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Correlation of Relatedness and Complexity with Patent Applications: A Regional Analysis from Türkiye

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ABSTRACT

Purpose: The aim of this paper is to test the hypothesis that regional innovativeness is positively correlated with the two main building variables of smart specialization: relatedness density (a region's potential to develop new technologies compatible with existing capabilities) and knowledge complexity (a region's potential to develop unique and hard-to-imitate technologies).
Methodology: Analysis are made over a panel regression model, using data from OECD-REGPAT database for the years 1978–2017 covering Türkiye's NUTS-3 regions. The dependent variable is innovativeness, and the independent variables are the average relatedness density and knowledge complexity indices for each region. Per capita income, number of universities, number of technoparks, Turkish Patent Institute, Türkiye-EU Customs Union agreement, and lagged value of the dependent variable are the control variables.
Findings: The results confirm that innovativeness and a region's potential to develop new technologies that are compatible with existing technological portfolios (relatedness density) are correlated, while the variable that measures a region's potential to develop unique technologies (knowledge complexity) is not statistically significant.
Originality: The originality of this work is that we demonstrate relatedness to be one of the building blocks of smart specialization as correlated with regional innovativeness; complexity, the other building block, is not correlated.

Keywords: Relatedness, Complexity, Smart Specialization, Türkiye, Regional Innovativeness.
JEL Codes: R10, R11, R58.

İlişkililik ve Karmaşıklık ile Patent Başvuruları Arasındaki Korelasyon: Türkiye İçin Bölgesel Bir Analiz

ÖZET

Amaç: Çalışmanın amacı, bölgesel yenilikçiliğin akıllı uzmanlaşmanın iki temel boyutu ile arasında pozitif bir korelasyon olduğu hipotezini test etmektir. Akıllı uzmanlaşmanın iki temel boyutu, ilişkililik yoğunluğu (bölgenin mevcut yeteneklerine uygun yeni teknolojileri kendine çekebilme potansiyeli) ve bilgi karmaşıklığıdır (bölgenin benzersiz ve taklit edilmesi güç teknolojileri yaratma potansiyeli).
Yöntem: Analizler panel regresyon modeli kullanılarak yapılmıştır. Çalışmanın verilerini Türkiye'nin İBB-3 düzey bölgeleri için 1978–2017 yılları kapsamında OECD-REGPAT veri tabanı oluşturmaktadır. Bağımlı değişken yenilikçilik ve bağımsız değişkenler bölgenin ilişkililik yoğunluğu ve bilgi karmaşıklığı indeksleridir. Kontrol değişkenleri olarak kişi başına gelir, üniversite sayısı, iki kukla değişken (Türk Patent Enstitüsü ile Türkiye-AB Gümrük Birliği anlaşması) ve bağımlı değişkenin gecikmeli değeri kullanılmıştır.
Bulgular: Sonuçlar, bölgesel yenilikçilik ile bölgenin mevcut teknoloji portföyü ile uyumlu yeni teknolojileri çekme potansiyeli arasında anlamlı bir ilişki olduğunu ortaya koymakta, ancak bölgenin benzersiz olma potansiyeli ile istatistiksel olarak bir bağlantı olmadığını doğrulamaktadır.
Özgünlük: Makalenin özgünlüğü, akıllı uzmanlaşmanın iki temel bileşeninden biri olan ilişkililik boyutunun bölgesel yenilikler ile bağlantılı olduğunu, diğer bileşeni olan karmaşıklık boyutunun ise yenilikler üzerinde bir etkisinin olmadığını göstermesidir.

Anahtar Kelimeler: İlişkililik, Karmaşıklık, Akıllı Uzmanlaşma, Türkiye, Bölgesel Yenilikçilik.
JEL Kodları: R10, R11, R58.

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1. INTRODUCTION

Literature on regional development contends that instead of “one-size-fits-all” policies, regions should focus on their distinctive attributes. Innovativeness has a profound impact on the overall productivity of regions. The best results for improved productivity can be achieved through regional innovation policies with a focus on a region’s unique strengths, experiences and accumulated knowledge (Tödtling and Trippl, 2005; Balland et al., 2019).

Smart specialization provides new employment opportunities that enhance economic growth and maximize regional competitive advantages. The aim is to use regional resources in line with their unique competitive attributes. Smart specialization is now an integral part of the European Union (EU)’s innovation and cohesion policy (Foray et al., 2009). The directive is that regions should specialize in distinct and unique areas rather than trying to produce technological knowledge in various and unrelated fields. The EU approach underscores the significance of unique resources, experiences and attributes of particular regions.

The two building blocks of smart specialization are “relatedness” and “complexity” (Balland et al., 2019). Relatedness measures the proximity, relationship and distance among technology classes (Kogler et al., 2013) by looking to industries and technological domains. Complexity is the degree of tacit or complex knowledge required by a technological field, and measures the sophistication of a technological field in a region. Complexity helps individuals understand the extent to which a region holds valuable knowledge (Balland et al., 2019). Crespo et al. (2017) highlight complexity as a way to demonstrate the potential benefits of regional investment as well as a way to discover the diversification capabilities of a given region. For this reason, complexity stands out as an element that may enhance regional development and increase the capacity of a region to create valuable and unique knowledge.

The literature includes studies that focus on the relationship between relatedness and/or complexity; jobs (Fernandes et al., 2019); growth (Davies and Maré, 2021); diversification (Balland et al., 2019); technological resilience (Balland et al., 2015); and patent citations (Fleming and Sorenson, 2001; Mewes, 2019). Studies on the links among relatedness, complexity and innovativeness are rather limited. Moreover, the literature on smart specialization opportunities of regions tends to focus on developed countries (the EU, US, Spain, Sweden etc.), while studies on emerging economies are limited.

Smart specialization is particularly important for enhancing regional competitiveness, mostly through productivity improvements. One of the fundamental elements of smart specialization is to increase productivity. In fact, the main factor behind the EU's smart specialization initiation is closing the growing productivity gap with transatlantic countries in the field of R&D (McCann and Ortega-Argilés, 2015; Van Ark, 2009: 51). The positive effects of smart specialization on productivity are also confirmed in recent studies (Rocchetta et al., 2021; Santos et al., 2022). Therefore, it can be expected that the implementation of innovation policies compatible with smart specialization framework in Türkiye will create an increase in productivity. This study aims to contribute to the improvement of productivity in Türkiye by investigating Türkiye’s technological structure in terms of smart specialization assumptions.

This study explores whether the two building blocks of smart specialization (technological relatedness and knowledge complexity) are related to a region’s innovativeness as measured by patent applications. We use Türkiye as a case study. We aim to understand whether relatedness and complexity are associated with innovativeness in Türkiye’s regions between 1978 and 2017. The research question is: “As the two building blocks of smart specialization, how do relatedness and complexity contribute to innovativeness of the regions?” The main hypothesis of this paper is that patent applications are positively correlated with relatedness and complexity of given regions.

The study proceeds as follows. The next section provides the literature review and theoretical background. Section 3 presents the data and methods. Section 4 provides the findings. Section 5 discusses the policy implications. The last section concludes.

2. LITERATURE REVIEW and THEORETICAL BACKGROUND

The literature helps us understand how innovation evolves in space; Rosenberg and Nathan (1994) propose that regional innovativeness is a process within a black box where little is known concerning the drivers of innovation. The literature on smart specialization provides new tools to explore how regions develop accumulated knowledge and innovations. Smart specialization focuses on regional specialization programs with specific emphases on the fields that are related to the regions’ own capabilities and competencies (Foray, 2018). The geographical distribution of innovations and networks of innovations has been a subject of particular importance (Camagni, 1991; Cooke, 2001).

Studies on the connection between innovativeness and smart specialization contend that patenting activities are enhanced with technological relatedness. For example, Paci and Usai (1999) show that specialization and diversity have a positive relationship on patents in Italy for the period 1978–1995. Ejermo (2005) finds the same is true for Swedish regions; Autant-Bernard (2001) for French regions; and O'hUallachain and Lee (2011) for US regions. Such parallel findings confirm that technological specialization is positively correlated with innovativeness as measured by patenting activities. Kogler et al. (2013) point out that technological diversity enhances the accumulation of knowledge in regions, while Fleming and Sorenson (2001) contend that knowledge accumulation and innovativeness are characterized by the complexity of knowledge. Moreover, Pintar and Scherngell (2018) propose that knowledge complexity does not correlate with the intensity of patenting activities in European regions. Balland et al. (2019) propose that there is a need for diversification into related technologies and a focus on increasing their overall economic complexity.

Enhancing innovations through smart specialization entails that regions should specialize in their existing sets of knowledge and skills while at the same time work toward more sophisticated products that are unique and difficult to copy by other regions. Both relatedness and complexity help regions increase their innovativeness. As explained above, despite the existence of several studies examining the relationship between innovativeness and the two building blocks of smart specialization (relatedness and complexity), their results are inconclusive (Boschma et al., 2014), causing this link to remain rather blurry. Little is known on how relatedness and complexity together help regions improve their innovative capabilities. This study aims to fill that gap by exploring the connection between innovativeness (operationalized by patent applications) and the two building blocks of smart specialization (relatedness and complexity) at the regional level by using Turkish regions as a case study.

Early studies on regional specialization in Türkiye demonstrate that spatial and organizational proximity positively impact regional innovativeness (Güngör and Gözlü, 2012). Studies on cluster formation demonstrate that the structure of the manufacturing industry consists of medium and medium-low technologies (Gezici et al., 2021), and that Türkiye lags behind many developed countries with respect to patenting activities. Similar findings are shown in Kaygalak (2018) and (Falcioğlu and Akgüngör, 2008) and suggest that most manufacturing activities require low skills. Although empirical studies point out the significant relationship between regional innovation and regional economic development in Türkiye (Atalay et al., 2013; Bozkurt, 2015), little is known on what determines regional innovativeness. Additionally, Türkiye's smart specialization opportunities have only recently started to be investigated. A recent study by Erdil and Çetin (2019) investigates the smart specialization capabilities of Turkish industry clusters and indicates that, even though smart specialization strategies are not on the agenda for national innovation policies in Türkiye, certain initiatives exist at the regional level. Only a handful of studies exist in Türkiye where at least one of the two building blocks of smart specialization is discussed (Erdil and Çetin, 2019, Kuştepeli et al., 2013; Akgüngör and Abay, 2021). There is a need for further research that systematically explores how regional innovations are connected with relatedness and complexity. Such knowledge will deliver a better understanding of the role of the two major components of smart specialization in designing regional innovation policies in Türkiye.

This study follows the framework of smart specialization. The foundations of smart specialization are based on the evolutionary economic geography approach with a distinct focus on the uneven distribution of economic agents such as companies, industries, networks, cities and regions across space and time. Evolutionary economic geography contends that a region's core knowledge and competencies determine regional competitiveness (Frenken and Boschma, 2015). Evolutionary economic geography focuses on individual and collective agents on the emergence and transformation of spatial formations of economic activities; it also attempts to understand the reasons behind differences in industrial concentration across time and geography. Evolutionary economic geography focuses on sustainable regional development and "developing new industries or new growth paths" and answers questions posed by economic geographers such as how economic activities are clustered across space and why development and growth vary across regions. The evolutionary perspective provides conceptual contributions and explanations in relation to the main topics in economic geography, such as clusters and networks, as well as the role of institutions in regional development (Boschma and Frenken, 2018: 213–219).

The evolutionary approach to regional development centers on understanding the process through which regional dynamics change through time. The underlying principle is the assumption that regional growth is dynamic and path dependent (Boschma and Frenken, 2018: 214; Martin and Sunley, 2010). What determines the economic performance of a given region is largely knowledge production and innovativeness. This point is demonstrated and argued by Schumpeter (1942), Solow (1956), and Nelson and Winter (1982). Regional economic performance is place and path dependent. Place and path dependency constitute the fundamental idea of the smart specialization framework. In such a framework, the factors of relatedness and complexity propose that regions will benefit most if they choose to work on economic activities highly related to their current portfolios. Simultaneously, smart specialization literature contends that regions should specialize and work on creating innovative activities unique to a region and that these activities should be difficult for other regions to copy. Balland et al. (2019) propose such a model.

Smart specialization is a policy that considers the distinct and unique characteristics of a region. Boschma and Frenken (2018: 219) propose that the relatedness concept, a significant one of smart specialization, corresponds to the idea that knowledge creation as an evolutionary process is the combination of existing ideas and that the diversification of economic activities is a branching process; thus the emergence of new technologies is not random but actually depends on past knowledge. Innovations and new technologies and thus the smart specialization of a region come from existing sets of capabilities.

In addition to the relatedness concept, the literature on smart specialization emphasizes the importance of complexity. Complexity refers to a region’s unique technologies that are hard to copy. Knowledge complexity for sustainable growth results from valuable and tacit knowledge, which is difficult to imitate and access by others (Hidalgo and Hausmann, 2009). Empirical investigation identifies relatedness and complexity as the two pillars of smart specialization. Balland et al. (2019) demonstrate that the two variables of smart specialization provide guidance for understanding potential routes for smart specialization. Their analysis brings forward the issue of whether focusing on activities that are interrelated to the regional portfolio (relatedness) and at the same time focus on inventing new and unique activities based on a region’s past experiences and competencies (complexity)-an ultimate smart specialization policy-has a connection with regional innovativeness.

Following the smart specialization framework presented above, the conceptual model of this paper is based on the connection between regional innovations and a region’s relatedness and complexity. The two main hypotheses are:

Hypothesis 1: Patent applications are positively correlated with the technological relatedness of a region.

Hypothesis 2: Patent applications are positively correlated with the knowledge complexity of a region.

3. DATA and METHODS

3.1. Variables

3.1.1. Measuring Innovation

The dependent variable is regional innovativeness. Innovativeness is measured by “Patent applications per 100.000 inhabitants” (PATPER), a variable which is considered a suitable proxy for innovations and the technological progressiveness of a region (Encaoua et al., 2006). PATPER is produced by counting patent applications rather than patent approvals. The reason for doing so is that it takes a long time for an application to be approved; therefore, approval-based counts do not always reflect the innovative activities of the relevant period in a region. As such, in line with a common approach in the literature, the variable measures the application-based patent counts (Maraut et al., 2008). Patent counts are aggregated into technological classes based on WIPO classification specified by Schmoch (2008). According to the May 2008 classification, International Patent Classification (IPC) codes are grouped according to 5 technology classes and 35 sub-technology classes. We use the latest version (July 2019) of the WIPO IPC-Technology Concordance Table to group the IPC codes of the patents into WIPO technology classes. (Abay et al., 2021.)

3.1.2. Measuring Relatedness and Complexity

Relatedness measures the proximity, or technological distance, between each pair of technological fields (Kogler et al., 2013). We follow the method introduced by Boschma et al. (2014), which is based on a co-occurrence matrix showing the incidence of two IPC codes in the same group of patents. Relatedness density is a variable that measures the extent to which a region possesses technologies that are part of its technological portfolio. We use the average relatedness density (ARD) variable to measure a region’s potential to develop new technologies. ARD represents the average relatedness between the technologies present in the region and all other technological domains outside its technological portfolio. ARD measures a region’s branching opportunities and potential to diversify into new and related technologies in Türkiye’s NUTS-3 regions.

The complexity index is calculated through the method of reflections, which links regions to the technology classes in which they specialize. The variable that measures the knowledge complexity of a region is the knowledge complexity index (KCI). KCI measures the extent to which a region can produce more exclusive goods, thereby promoting a more complex regional economy. As stated above, regions with more complex economies enjoy advantages in producing specific technologies. Computational details related to relatedness density and the knowledge complexity index are presented in Akgüngör and Abay (2021).

3.1.3. Control Variables in the Model

The model includes regional per capita GDP (PCGDP), the number of universities in the region (UNI), the number of technoparks (TPARK) which is a proxy for the number of technology development zones and two dummy variables that take into account of the establishment of the Turkish Patent Institute in 1994 (TPI) and the start of accession negotiations between Türkiye and the EU in 2006 (AN). The dummy variables are included to take into account structural changes in patenting behavior in Türkiye. We add a one year lagged value of the dependent variable (PATPER) to control for the impact of knowledge accumulation on innovative activity in the regions.

3.1.4. Data Sources

The dependent variable (PATPER) and smart specialization variables (ARD and KCI) are generated using patent data for regions from the OECD-REGPAT January 2020 Edition database (OECD, 2020). PCGDP data at the NUTS-3 level (2009 constant prices) are from Turkstat and are compiled by Karaca (2018).[3] The UNI variable is from the Turkish Council of Higher Education, and the TPARK variable is from the Republic of Türkiye's Ministry of Industry and Technology (2021). Both the UNI and TPARK variables measure the total number of universities and technoparks at time t.

The dataset includes annual observations from 1978 until 2017. Owing to a relatively low level of patent applications, we combine data for 5-year period intervals (windows: W1 through W8)[4] leading to a panel data set for 58 NUTS-3 regions and 8 periods (windows). Table 1 provides the descriptive statistics of the data.

Table 1. Descriptive statistics

Variable	*Observations*	*Average*	*Standard Deviation*	*Minimum Value*	*Maximum Value*
PATPER	148	1.597817	4.889096	0.033054	52.14779
ARD	148	14.64865	20.88839	0	100
KCI	148	44.32464	33.26627	0	100
PCGDP	148	14108.07	5204.704	3873	32355
TPARK	148	0.7297297	1.286215	0	8
UNI	148	3.182432	7.295546	0	58
TPI	148	0.9189189	0.2738865	0	1
AN	148	0.75	0.434483	0	1

3.2. Analysis Methods

We applied the Breusch-Pagan Lagrange multiplier (BP-LM) test for random effects and the F-test for fixed effects (Baltagi, 2005: 59; Park, 2011; Torres-Reyna, 2007). Both BP-LM and F-test results favored pooled OLS against RE and FE. Since both specification tests revealed no evidence for panel effect in the data, we did not apply the Hausmann test. Diagnostic tests reveal issues of heteroskedasticity and autocorrelation. To overcome these issues, the model uses clustered standard errors.

The econometric model is estimated without taking the logarithms of the variables since the non-logarithmic models are more common in the SS literature (Balland et al., 2019; Kogler et al., 2017; Boschma et al., 2014). One possible justification is that the ARD and KCI variables are between 0-100 where the coefficient estimates are interpreted as percentage changes. Applying logarithmic transformation to the ARD and KCI makes it complicated to interpret the results. Moreover, the log model neccesitated the omission of the TPI variable due to an emerging problem of multicollinearity. We therefore estimate the models using the non-log versions of the variables. We use one period lagged values of the independent variables.

[3] Regional income data can be reached through the following: https://sites.google.com/site/okaraccaeng/data.
[4] W1: 1978–1982: W2: 1983–1987; W3: 1988–1992; W4: 1993–1997; W5: 1998–2002; W6: 2003-2007; W7: 2008-2012; W8: 2013-2017

4. FINDINGS

Following the theoretical framework explained above, we expect to see a statistically significant positive relationship between relatedness and innovation, as well as between complexity and innovation. Figures 1 and 2 present the graphical demonstration of the relations between the variables.

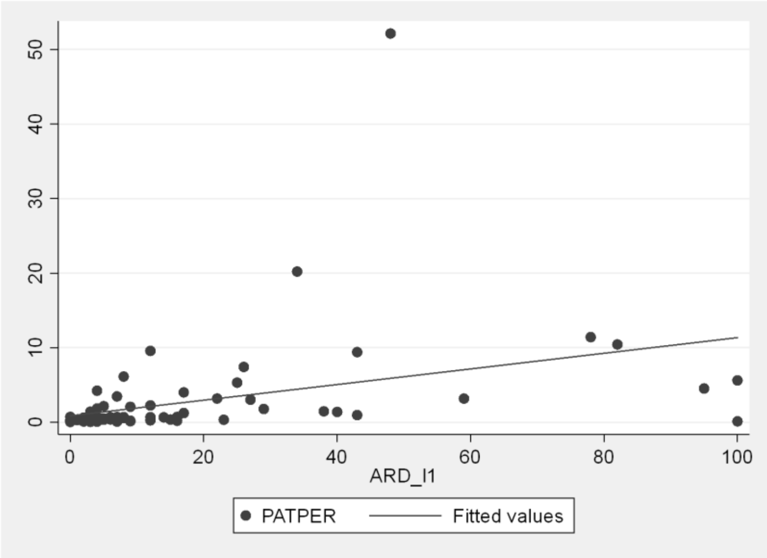

Figure 1. Patent applications per 100.000 inhabitants (PATPER) and one period lagged average relatedness density (ARD_l1), 1978-2017[5]

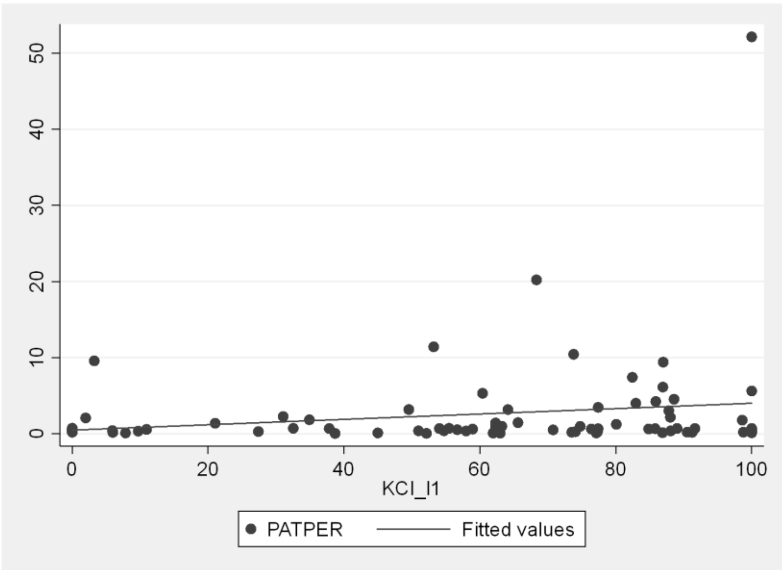

Figure 2. Patent applications per 100.000 inhabitants (PATPER) and one period lagged knowledge complexity index (KCI_l1), 1978-2017[6]

Table 2 presents the results of the regression analysis. Since there is multicollinearity between the two dummy variables, we estimate two models that incorporate only one of the dummy variables. Both models reveal positive and significant relationship between the lagged value of ARD (ARD_l1) and PATPER (PATPER_l1). The results justify the hypothesis that average relatedness density is an important factor for regional innovativeness in Türkiye between 1978 and 2017. Accordingly, a 1%[7] rise in average relatedness density for a region increases patent applications per 100.000 inhabitants in that region by nearly 0,03 patents. This result suggests that patent applications increase when potential new activities are

[5] Source: OECD-REGPAT database (OECD, 2020), own calculations
[6] Source: OECD-REGPAT database (OECD, 2020), own calculations
[7] Since the value of ARD ranges between 0-100 by definition, its coefficient can be interpreted in percentage terms.

incorporated into the preexisting skill-sets and capabilities of a particular region. The lagged value of KCI (KCI_l1) is not statistically significant. However, the negative sign of its coefficient may be interpreted as an occasion to question the difficulty of generating patents in regions with unique technologies that are hard to copy. Additional analysis and research are needed to explore the reasons why more complex regions (regions with unique technologies) have fewer patent applications.

The lagged value of UNI (UNI_l1) and the lagged value of the dependent variable reveal statistically significant coefficients in both models, whereas the coefficient of the lagged value of TPARK (TPARK_l1) is significant only in the first model. PATPER_l1 has a positive impact on regional innovativeness, showing that innovation is a path-dependent process based on knowledge accumulation. On the other hand, UNI_l1 and TPARK_l1 have negative impacts on regional innovativeness. The findings provide justification for further research on the effectiveness of university-industry cooperation in Türkiye in line with the existing studies in the literature with similar findings (Atmaca, 2011; Karaca, 2021).

The results show that a one unit increase in UNI_l1 decreases PATPER by 0.24-0.25, a one unit increase in TPARK_l1 decreases PATPER by 0.49, and a one unit increase in a one year lagged value of PATPER increases PATPER by 2.32-2.35.

Table 2: Econometric results

Dependent Variable: Patent applications per 100.000 inhabitants (PATPER)		
Independent Variables	*Model 1*	*Model 2*
ARD_l1	0.0388610***	0.0324706***
	(0.0081945)	(0.0072592)
KCI_l1	-0.0064154	-0.0035072
	(0.0080175)	(0.0063625)
PCGDP_l1	0.0000093	-0.0000087
	(0.0000382)	(0.0000397)
UNI_l1	-0.2422364***	-0.2524858***
	(0.0222533)	(0.0250073)
TPARK_l1	-0.4865206*	-0.2637496
	(0.2827549)	(0.2437996)
PATPER_l1	2.3171332***	2.3539264***
	(0.1236076)	(0.1193654)
TPI_l1	0.3488207	
	(0.4096895)	
AN_l1		-0.8608876
		(0.5553694)
Constant	0.3138478	1.2305241
	(0.9375021)	(1.0099798)
Observations	76	76
R-squared	0.9300415	0.9324469

Notes: Parentheses show standard errors. * significant at the α≤0.1 level, ** significant at the α≤0.05 level and *** significant at the α≤0.01 level.

5. POLICY IMPLICATIONS

The findings of this study support the notion that relatedness of a region's existing portfolio with technologies that are not yet present increase patenting activities. Patent applications increase as a region's branching opportunities to diversify into new and related technologies increase. Technological flexibility is an important tool for innovativeness. Based on these findings, we suggest that regional policies should have focus on increasing regional technological flexibility so that it becomes feasible to attract technologies closely related to a region's existing portfolio.

For example, an exploratory analysis reveals that over the 2003-2017 period, İzmir's existing technological portfolio included "medical technology," "basic materials chemistry," "motor pumps and turbines," "other special machinery," "mechanical elements," and "civil engineering." The analysis further reveals that potential new technologies closely related to İzmir's existing portfolio included "audio-visual technologies," "telecommunication," "digital communication," "computer technology," "semiconductors," “organic fine chemistry,” and “biotechnology.” The policy recommendation for İzmir is to combine the city’s existing portfolio with suggested potential technologies. For example, medical technology can be combined with computer technology as well as chemistry and biotechnology. Similarly, machinery-related activities can be combined with digital communication as well as computer technologies and the like. Smart specialization opportunities no doubt need to be supported with stakeholder contributions as well as room for entrepreneurial discovery. Furthermore, more focus is needed to support investments and R&D activities for those technologies closely related to İzmir’s technological portfolio (Akgüngör and Abay, 2022).

It is therefore imperative to understand a region’s technological portfolio and suggest potential related technologies via desk research. Smart specialization policies should be further supported with stakeholder communications as well as policies to promote entrepreneurial discovery to promote new combinations and innovative products across a region’s existing portfolio and potential activities, raising the region’s value and its unique technological portfolio.

6. CONCLUSION

This paper investigates how a region can benefit from their preexisting skills for enhanced innovations. The findings imply that preexisting skills are important for innovativeness while the uniqueness of a region’s capabilities is not significant. The results imply that regions that work to augment their skills with more innovative products provide advantages.

This paper offers initial findings on how regional capabilities can be used for enhancing innovativeness. Relatedness, one of the two building blocks of smart specialization, along with potential new activities compatible with a region’s experience and tacit knowledge provide a significant base for innovativeness. When a region becomes unique with hard-to-imitate capabilities, complexity, the other building block of specialization, does not provide significant room for enhanced innovativeness.

The results are only valid for Türkiye as a case study. Focusing only on Turkish data is a limitation of this study. Findings are yet to be explored for other countries in different settings. Another limitation in regard to this study is related to the unit of analysis. The data is designed for Türkiye’s 81 NUTS3 level regions, which may limit the availability of frequency of patent observations. Defining larger regions and agglomerating their patent applications might provide different conclusions.

There are two major points of departure for further research. First, the reasons why regional complexity does not lead to more patent applications should be further explored. It could be that regions with unique and hard-to-imitate capabilities, products and activities might experience a sense of regional lock-in and therefore be less flexible in creating innovations. Second, further research is needed to quantify the innovation impact of smart specialization tools (relatedness and complexity) on productivity at the regional and firm level. Doing so may require comparative studies across regions with different levels of relatedness density and technological complexity with regards to firm performance (e.g. innovativeness) and productivity.

The findings reveal that high levels of technological relatedness in a region are associated with innovative activities, while the effect of knowledge complexity on innovativeness cannot be confirmed. A region with a high potential to develop new technologies related to its existing technologies and capabilities tends to be more innovative. The results confirm that policies that attract new and related industries to a region’s current portfolio are significant determinants of innovativeness. Regions with unique and hard-to-imitate knowledge bases (i.e., regions with high technological complexity) do not produce innovations. Why that is so needs to be further investigated.

In addition, the findings emphasize the importance of smart specialization in terms of productivity. It is known that innovation is a driver of productivity growth (Griffith et al., 2006; Mohnen and Hall, 2013: 12; Van Ark, 2009). Branching of regions into fields that require similar resources with their technological structures and capabilities leads to new patent creation and knowledge accumulation in the regions. This accumulation triggers the creation of new knowledge in the regions in the long run and has an indirect effect on productivity (Varga et al., 2018). Therefore, the findings of the study reveal the potential of relatedness as a factor to improve productivity growth.

Consequently, regional diversification policies that focus on domains with low risk (regions with high relatedness) rather than branching into fields unique to a region would work better in enhancing innovativeness. Policies that draw potential new technologies close to the existing portfolio of a region result in regional patenting activities. This paper supports the idea that innovative regional activities will increase if we focus on a region’s existing technological portfolio and policies. Regional innovation policies work best if regional actors enhance new activities that remain in close correlation with a region’s current portfolio.

Yazar Katkıları / *Author Contributions*

Mert Abay: Literatür taraması, Kavramsallaştırma, Metodoloji, Veri Derleme, Analiz, Makale Yazımı-orijinal taslak Sedef Akgüngör: Makale Yazımı-inceleme ve düzenleme

Mert Abay: Literature review, Conceptualization, Methodology, Data Curation, Analysis, Writing-original draft Sedef Akgüngör: Writing-review and editing

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It was declared by the authors that the tools and methods used in the study do not require the permission of the Ethics Committee.

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REFERENCES

Abay, M., Akgüngör, S. and Akyıldız, Y.T. (2021). “Innovation, Relatedness and Complexity in Turkey: A Regional Analysis for 1978-2017”, *Ekonomi-tek*, 10(3), 135-171.

Akgüngör, S. and Abay, M. (2022). “İzmir’de Teknolojik Yeniliklerin Gelişimi ve İzmir İçin Bir Akıllı Uzmanlaşma Önerisi”, Presentation in the Panel on *Kurtuluşunun 100. Yilinda İzmir'in Ekonomisi ve Ticareti*, May, 26.2022.

Akgüngör, S. and Abay, M. (2021). “Knowledge Space, Relatedness and Complexity: A Regional Analysis in Turkey”, *Yildiz Social Science Review*, 7(2), 123-136.

Atalay, M., Anafarta, N. and Sarvan, F. (2013). “The Relationship Between innovation and firm Performance: An Empirical Evidence from Turkish Automotive Supplier Industry”, *Procedia-Social and Behavioral Sciences*, *75*, 226-235.

Atmaca, S. (2011). “Patents from the Academe: A Methodology Research for the Analysis of University Patents and Preliminary Findings for Turkey”, *TEKPOL Working Paper Series*, 11/01.

Autant-Bernard, C. (2001). “The Geography of Knowledge Spillovers and Technological Proximity”, *Economics of Innovation and New Technology*, 10, 237-254.

Balland, P.A., Boschma, R., Crespo, J. and Rigby, D. (2019). “Smart Specialization Policy in the European Union: Relatedness, Knowledge Complexity and Regional Diversification”, *Regional Studies*, 53(9), 1252-1268.

Balland, P.A., Rigby, D. and Boschma, R. (2015). “The Technological Resilience of US Cities”, *Cambridge Journal of Regions, Economy and Society*, 8(2), 167-184. doi:10.1093/cjres/rsv007

Baltagi, B. H. (2008). “Econometric Analysis of Panel Data (Vol. 4)”, John Wiley & Sons, Chichester.

Boschma, R. and Frenken, K. (2018). “Evolutionary Economic Geography”, *Oxford Handbooks Online* Editors: Clark, G. L., Feldman, M.P., Gertler, M.S., and Wójcik, D., 213-229.

Boschma, R., Balland, P.A. and Kogler, D.F. (2014). “Relatedness and Technological Change in Cities: The Rise and Fall of Technological Knowledge in US Metropolitan Areas from 1981 to 2010”, *Industrial and Corporate Change*, 24(1), 223-250.

Bozkurt, C. (2015). “R&D Expenditures and Economic Growth Relationship in Turkey”, *International Journal of Economics and Financial Issues*, *5*(1), 188.

Camagni, R.P. (1991). “Technological Change, Uncertainty and Innovation Networks: Towards a Dynamic Theory of Economic Space”, *Regional Science*, Editor: Boyce D. E., Nijkamp P., and Shefer D., Berlin, Germany: Springer, 211-249.

Cooke, P. (2001). “Regional Innovation Systems, Clusters, and the Knowledge Economy”, *Industrial and Corporate Change*, 10(4), 945-974.

Crespo, J., Balland, P.A., Boschma, R. and Rigby, D. (2017). “Regional Diversification Opportunities and Smart Specialization Strategies”, European Commission, Directorate-General for Research and Innovation.

Davies, B. and Maré, D.C. (2021). “Relatedness, Complexity and Local Growth”, *Regional Studies*, 55(3), 479-494.

Ejermo, O. (2005). “Technological Diversity and Jacobs’ Externality Hypothesis Revisited”, *Growth and Change*, 36, 167-195.

Encaoua, D., Guellec, D. and Mart, C. (2006). “Patent Systems for Encouraging Innovation: Lessons from Economic Analysis”, *Research Policy*, 35, 1423-1440.

Erdil, E., and Çetin, D. (2019). “Smart Specialization and R&I Policy Framework in Turkey”, *Smart Specialization Strategies and the Role of Entrepreneurial Universities,* 209-233, IGI Global.

Falcioğlu, P. and Akgüngör, S. (2008). “Regional Specialization and Industrial Concentration Patterns in the Turkish Manufacturing Industry: An Assessment for the 1980–2000 Period”, *European Planning Studie*s, 16(2), 303-323.

Fernandes, T.F., Balland, P.A., Morrison, A. and Boschma, R. (2019). “What Drives the Geography of Jobs in the US? Unpacking Relatedness”, *Industry and Innovation*, 26(9), 988-1022.

Fleming, L. and Sorenson, O. (2001). “Technology as a Complex Adaptive System: Evidence from Patent Data”, *Research Policy*, 30(7), 1019-1039.

Foray, D. (2018). “Smart Specialization Strategies as a Case of Mission-Oriented Policy—A Case Study on the Emergence of New Policy Practices”, *Industrial and Corporate Change*, 27(5), 817-832.

Foray, D., David, P.A. and Hall, B. (2009). “Smart Specialisation – The Concept”, *Knowledge Economists Policy Brief,* No: 9.

Frenken, K. and Boschma, R. (2015). “Geographic Clustering in Evolutionary Economic Geography”, *Handbook of Research Methods and Applications in Economic Geography*, Edward Elgar Publishing, 291-302.

Gezici, F., Müderrisoğlu, B., Salihoğlu, G. and Başarır, G. (2021). "What is The Role of Techno-Parks on Regional Innovation in Turkey?", *Journal of Science Part B: Art Humanities Design and Planning*. Gazi University, 9(1), 43-59.

Güngör, D.Ö. and Gözlü, S. (2012). "Influencing Factors of Innovation for Turkish Companies", *International Journal of Quality and Service Sciences*, 4(4), 374-386.

Griffith, R., Huergo, E., Mairesse, J. and Peters, B. (2006). "Innovation and Productivity Across Four European Countries", *Oxford Review of Economic Policy*, *22*(4), 483-498.

Hidalgo, C.A. and Hausmann, R. (2009). "The Building Blocks of Economic Complexity", *Proceedings of the National Academy of Sciences*, 106(26), 10570-10575.

Karaca, O. (2018). "50 Years of Regional Convergence in Turkey: New Data Set and Analysis for the Period 1960-2010", *Sosyoekonomi*, 26(35), 207-228.

Karaca, Z. (2021). "İllerin Patent Sayısını Etkileyen Faktörler Üzerine Bir Uygulama", *Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *23*(3), 1179-1192.

Kaygalak, İ. (2018). "Localization and Specialization Tendency of Manufacturing in Turkey", *International Journal of Geography and Geography Education*, 38, 171-186.

Kogler, D.F., Essletzbichler, J. and Rigby, D.L. (2017). "The Evolution of Specialization in the EU15 Knowledge Space", *Journal of Economic Geography*, 17(2), 345-373.

Kogler, D.F., Rigby, D.L. and Tucker, I. (2013). "Mapping Knowledge Space and Technological Relatedness in US Cities", *European Planning Studies*, 21(9), 1374-1391.

Kuştepeli, Y., Gülcan, Y. and Akgüngör, S. (2013). "The Innovativeness of the Turkish Textile Industry Within Similar Knowledge Bases Across Different Regional Innovation Systems", *European Urban and Regional Studies*, 20(2), 227-242.

Maraut, S., Dernis, H., Webb, C., Spiezia, V. and Guellec, D. (2008). "The OECD REGPAT Database: A Presentation", *OECD Science, Technology and Industry Working Papers (2008/02)*.

Martin, R. and Sunley, P. (2010). "The Place of Path Dependence in an Evolutionary Perspective on the Economic Landscape", *The Handbook of Evolutionary Economic Geography*. Edward Elgar Publishing.

McCann, P. and Ortega-Argilés, R. (2015). "Smart Specialization, Regional Growth and Applications to European Union Cohesion Policy", *Regional studies*, *49*(8), 1291-1302.

Mewes, L. (2019). Quality "Dimensions of Knowledge and Regional Development: Relatedness, Complexity, Novelty, and Impact of Knowledge", Unpublished Doctoral Dissertation, Utrecht University.

Mohnen, P. and Hall, B.H. (2013). "Innovation and Productivity: An update", *Eurasian Business Review*, *3*(1), 47-65.

Nelson, R.R. and Winter., S.G. (1982). "An Evolutionary Theory of Economic Change", *Cambridge, Mass.: Harvard University Press*.

O'hUallachain, B. and Lee, D-S. (2011). "Technological Specialization and Variety in Urban Invention", *Regional Studies*, 45(1), 67-88.

OECD. (2020). REGPAT database, January 2020.

Paci, R. and Usai, S. (1999). "Externalities, Knowledge Spillovers and the Spatial Distribution of Innovation", *GeoJournal*, 49, 381-390.

Park, H.M. (2011). "Practical Guides to Panel Data Modeling: A Step-by-step Analysis Using Stata", Public Management and Policy Analysis Program, Graduate School of International Relations, International University of Japan, 12, 1-52.

Pintar, N. and Scherngell, T. (2018). "Grasping the Complexity of Regional Knowledge Production: Evidence on European regions", *STI 2018 Conference Proceedings*, 1266-1278.

Republic of Turkey Ministry of Industry and Technology. (2021). "Technology Development Zones", http://www.sanayi.gov.tr/istatistikler/istatistiki-bilgiler/mi0203011501, (Access Date: 15.01.2022).

Rocchetta, S., Ortega-Argilés, R. and Kogler, D.F. (2021). "The Non-Linear Effect of Technological Diversification on Regional Productivity: Implications for Growth and Smart Specialisation Strategies", *Regional Studies*, 1-16.

Rosenberg, N. and Nathan, R. (1994). "Exploring the Black Box: Technology, Economics, and History", *Cambridge University Press*.

Santos, A., Edwards, J. and Neto, P. (2022). "Does Smart Specialisation Improve Any Innovation Subsidy Effect on Regional Productivity? The Portuguese Case", *European Planning Studies*, 1-22.

Schmoch, U. (2008). "Concept of a Technology Classification for Country Comparisons (Final Report to the World Intellectual Property Organisation - WIPO)".

Schumpeter, J.A. (1942). "Capitalism, Socialism and Democracy", New York: Harper & Row.

Solow, R.M. (1956). "A Contribution to the Theory of Economic Growth", *The Quarterly Journal of Economics*, Oxford University Press, 70(1), 65-94.

Torres-Reyna, O. (2007). "Panel Data Analysis Fixed and Random Effects Using Stata (v. 4.2)", *Data & Statistical Services*, Princeton University, 112.

Tödtling, F. and Trippl, M. (2005). "One Size Fits All? Towards a Differentiated Regional Innovation Policy Approach", *Research Policy*, 34(8), 1203-1219.

Van Ark, B. (2009). ""Whose Lessons to be Learned?" Reflections on New Orientations in US and European İnnovation Policies", *Knowledge for Growth: Prospects for Science, Technology and Innovation,* Editor: Foray, D., David, P., and Hall, B., 50-53.

Varga, A., Sebestyén, T., Szabó, N. and Szerb, L. (2018). "Estimating the Economic Impacts of Knowledge Network and Entrepreneurship Development in Smart Specialization Policy", *Regional Studies*.