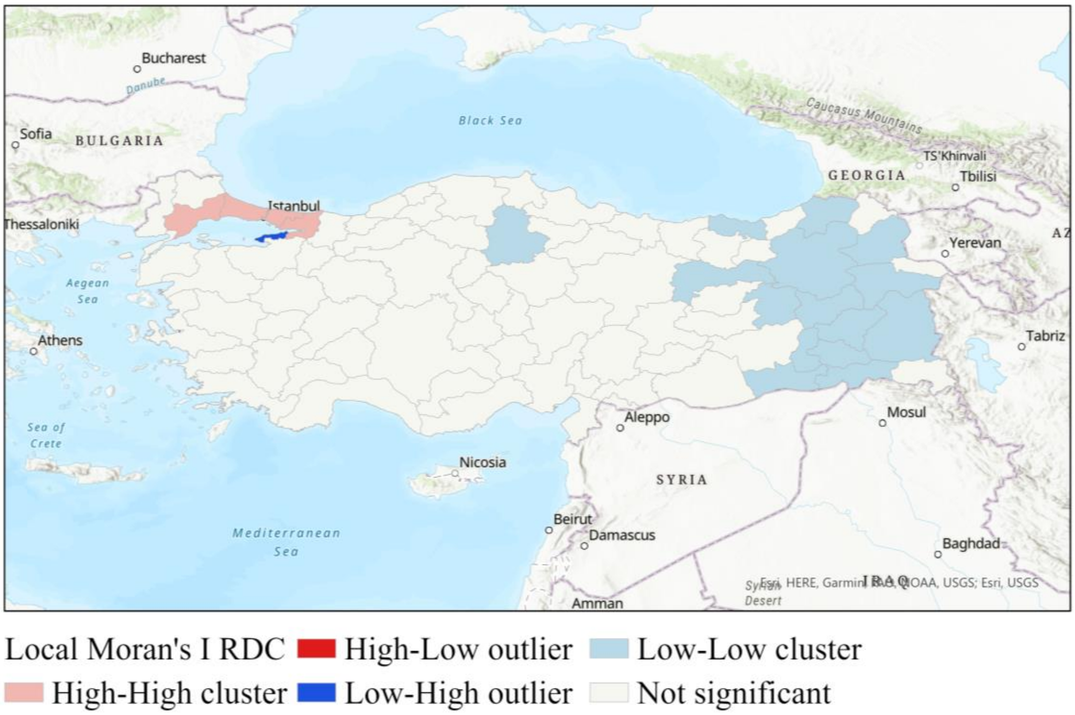

Figure 5.12. Local Moran’s I values for RDC variable

Especially as seen on the map, the impact of Research and Development centers (Figure 5.13) on innovation output for eastern provinces is very low compared to western provinces. This result leads to make the following type of inference. Increasing the number of Research and Development centers that have been concluded to contribute to innovation does not lead to an increase in innovation output at the same rate in every province. Steps can be taken about RDCs considering their impact on innovative outputs and their current deficiencies (Figure 5.12) in number.

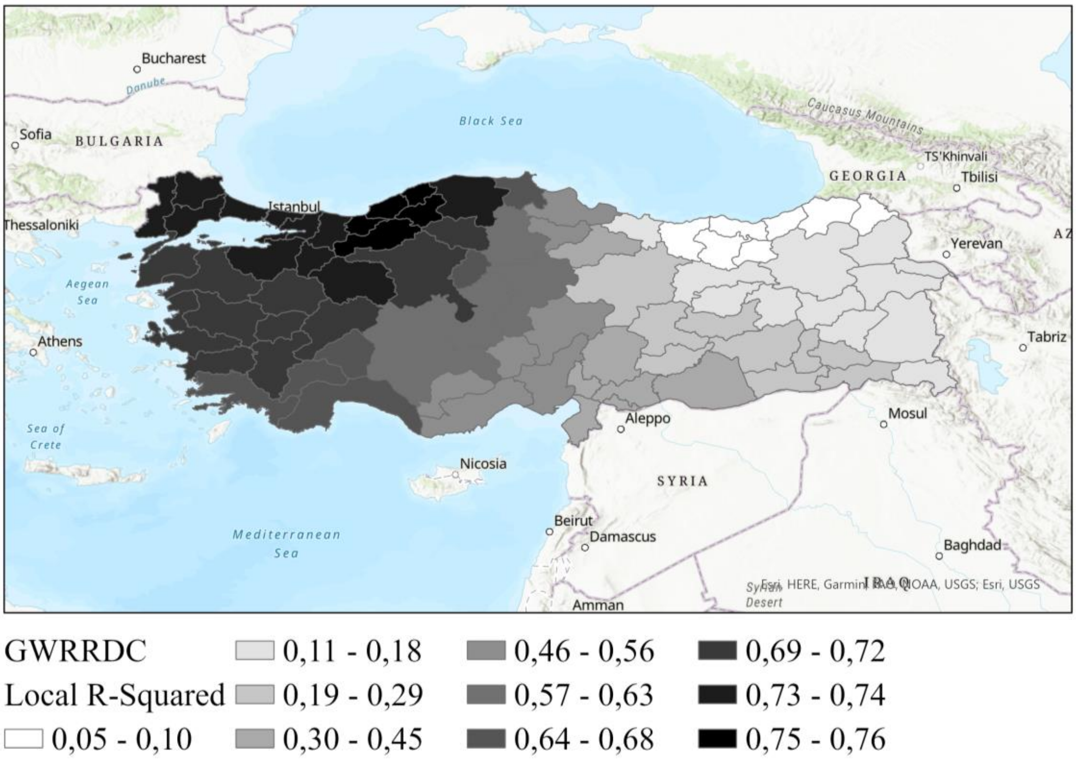

Figure 5.13. GWR local r-squared values map of RDC variable

As for conclusion and a respond to the third research question, in some regions, high and low values are seen to be clustered. On the other hand, it has been observed that some provinces have outlier values, as having different values with the surrounding provinces. In addition, it is useful to analyze both the existing capacities that are expected to result in innovative output and the impact of these capacities on these outputs together and individually.

In order to avoid making generalizations with OLS models that have static and consistent explanatory approach for the entire study area, GWR, global and local spatial autocorrelation models are implemented. AIC values of each model is provided (Table 5.19). The purpose of the comparison between models according to AIC values is to estimate the loss of information that occurs while constructing each model (Wagenmakers and Farrell, 2004).

Table 5.19. Comparison of AICc values of models

Model	**AICc**
Model 1	-74.479718
Model 2	-117.947650
Model 3	-108.999376
Model 4	-85.558625
Model 5	-124.321375
GWR	-117.3868

As the number of variables increases, the loss of information also increases. This may be due to the similarities (multicollinearity) between the variables. Since the data sources at the province level are limited, such models were applied with the existing data. From another point of view, it is observed that the local model (GWR) has less information loss compared to the global model (Model 5). This reveals the importance of including local models as well as global models.

5.6 Method limitations

In addition to the limitations related to the thesis in general mentioned in the introduction chapter, additional limitations related to the method part are discussed in this subsection. There are details to be considered while interpreting the local r-squared values in the GWR analysis results. Local r-squared values show both how sound the model can replicate the available data and how fixed the procedures in the model can be predicted (Fotheringham et al., 2002).

Within the scope of the GWR analysis, areas with high variable values indicate a strong association between the dependent variable and the explanatory variables. However, this strong association does not necessarily indicate spatial autocorrelation (Getis, 2010). In order to overcome this obstacle, coefficient surfaces were also created for each variable and the total model and compared with local r-squared values. Additionally, both GWR results and Anselin Local Moran's I results were examined.

Research and development employment and expense data is transformed from NUTS 2 level since the unavailability of the data at NUTS 3 level. Expenses are weighted by the GDP per capita of each province. Employment is weighted by the total province employment.

Local models have limitations as well as the global model. This research aims to show that modeling at different scales leads to different discussions, rather than presenting one approach can produce better predictions than the other. As Fotheringham et al. (2002) state that local models analyze diversity in local situations, reveal the possibility that the global model may misidentify this diversity, drives the development of global models, and opens up dialogues that global models do not start.

CHAPTER 6

CONCLUSION

In the conclusion chapter of the research, key findings are presented. There are also some suggestions for policy making and future studies as a result of the existing circumstances assessment of the whole research in Turkish province level innovation. There are four main subsections to be discussed. First of all, summary of innovation approaches in Turkey is provided. Secondly, there are a number of key findings in order to present the regional innovation condition in Turkey in the light of the statistical research models. Afterward, some recommendations for regional innovation discourse in Turkey are provided. At last, further reseach aspects are discussed.

6.1 Summary of approaches in Turkey to the topic

The conclusion drawn from the part in this thesis examining the approach to innovation at the national level indicates that the public-dominated control of the market in Turkey prevents the creation and development of the concept of innovation, which, in essence, embraces radical changes of the existing systems. For Turkey, which is in the emerging innovator group among the current innovation groupings among other European countries, especially in 2021, the decrease in applications for the registration of innovation in forms of patent and design, the scarcity of enterprises providing ICT training, and the lack of environmental technologies have led to a decrease in innovation performance.

Several academic research contributes to this discussion. The majority of industrial production in Turkey consists of sectors that do not require high skills and knowledge, and therefore, lagging behind in technological developments. Due to this lack of development, the competitive advantages of the regions are low. It has been suggested that the dynamics of the manufacturing industry should be well understood and supported by technology-intensive sectors where applicable, as well as the spaces such as technology development zones.

Regional innovation strategies and plans prepared by regional development agencies are additionally evaluated in terms of both their strategic and institutional dynamics and their relations with technology and innovation principles. Main strategy is to increase the R&D expenditures and the number of researchers within the regions in order to support regional innovation. From sectoral perspective, most of the supported sectors are mainly labor-intensive sectors. The machinery manufacturing sector is the lead among all the other supported sectors. For the case of actors, most documents recommend strengthening inter-institutional cooperation, but only a few develop detailed strategies on how to strengthen this cooperation. In order to compare the national and regional approaches, it is observed that public-oriented innovation strategies are not abandoned on national level. In addition, local strategies are not developed in detail sufficiently.

6.2 Key findings

The structural requirements for the innovation outputs of the provinces in Turkey are examined with research models by asking these research questions.

Research Question 1: What are the key components contributing to province level innovation output in Turkey?

Research Question 2: What is the relationship between innovation output encouraging key components and space at the province level in Turkey?

Research Question 3: Which key components show spatial dependency differences at Turkish NUTS 3 regions in explaining the innovation output?

This research measures the effects of structural and territorial variables that play a role in innovation at the regional level in Turkey. The variables affecting innovation are not the same in every province. The global regression model is constructed to obtain a common average for all provinces. Testing the results from the global model locally provides more knowledge specific to the provinces.

Among all other variables, according to the results of the global model, the key components that have a positive effect on innovation output in Turkish provinces can be named as employees in innovative sectors and R&D departments, R&D expenditures, OIDs, R&D centers, economic development level, population density and newly opened innovative enterprises. Examining all of these key components and individually with geographically weighted models shows that space have different effects on innovative output. In general, the percentage of R&D employees among all employees, the percentage of innovative enterprises in new enterprises, SMEs, RDCs, and NGOs such as chambers of commerce and trade show high values in terms of local r-squared values in explaining local models.

According to the overlapped values from local models, the variables vary in geographical context, even outside the provincial borders. It is vital to interpret the changes, geographical location in Turkey is important in models constructed with variables that affect regional innovation. Correspondingly, the determination of the variables included in the innovative output of a region and the current conditions in terms of those variables are thoroughly examined, and the regional innovation issue is addressed.

The distribution of the variables to the provinces and their effects on the innovation output vary in different provinces. For this reason, the strategies should be developed by applying both global and local models. Increasing the variables that affect the innovation output in numbers or percentage does not necessarily lead the same results in every province in Turkey.

6.3 Recommendations for regional innovation discourse in Turkey

Due to the decline in patent applications in recent years, the decrease in the training provided by enterprises in the field of ICT and the lack of development of environmental-related technologies, Turkey has to develop a more local perspective on the determinants of regional innovation beyond the classification of provinces and regions. Since the innovation outputs are directly related to the production and space, the policies to improve regional innovation should be designed by considering the forms of production, technology and R&D intensities of the sectors in provinces and regions.

It is seen that the state dominates national innovation strategies and local enterprises. Although regional innovation strategies prepared by regional development agencies are a starting point, these supports are still public-oriented. While the government support given to private sector R&D is not denied, there is still a need for attracting exogenous resources such as capital and R&D in order to catch up with the worldwide trends.

Understanding the existing local capacity is beneficial in the promotion of place-based innovation policies for Turkey. Research in many different fields requires data on a regional scale. The most important thing that needs to be developed in Turkey in this area is to produce policies to ensure consistency within the scope of inter-institutional data collection and storage.

For analysis methods, general and local models should be utilized to better understand regional innovation dynamics. It would be more effective to create development strategies by considering the unique characteristics of the places.

It is observed that the variables affecting innovation in Turkey are not distributed according to a pattern in the space. There are inequalities in the distribution of innovative outputs. The clustering of high values in the West and low values in the East is in line with the results of East-West development differences in Turkey so far. However, the fact that some provinces have outliers can be considered as a guide to improve and increase innovation from these outliers. For example, in order to benefit from the relatively more developed infrastructures of neighboring provinces, policies can be developed to increase resource sharing and cooperation between provinces with preconditions such as NUTS 2 classification or border sharing.

6.4 Further research

In the Turkish literature, there are studies that classify regions and provinces in the context of innovation and competitiveness. Such analysis of the factors that support regional innovation at the province level in Turkey has not been made in this detail and perspective according to the review has been done herein. Although, recently, research on regional scales in different disciplines has increased. Despite data limitations, there are attempts in the context of statistical models. It is observed that approaching regions from a quantitative perspective has the potential to provide input to qualitative discussions.

The spatial approach can be diversified via the inclusion of the different methodologies. From province to firm perspectives, novel datasets should be provided. A longitudinal research approach has potential in case there are existing data for the case of Turkish provinces. In case data is unavailable, data collection for extended periods should be encouraged. Using such a comprehensive approach would give more insights into the causes of annual changes.

There is an increased need to create a database to be used in regional innovation studies in Turkey. Through such databases, more detailed and more efficient analysis models are constructed in the worldwide literature to analyze the change over the years. In addition to the patent data, other variables affecting innovation detailed and explained in the thesis had to be observed and recorded in the Turkey case. The possible creation of these databases is expected to contribute significantly to the development of place-based innovation policies. Annual and location-dependent changes and different effects would provide the basis for stakeholders in the region to produce target-driven policies instead of making one-size-fits-all policies.

In conclusion, this study aims to constitute a base for future studies in the field. There is a clear need for data comparability to conduct more thorough analyses. Therefore, the methods of collecting/producing, and publishing the data used in the thesis and obtained from various institutions should change to contribute to future research. For example, if collected and shared systematically, patent citation data allows the dissemination of knowledge and innovation to be measured. Retrospective research could be done if, for example, more detailed data about the registration processes of patents and utility models. Suppose the data on the institutions, locations and partners of the patent and utility model owners are expanded. In that case, more comprehensive studies can be carried out based on sectors and provinces for Turkey. The collection and availability of all these data would be beneficial both in providing practical input to academic research and policymaking.

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APPENDICES

Appendix A

Regional Innovation Determinants

Attributes	**Level**	**Measurement**
<u>INNOVATION</u>	Input Patent Application	+ *"Per million inhabitants"* (Sternberg and Arndt, 2001; Hauser et al., 2018; Miguelez and Moreno, 2018) +*"per 100,000 inhabitants"* (Gömleksiz and Özşahin, 2019) + *"Per 10,000 inhabitants"* (Hornych and Schwartz, 2009) + *"Per capita"* – [*Total number of patents / economically active working population aged 15 to 64 * 10,000] (Çelebioğlu, 2010; Ott and Rondé, 2019; Mewes and Broekel, 2020*) + "*Density*" [Per regional employment * 100] (Türkcan, 2015) + "*High-tech share*" [Total regional patents in high-tech classes divided by total

		number of regional patents * 100] (as defined by Eurostat (2016)] (Mewes and Broekel, 2020) + *"Per billion GDP"* (Lopes et al., 2021) + "*Per regional Gross Added Value"* (Cabrer-Borras and Serrano-Domingo, 2007)
	Output Patent registration	+ *"Per million inhabitants"* (Furman et al., 2002; Börü et al., 2020) + *"Per 100,000 inhabitants"* (Araújo and Garcia, 2019) + *"Share of regional patents normalized by population"* (Capello and Lenzi, 2013) + *"High-tech share"* (Pinto and Guerreiro, 2010)
	Input+Output	+ *Both* [Total number of patent and utility model application and registration per 1000 people]

		(Kutgi and Işık Maden, 2020)
	Patent + Others	+ "Trademark Application or Registration" (Akpınar et al., 2015) + "Patent and utility model mean values" (Gezici et al., 2021)
	Capacity	+ "*Patent stock*" (cumulative patents) (Furman et al., 2002) + "*Capacity*" [Earlier filed patents] (Thakur and Malecki, 2015)
	Patent Success	+ "*Patent registration/Patent application*" (Çetin and Erdil, 2020)
	Spatial Spillover	+ "*The number of innovative firms in functional region*" (Tavassoli and Karlsson, 2021) + "*The average of neighbor's patents per capita*" (Gonçalves and Almeida, 2009)
	Patent Quotients	+ "*Innovative specialization index*" [(Regional patent application in sector i / Total regional patent application) /

		(Total country patent application in sector i / Total country patent application)] (Altuğ and Şahin, 2017) + “*Technological specialization index of general purpose technologies – 30 IPC sectors”* (Capello and Lenzi, 2013)
HUMAN CAPITAL	Education	+ “*Percentage of people completed tertiary education (ages from 25 to 64)”* (Sternberg and Arndt, 2001; Crescenzi et al., 2007; Gonçalves and Almeida, 2009; Capello and Lenzi, 2013; Hauser et al., 2018; Capello and Lenzi, 2019; Gömleksiz and Özşahin, 2019; Börü et al., 2020; Kutgi and Işık Maden, 2020; Mewes and Broekel, 2020) + “*Percentage of people completed post-secondary education (Masters and PhD degree – ages of 15+)”* (Akpınar et al., 2015; Kutgi and

		Işık Maden, 2020; Ganau and Grandinetti, 2021) + "*Literacy rates*" (Çelebioğlu, 2010) + "*Number of bachelor students*" (Ott and Rondé, 2019) + "*Ratio of university graduates and academic stuff*" (Gezici et al., 2017; Gezici et al., 2021) + "*Percentage of people who participated Life-long learning*" (Oerlemans et al., 2001; Crescenzi et al., 2007; Ganau and Grandinetti, 2021)
	Employment	+ "Share of regional population with higher education (within the group of workers aged 25+)" (Cabrer-Borras and Serrano-Domingo, 2007; Crescenzi et al., 2007; Kutgi and Işık Maden, 2020; Grillitsch et al., 2021) + "*Share of science and technology employment*" (Furman et al., 2002; Capello and

		Lenzi, 2013; Miguelez and Moreno, 2018; Capello and Lenzi, 2019) + "*Share of inventors*" (Capello and Lenzi, 2013)
	Products	+ "percentage of people with tertiary education, attractiveness of the university system i.e. students' net migration rate, lifelong learning i.e. percentage of adults 25-64 who attend educational and/or professional courses over total population 25- 64)" (Ascani et al., 2020)
R&D	Input (Expense)	+ "*Share of regional R&D expenditure on GDP*" (Sternberg and Arndt, 2001; Moreno et al., 2005; Crescenzi et al., 2007; Capello and Lenzi, 2013; Malik, 2019; Ascani et al., 2020) + "*Share of R&D expenditures over gross added value*" (Cabrer-Borras and

		Serrano-Domingo, 2007) + "Private sector, government, higher education R&D expenditures" (Furman et al., 2002; Hauser et al., 2018) + "Per capita regional R&D expense" (Miguelez and Moreno, 2018) + "*Patent applications per million inhabitants in the province"* (Albahari et al., 2018)
	Input (People - Employment)	+ "R&D employees – high & medium level technology, having tertiary degree in engineering or in the natural sciences" (Pinto and Guerreiro, 2010; Fritsch and Slavtchev, 2011; Çetin and Kalaycı, 2016; Tavassoli and Karlsson, 2021) + "*Industrial R&D of a region –* percentage of employees in manufacturing and mining ('engineer', 'chemist',

		'physicist', 'mathematician' or 'other natural scientist') working and acting in R&D activities per total employees - the share of workers occupied in R&D" (Hornych and Schwartz, 2009; Araújo and Garcia, 2019)
	Input (People – Science/Graduate)	+ "*University research capacity* – PhD research staff at Master's and doctorate courses" (Gonçalves and Almeida, 2009)
	Output	+ "*Scientific publications* per capita or share of regional R&D expense" (Lenger, 2008; Ott and Rondé, 2019; Börü et al., 2020) + "*(product)* most-cited publications, public-private co-publications, and international scientific co-publications" (Ganau and Grandinetti, 2021) + "*Scientific projects ARDEB"* (Kutgi and Işık Maden, 2020)

	Products	+ "*University R&D* - RDU_prof (Number of university professors with full dedication per 10,000 inhabitants) + RDU_stu (Number of students in master's, doctoral or post-doctoral programmes per 10,000 inhabitants)" (Araújo and Garcia, 2019)
<u>LOCAL STRUCTURE/SETTING</u>	Economy	+ "*Regional GDP*" (Crescenzi et al., 2007) + "*GDP per capita*" (Alkay and Hewings, 2012; Albahari et al., 2018; Ganau and Grandinetti, 2021) + "*Share of gross capital formation in GDP*" (Börü et al., 2020)
	Socio-economy	+ "*SEGE index numbers*" (Gönül and Erkut, 2019)
	Population	+ "*Density*" (Moreno et al., 2005; Fritsch and Slavtchev, 2011; Yıldırım et al., 2020; Mewes and Broekel, 2020; Grillitsch et al., 2021)

		+ “*Regional size heterogeneity”* (Ganau and Grandinetti, 2021) + “*Age* – People aged 15-24 as % of total population” (Crescenzi et al., 2007) + “*Growth* – labor input” (Börü et al., 2020)
	Production and Labor	+ “*Manufacturing* – firm size” (Fritsch and Slavtchev, 2011; Gezici et al. 2021); share of manufacturing employment [*Employees in manufacturing divided by total number of employees * 100] (Sternberg and Arndt, 2001; Miguelez and Moreno, 2018; Hauser et al., 2018; *Mewes and Broekel, 2020; Grillitsch et al., 2021) + “*Unemployment rate”* [*Unemployed persons divided by economically active population * 100] (Crescenzi et al., 2007; Gömleksiz and

		Özşahin, 2019; Ascani et al., 2020; *Mewes and Broekel, 2020; Ganau and Grandinetti, 2021)
	Openness (Entrepreneurship, Competition and innovation)	+ “*New firms, start-ups”* (Gezici et al. 2021) + “*Establishments per worker”* (Grillitsch et al., 2021) + “*ICT enterprise share”* (Kutgi and Işık Maden, 2020) + “*Share of regional employment in high-tech technology sectors and knowledge-intensive services”* (Gezici et al., 2021; Grillitsch et al., 2021) + “Share of exports and exports per capita” (Akpınar et al., 2015; Sakarya and İbişoğlu, 2015)
<u>EXTERNALITIES</u>	Specialization/Diversification	+ “Krugman index of specialization” (Crescenzi et al., 2007; Araújo and Garcia, 2019) + “Other indexes” (Hornych and Schwartz, 2009; Gonçalves and Almeida, 2009;

		Ersoy and Taylor, 2012; Ascani et al., 2020)
	Agglomeration	+ "*Size* – number of hospitals" (Gonçalves and Almeida, 2009) + "*Population density of micro-regions and urban areas"* (Capello and Lenzi, 2013; Hauser et al., 2018; Araújo and Garcia, 2019) + "*Employment density per sq kms"* (Ganau and Grandinetti, 2021) + "*Total regional GDP/ Population density"* (Crescenzi et al., 2007)
	Urbanization	+ "*Number of universities"* (Alkay and Hewings, 2012) + "*Shares of industrial and service sector employment"* (Fritsch and Slavtchev, 2011; Alkay and Hewings, 2012) + "*Employment density* - the number of workers is divided by the square territorial area of the micro

		region” (Gonçalves and Almeida, 2009)
SPACES/INSTITUTIONS	Production	+ “*Organized Industrial Districts or Zones - OIDs or OIZs*” (Gezici et al., 2017) + “*SMEs”* (Ganau and Grandinetti, 2021) + “*Public and higher education laboratories”* (Ersoy and Taylor, 2012)
	Research and Technology	+ “*Universities”* (Oerlemans et al., 2001; Lenger, 2008; Çelebioğlu, 2010; Capello and Lenzi, 2013) + “*Research and Development Centers (RDC) and departments”* (Alkay and Hewings, 2012; Capello and Lenzi, 2013; Thakur and Malecki, 2015; Kutgi and Işık Maden, 2020) + “*Technology Development Zones (TDZ)”* (Lenger, 2008; Kutgi and Işık Maden, 2020) + “*Technology Development*

		Centers" (Lenger, 2008) + "*Techno-parks (performance index)"* (Gezici et al., 2021) + "*Design Centers (DC)"* (Kutgi and Işık Maden, 2020)
	Bridging	+ "*Innovation centres, business associations and private consultants"* (Oerlemans et al., 2001) + "*TUBITAK, KOSGEB"* (Lenger, 2008) + "NGOs" (Ersoy and Taylor, 2012)
<u>CONTROLS</u>	Population	+ Regional or province populations
	Employment/Sectors	+ "*Eurostat classification* based on technology and knowledge intensity" (Çelik et al., 2019) + "OECD classification based on high- and medium-high-technology manufacturing and knowledge intensive service sectors" (Ersoy and Taylor, 2012;

		Akpınar et al., 2015; Gezici et al., 2017; Miguelez and Moreno, 2018; Ganau and Grandinetti, 2021; Tavassoli and Karlsson, 2021; Lopes et al., 2021) + "*Pavitt sector dummy* - supplier dominated, scale-intensive, specialized supplier, science based sector" (Oerlemans et al., 2001; Çetin and Kalaycı, 2016) + "*Sectoral propensity to patent* –the share of employment in ten most patenting sectors" (Gonçalves and Almeida, 2009)
	Work place	+ Total work place + Sectoral work place

Appendix B

TPTO Registration Data Details

ID	ECONOMIC ACTIVITY	NACE Rev.2 (full i.e. division, group and class)	NACE Rev.2 (division only)
1	Manufacture of batteries and accumulators	27.20	27
2	Manufacture of basic metals	24	24
3	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	16	16
4	Printing and service activities related to printing	18.10	18
5	Manufacture of fasteners and screw machine products	25.94	25
6	Manufacture of other general-purpose machinery n.e.c.	28.29	28
7	Manufacture of other special-purpose machinery n.e.c.	28.99	28
8	Other manufacturing n.e.c.	32.99	32
9	Computer programming, consultancy and related activities	62.0	62
10	Manufacture of computers and peripheral equipment	26.20	26
11	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	20.30	20
12	Manufacture of steam generators, except central heating hot water boilers	25.30	25

13	Manufacture of office machinery and equipment (except computers and peripheral equipment)	28.23	28
14	Manufacture of glass and glass products	23.10	23
15	Manufacture of leather and related products	15	15
16	Manufacture of other electrical equipment	27.90	27
17	Manufacture of other fabricated metal products n.e.c.	25.99	25
18	Other manufacturing	32	32
19	Manufacture of other chemical products	20.5	20
20	Manufacture of other non-metallic mineral products n.e.c.	23.99	23
21	Manufacture of other taps and valves	28.14	28
22	Manufacture of other transport equipment	30	30
23	Manufacture of other special-purpose machinery	28.9	28
24	Manufacture of electricity distribution and control apparatus	27.12	27
25	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	27.10	27
26	Manufacture of electric lighting equipment	27.40	27

27	Manufacture of electronic components	26.11	26
28	Manufacture of loaded electronic boards	26.12	26
29	Manufacture of domestic appliances	27.5	27
30	Manufacture of ovens, furnaces and furnace burners	28.21	28
31	Manufacture of other general-purpose machinery	28.2	28
32	Manufacture of wearing apparel	14	14
33	Manufacture of food products	10	10
34	Manufacture of pesticides and other agrochemical products	20.2	20
35	Construction of utility projects	42.2	42
36	Manufacture of irradiation, electro-medical and electrotherapeutic equipment	26.6	26
37	Manufacture of wiring devices	27.33	27
38	Manufacture of other electronic and electric wires and cables	27.32	27
39	Manufacture of lifting and handling equipment	28.22	28
40	Manufacture of rubber and plastic products	22	22
41	Manufacture of rubber products	22.1	22
42	Manufacture of paper and paper products	17	17

43	Manufacture of machinery for paper and paperboard production	28.95	28
44	Manufacture of clay building materials	23.3	23
45	Manufacture of coke and refined petroleum products	19	19
46	Manufacture of watches and clocks	26.52	26
47	Manufacture of machinery for mining, quarrying and construction	28.92	28
48	Manufacture of magnetic and optical media	26.8	26
49	Manufacture of metal forming machinery and machine tools	28.4	28
50	Manufacture of tanks, reservoirs and containers of metal	25.2	25
51	Manufacture of structural metal products	25.1	25
52	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	25.5	25
53	Treatment and coating of metals; machining	25.6	25
54	Manufacture of furniture	31	31
55	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	28.11	28
56	Manufacture of parts and accessories for motor vehicles	29.3	29
57	Manufacture of motor vehicles	29.1	29
58	Processing of nuclear fuel	24.46	24

59	Manufacture of optical instruments and photographic equipment	26.7	26
60	Manufacture of perfumes and toilet preparations	20.42	20
61	Manufacture of explosives	20.51	20
62	Manufacture of plastic products	22.2	22
63	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	20.4	20
64	Manufacture of ceramic sanitary fixtures	23.42	23
65	Manufacture of weapons and ammunition	25.4	25
66	Manufacture of non-domestic cooling and ventilation equipment	28.25	28
67	Construction of water projects	42.91	42
68	Manufacture of man-made fibers	20.6	20
69	Manufacture of dairy products	10.5	10
70	Manufacture of agricultural and forestry machinery	28.3	28
71	Manufacture of textiles	13	13
72	Manufacture of machinery for textile, apparel and leather production	28.94	28
73	Manufacture of basic pharmaceutical products and pharmaceutical preparations	21	21

74	Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms	20.1	20
75	Manufacture of consumer electronics	26.4	26
76	Manufacture of tobacco products	12	12
77	Manufacture of medical and dental instruments and supplies	32.5	32
78	Manufacture of cutlery, tools and general hardware	25.7	25
79	Manufacture of cement, lime and plaster	23.5	23
80	Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	26.5	26
81	Manufacture of instruments and appliances for measuring, testing and navigation	26.51	26
82	Specialized construction activities	43	43
83	Manufacture of communication equipment	26.3	26
84	Manufacture of beverages	11	11

Appendix C

NACE IPC Concordance Table (WIPO, TPTO)

NACE Rev. 2	Economic activity	IPC Codes
10	Manufacture of Food Products	A01H, A01J, A21D, A23B, A23C, A23D, A23F, A23G, A23J, A23K, A23L 1-35, A23P, C12J, C13B, C13F, C13J, C13K
11	Manufacture of Beverages	A23L 2, C12C, C12F, C12G, C12H
12	Manufacture of Tobacco Products	A24B, A24D, A24F
13	Manufacture of Textiles	D04D, D04H, D06C, D06J, D06M, D06N, D06P, D06Q
14	Manufacture of Wearing Apparel	A41B, A41C, A41D, A41F
15	Manufacture of Leather and Related Products	A43B, A43C, B68B, B68C
16	Manufacture of Wood and of Products of Wood and Cork, Except Furniture; Manufacture of	B27D, B27H, B27M, B27N

	Articles of Straw and Plaiting Materials	
17	Manufacture of Paper and Paper Products	B42F, D21C, D21H, D21J
18	Printing and Service Activities Related to Printing	B41M, B42D, B44F
19	Manufacture of Coke and Refined Petroleum Products	C10G, C10L
20	Manufacture of Chemicals and Chemical Products	A01N-P, A61K 8, A61Q, A61D, B01J, B09B-C, B27K, C01B-C-D-F-G, C02F, C05B-C-D-F-G, C06B-C-D, C07B-C-F-G, C08B-F-G-H-J-K-L, C09B-C-D-F-G-H-J-K, C10B-C-H-J-K-M-N, C11B-C-D, C12S, C14C, C23F-G, C25B, C40B, D01C-F, D06L, F17C-D, F25J, F42B-D, G21F
21	Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations	A61K 6-135, A61P, C07D-H-J-K, C12N-P-Q
22	Manufacture of Rubber and Plastic Products	B29B-C-D, B60C, B67D, C08C
23	Manufacture of Other Non-Metallic Mineral Products	B28B-C, B32B, C03B-C, C04B, E03D

24	Manufacture of Basic Metals	B21C, B22D, C21B-C-D, C22B-C-F, C25C-F, G21H
25	Manufacture of Fabricated Metal Products, Except Machinery and Equipment	A01L, A44B, A47H, B21G, B22F, B63G, C23D, C25D, E05B-C-D-F, E06B, F16B-T; F17B, F22B-G, F24J, F27D, F41A-B-C-F-G-H-J, F42C, G21B-C-D-J
26	Manufacture of Computer, Electronic and Optical Products	A61N, B81B-C, B82B-Y, C30B, F15C, G01B-C-D-F-H-J-K-L-M-N-Q-R-S-V-W, G02B-C-F, G03B-C-H, G04B-C-D-F-G-R, G05B-F, G06C-D-E-F-G-J-N-T, G08B-C, G09C, G11C, G12B, G21K, H01C-F-G-J-L-Q-S, H03B-C-D-F-G-H-J-K-L-M, H04B-H-J-K-L-M-N-Q-R-S-W, H05G-H-K
27	Manufacture of Electrical Equipment	A21B, A45D, A47G-J-L, B01B, B60M, B61L, D06F, E06C, F21H-K-L-M-P-Q-S-V-W-Y, F24B-C-D, F25D, G08G, G10K, H01B-H-K-M-P-R-T, H02B-G-H-J-K-M-N-P-S, H05B-C
28	Manufacture of Machinery and Equipment n.e.c.	A01B-C-D-F-G-K-M, A21C, A22B-C, A23N, A24C, A41H, A42C, A43D, A47K, A62C, B01D-F, B02B-C, B03B-C-D, B04C, B05B-C-D, B06B, B07B-C, B08B, B21B-D-F-H-J-K-L, B22C, B23B-C-D-F-G-H-K-P-Q, B24B-C-D, B25B-C-D-F-G-H-J, B26B-D-F, B27B-C-F-G-J-L, B28D, B30B, B31B-C-D-F, B33Y, B41B-C-D-F-G-J-K-L-N, B42B-C, B43M, B44B-C, B60S, B61B, B65F 1-9, B65G-H, B66B-C-F, B67B-C, B68F, C10F, C12L, C13D-G-H, C14B,

		C23C, D01B-D-G-H, D02G-H-J, D03C-D-J, D04B-C, D05B-C, D06B-G-H, D21B-D-F-G, E01C-D-F-H, E02C-D-F, E05G, E21B-C-D-F, F01B-C-D-K-M-N-P, F02C-G-K, F03B-C-D-G, F04B-C-D-F, F15B-D, F16C-D-F-G-H-K-M-N-P, F22D, F23B-C-D-G-H-J-K-L-M-N-R, F24F-H, F25B, F26B, F27B, F28B-C-D-F-G, G01G, G03G, G05D-G, G06K-M, G07B-C-D-F-G, G09D-G, G10L, G11B, H05F
29	Manufacture of Motor Vehicles, Trailers and Semi-trailers	B60B-D-G-H-J-K-L-N-P-Q-R-T-W, B62D, F01L, F02B-D-F-M-N-P, F16J, G01P
30	Manufacture of Other Transport Equipment	B60F-V, B61C-D-F-G-H-J-K, B62C-H-J-K-L-M, B63B-C-H-J, B64B-C-D-F-G, B65F 3, E01B, F03H
31	Manufacture of Furniture	A47B-C-D-F
32	Other Manufacturing	A41G, A42B, A44C, A45C-F, A46B-D, A61B-C-D-F-G-H-J-L-M, A62B, A63B-C-D-G-H-J-K, B01L, B04B, B43K-L, B44D, B62B, B65D, B68G, C06F, C12M, D07B, F16L, F23Q, G01T, G03D-F, G09B-F, G10B-C-D-F-G-H, G21G
42	Civil Engineering	E02B, E03B-C
43	Specialised Construction Activities	E03F, E04B-C-D-F-G-H

62	Computer Programming, Consultancy and Related Activities	G06Q

Appendix D

OECD Taxonomy of Economic Activities Based on Technological Intensity (2016)

Group	Economic activity	NACE Rev.2 Division
High-tech	"Manufacture of basic pharmaceutical products and pharmaceutical preparations; Manufacture of computer, electronic and optical products; Manufacture of air and spacecraft and related machinery"	21 26 30 (but only 30.30)
Medium-high tech	"Manufacture of chemicals and chemical products; Manufacture of weapons and ammunition; Manufacture of electrical equipment; Manufacture of machinery and equipment n.e.c.; Manufacture of motor vehicles, trailers and semi-trailers; Manufacture of other transport equipment excluding building of	20 27 28 29 30 (except 30.30)

	ships and boats and excluding manufacture of air and spacecraft and related machinery; Manufacture of medical and dental instruments and supplies”	
Knowledge intensive activities (total)	“Mining support service activities; Manufacture of coke and refined petroleum products; Manufacture of basic pharmaceutical products and pharmaceutical preparations; Manufacture of computer, electronic and optical products; Air transport; Publishing activities; Motion picture, video and television programme production and pharmaceutical preparations; Programming and broadcasting activities; Telecommunications; Computer programming, consultancy and related	9 19 21 26 51 58 59 60 61 62 63 64 65 66 69 70

	activities; Information service activities; Financial service activities, except insurance and pension funding; Insurance, reinsurance and pension funding, except compulsory social security; Activities auxiliary to financial services and insurance activities; Legal and accounting activities; Activities of head offices, management consultancy activities; Architectural and engineering activities, technical testing and analysis; Scientific research and development; Advertising and market research; Other professional, scientific and technical activities; Veterinary activities; Employment activities; Travel agency, tour	71 72 73 74 75 78 79 84 85 86 90 91 94 99

	operator reservation service and related activities; Public administration and defenc, compulsory social security; Education; Human health activities; Creative, arts and entertainment activities; Libraries, archives, museums and other cultural activities; Activities of membership organisations; Activities of extraterritorial organisations and bodies”	

Appendix E

Eurostat classification on high-tech, medium-high tech economic activities of the manufacturing industry and knowledge-based services according to technological intensity

Group	Economic activity	NACE Rev.2 Division
High-tech	"Manufacture of basic pharmaceutical products and pharmaceutical preparations, computer, electronic and optical products, air and spacecraft and related machinery"	21 26
Medium-high tech	"Manufacture of chemicals and chemical products, weapons and ammunition, electrical equipment, machinery and equipment n.e.c., motor vehicles, trailers and semi-trailers, other transport equipment excluding building of ships and boats and excluding manufacture of air and spacecraft and related machinery, medical and dental instruments and supplies"	20 27 28 29 30

Medium-low tech	"Reproduction of recorded media, manufacture of coke and refined petroleum products, rubber and plastic products, other non-metallic mineral products, basic metals, fabricated metal products, except machinery and equipment excluding Manufacture of weapons and ammunition, building of ships and boats, repair and installation of machinery and equipment"	19 22 23 24 25 33
Knowledge intensive services	"Water transport, Air transport, Publishing activities, Motion picture, video and television programme production, sound recording and music publish activities, Programming and broadcasting activities, Telecommunications, computer programming, consultancy and related activities, Information service activities (section J), Financial and insurance activities (section K), Legal	50 51 58-63 64-66 69-75 78 80 84-93

	and accounting activities, Activities of head offices, management consultancy activities, Architectural and engineering activities, technical testing and analysis, Scientific research and development, Advertising and market research, Other professional, scientific and technical activities, Veterinary activities (section M), Employment activities, Security and investigation activities, Public administration and defense, compulsory social security (section O), Education (section P), Human health and social work activities (section Q), Arts, entertainment and recreation (section R)”	

Appendix F

Dependent variable information, distribution by provinces

PROVINCE	TOTREG19
İstanbul	1898
Ankara	399
Bursa	265
İzmir	182
Kocaeli	158
Konya	108
Manisa	89
Tekirdağ	71
Sakarya	67
Gaziantep	61
Kayseri	52
Antalya	48
Denizli	27
Eskişehir	27
Adana	21
Mersin	20
Kütahya	19
Muğla	17
Aydın	16
Rize	16
Samsun	14
Sivas	13
Hatay	11
Nevşehir	11
Kahramanmaraş	8

Trabzon	8
Balıkesir	7
Çorum	7
Isparta	7
Afyonkarahisar	6
Çanakkale	6
Düzce	6
Kırklareli	6
Van	6
Aksaray	5
Burdur	5
Edirne	5
Giresun	5
Tokat	5
Elazığ	4
Erzurum	4
Kastamonu	4
Malatya	4
Osmaniye	4
Uşak	4
Bilecik	3
Çankırı	3
Karabük	3
Karaman	3
Yalova	3
Yozgat	3
Amasya	2
Batman	2
Bingöl	2

Bolu	2
Diyarbakır	2
Kırıkkale	2
Kilis	2
Sinop	2
Şanlıurfa	2
Zonguldak	2
Adıyaman	1
Gümüşhane	1
Tunceli	1
Ağrı	0
Ardahan	0
Artvin	0
Bartın	0
Bayburt	0
Bitlis	0
Erzincan	0
Hakkari	0
Iğdır	0
Kars	0
Kırşehir	0
Mardin	0
Muş	0
Niğde	0
Ordu	0
Siirt	0
Şırnak	0

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1. Husár, M., Ondrejička, V., and Varış, S. C. (2017, October). Smart cities and the idea of smartness in urban development–a critical review. In *IOP conference series: materials science and engineering* (Vol. 245, No. 8, p. 082008). IOP Publishing.

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