Regional Economic Growth and Financial Innovation: Perspectives from the Turkish Banking Sector

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Bölgesel Ekonomik Büyüme ve Finansal İnovasyon: Türk Bankacılık Sektöründen Perspektifler

Abstract

The study aims to reveal the relationship between financial innovation in the banking sector and economic growth for Statistical Region Units Level-1 (12 regions) and Türkiye's 81 provinces. In the study, annual data from 2010 to 2021 was employed. The Arellano-Bond GMM first differences and Pooled Data approach were used as models. The coefficient of the variable measuring financial innovation in the banking industry was significant and positive for the regions and provinces. The findings suggest that the banking sector's innovative goods and services, led by technical advancements and globalisation, contribute positively to the economies of certain Turkish regions and provinces. These empirical validate Schumpeter's theory and ideas of endogenous growth.

Keywords : Financial Innovation, Banking Sector, Regions-Provinces, Dynamic Panel GMM Method, Pooled Data Method.

JEL Classification Codes : G21, O16.

Öz

Çalışma, İstatistiksel Bölge Birimleri Düzey-1 (12 bölge) ve Türkiye'nin 81 ili için bankacılık sektörü için finansal inovasyon ve ekonomik büyüme arasındaki ilişkiye odaklanmaktadır. Çalışmada 2010-2021 yılları arasındaki yıllık veriler kullanılmıştır. Model olarak Arellano-Bond GMM birinci farkları ve Pooled Data yöntemi uygulanmıştır. Türkiye'de bazı bölge ve iller için bankacılık sektörü finansal inovasyon değişkeni katsayısının anlamlı ve pozitif olduğu tespit edilmiştir. Sonuçlar, bankacılık sektörünün teknolojik gelişmeler ve küreselleşme öncülüğünde inovasyona dayalı ürün ve hizmetlerinin ekonomik büyümeye olumlu katkılar sunduğunu desteklemektedir. Bu ampirik bulgular, Schumpeter'in fikrini ve içsel büyüme teorilerini doğrulamaktadır.

Anahtar Sözcükler : Finansal İnovasyon, Bankacılık Sektörü, Bölgeler-İller, Dinamik Panel GMM Yöntemi, Havuzlanmış Veri Yöntemi.

1. Introduction

Achieving and maintaining economic growth is crucial for both developing and developed economies. These economies' financial markets and regions contribute significantly to economic growth. In recent years, the number of research papers that explain the relationship between economic growth and financial development has expanded (Ahmed & Ansari, 1998; Odedokun, 1999; Beck et al., 2000; Al-Yousif, 2002; Calderon & Liu, 2003; Aslan & Korap, 2006; Güneş, 2013; Sağlam & Sonmez, 2017). After the 1980s, globalisation, technical advancements, and innovations propelled the growth of financial markets. After 1990, this type of research gained popularity. Schumpeter, who appears to have done pioneering research on the relationship between financial development and growth, asserts that an economy will grow faster if its financial system works well. Schumpeter suggests that the banking sector, a critical system component, enables the economy to grow through efficient fund allocation. This is because of globalisation, technology, and the increase in the number and wide range of financial innovations. In other words, an efficient banking system is an essential part of economic growth. In this study, it is underlined that the banking sector is the foundation of economic expansion.

In addition to its role as an intermediary between capital-seeking firms and capital-saving households, the banking sector, which occupies an eminent position in the financial system, contributes significantly to the economic growth of countries and regions through loans and innovations. As a result of globalisation's impact on competition, banks have been compelled to emphasise the development of innovative goods and services alongside technological progress. The study aims to determine the relationship between economic growth and banking sector-based financial innovation for Türkiye's Nomenclature of Territorial Units for Statistics (NUTS 1) and 81 provinces. Most research focuses on the connection between financial development and economic growth. Due to the limited number of studies in the banking sector based on regions and provinces, the new method of this study is to evaluate the relationship between financial development and growth from a regional viewpoint, with a particular emphasis on financial innovations in the banking industry.

There has yet to be a consensus on the definition of innovation in finance. Van Horne (1985) gave the most commonly encountered definitions for financial innovation:

> "*products or processes established to take advantage of profit opportunities that arise as a result of ineffective financial intermediation and/or incomplete financial markets*" (Van Horne, 1985: 621).

However, there is no agreed-upon classification scheme for financial innovations. Different classifications have been developed for various purposes (Llewellyn, 2009). According to the previous concept, Van Horne (1985) divides financial innovations into "process" and "product" classes. Automatic cash machines, point-of-sale terminals, financial transactions with personal computers, the electronic fund transfer system, and credit cards are examples of process-based financial innovation; product-based financial innovation

includes money market investment accounts, money options, universal life insurance, put options on bonds, interest, and currency swaps, interest rate and stock indexed futures, and options on futures (Van Horne, 1985).

On the other hand, Frame and White (2004) categorise financial innovations as services, products, production techniques, and organisations. Online securities trading and internet banking are innovations based on a service basis; exchange-traded funds and variable-rate mortgages are innovations based on a product basis; credit rating facilities and electronic recording of securities are innovations based on a production process basis; and creating a banking system that can only be done via the internet is an innovation based on an organisational basis (Frame & White, 2004).

Differences in human capital, demographics, and social elements, such as agriculture, service, industry, trade, finance, communication, transportation, health, and education, cause regional socioeconomic disparities. Moreover, these disparities result in diverse income distributions between regions. In Türkiye, the problem of regional imbalance is tied to the problem of income inequality (DPT, 2001).

Regional evaluation based on their level of development is a dynamic process. There are differences in regional and national levels of development. Consequently, regions are categorised as "developed regions" or "underdeveloped regions" according to their levels of economic development (Ildırar, 2004). Regional imbalances can be discussed in developed countries, but the situation is far more acute in developing countries. Due to the industrialisation of developed nations, technology is adopted, investments are increased, globalisation is hastened in every aspect, and innovations are implemented. Naturally, regional disparities are less pronounced in rich countries than in poor ones. As a result of the beginning of industrialisation in the nineteenth century and the opening to the West, interregional development inequalities have occurred throughout history. Western Anatolia's cities and ports, renowned for their geographical location and natural riches, have strengthened their business ties with Western European countries. Because of this, these regions have become more important when interacting with other regions (Dinler, 2005).

Besides, agriculture, industry, the service sector, per capita income, urbanisation, innovation, knowledge, industrialisation, R&D activities, unemployment, schooling, investment level, regional economic efficiency, capital, and savings all impact regional growth and development. Economic consequences include geographic and historical effects; labour force; transportation costs; technological innovations; energy resources; taxes and incentives; infrastructure services; raw material supply; and the market centre (Karaalp, 2008).

Significant regional and provincial development inequalities were discovered in the study by Uyan (2009) on regional development dynamics in Türkiye for 81 provinces. Innovation, human capital, intellectual capital, industrial production, and international trade were significant causes of these differences (Uyan, 2009). The components that Uyan (2009)

revealed in his doctoral thesis, which was based on identifying the factors affecting economic development at the local and regional level, include trade openness, the presence of small and medium-sized enterprises, the capacity of entrepreneurs, population, and education. By revealing the relationship between innovation and growth on a provincial and regional basis, this study is expected to contribute to Uyan (2009).

Instead of analysing the relationship between financial intermediation and economic growth on a country level, this study analyses the local dynamics of the structural transformations that emerged during the 2007-2008 Global Financial Crisis. We aim to examine 12 statistical regions and 81 provinces of Türkiye and contribute to the literature on the relationship between financial development and economic growth during the research period when the banking sector shaped its international activities according to local dynamics to compensate for falling profitability levels within the context of the legal obligations brought about by structural transformations. Due to technical considerations such as the insufficiency of studies on regional and provincial economic development in Türkiye, the homogeneity of regional variables, the similarity of legal and institutional factors, and the effective definition of the relevant financial market, it was deemed appropriate to establish the scope of the study based on provinces and regions. Based on cross-country analyses, the study also analysed the effects of various banking innovations in Türkiye's 12 statistical regions and 81 provinces between 2010 and 2021.

In multivariate statistical analysis methods, the large number of innovation variables employed for the regions and provinces causes various issues, particularly the degree of freedom concerns. Economic and financial relationships are, in general, dynamic, and the events that occur over time are the result of experiences. To create innovation indices over eigenvalue and eigenvector factor loads, the independent variables that are believed to be associated with innovation in the banking sector are utilised with the Principal Component Analysis (PCA) method, which is one of the adaptive dimension reduction methods. This investigation employs three econometric techniques: Arellano-Bond GMM first differences pooled Ordinary Least Squares (OLS) and pooled estimated generalised least squares (EGLS) (cross-section random effects). In the analysis performed for the regions and provinces of Türkiye, the application of dynamic panel data methods, Arellano-Bond Generalized Methods of Monets (GMM) first differences estimation method, and standard pooled OLS and EGLS panel data methods in annual data for the period 2010-2021 was necessitated by an insufficient number of time and/or cross-section dimensions.

The remainder of the study comprises five sections. The second section examines the historical evolution of the Turkish banking industry. We discuss EFT (Electronic Fund Transfer), ATM (Automated Teller Machine), POS (Point-of-Sale Terminals), debit and credit cards, internet banking, telephone banking, and mobile banking, which are novel goods and services driven by the infrastructure of technology. In the third section, the paper analyses the determinants of regional growth and the factors of regional economic development, representing the advanced phase of regional economic growth. The fourth section presents PCA, dynamic GMM, and pooled data for regions and provinces. The

results of the analysis are reported in the fifth section. The last section presents the results and policy implications.

2. The Development of the Turkish Banking Sector: Technology-Led Products and Services in the Banking Sector

The process of financial liberalisation, which accelerated during the second half of the 1980s, constitutes a watershed moment for the financial industry, notably the banking sector. Until 1980, the Turkish banking system could be described as having limited market access, being close to the rest of the world, being non-competitive, operating at manageable interest rates, providing multi-branch retail banking, being non-specialized, and meeting the financial needs of its shareholdings (Çolak, 2005). With the emergence of an opening-up trend in the banking industry, interest rates on deposits and loans were liberalised, and banks were authorised to provide certificates of deposit. In addition, many foreign banks began to operate at the commercial, investment, and branch levels, and foreign banks created partnerships with Turkish banks. Turkish banks were organised during this time by establishing overseas branches and new banks (Akgüç, 1989). Between 1980 and 2000, the banking sector's total assets grew by four times, its total deposits increased by six times, and its total loans grew by two times (Coşkun et al., 2012).

As the financial liberalisation process has advanced since the second half of the 1980s, some financial crises have occurred throughout the world since 1990 (Mexico in 1994, Southeast Asia in 1997, Russia in 1998, Brazil in 1999, Türkiye and Argentina in 2000-2001) (Özkan, 2008). Other internal determinants, such as countries' unsustainable domestic debt dynamics, poor functioning of public banks and financial markets, and structural flaws in the financial system, also played a role in the crises (CBRT, 2001). The Turkish economy fell significantly due to the financial crisis in the first quarter of 2001. Comparing the first nine months of the year, the change in GNP is 8.3%, while the change in GDP is 6.4%. The failure to keep the exchange rate policy was due to the sudden capital outflows induced by the economic crisis, the growing exchange rate volatility, and the loss of confidence. Following a period of robust expansion in 2000, the impact of the financial crisis (February 2001) resulted in significant declines in added value across all industries, particularly the manufacturing and retail sectors (CBRT, 2002).

Due to the rising interest and inflation rates driven by the crisis of 2001 and the volatility in exchange rates, economic insecurity persisted. The inflation rate increased from 39% to 69%, as the real gross domestic product declined by 9.4%, and the rate rose from 39% to 69%. The banking industry lost 77% of its funds in 2001. Immediately after the crisis, the "Strong Economy Transition Program" (SETP) was announced to avoid structural problems and strengthen the financial system's financial structure. Significant changes were made to economic policy. This program's implementations include a monetary policy that ensures an effective fight against inflation and price stability, a disciplined fiscal policy, and structural arrangements that strengthen the financial sector's financial structure, particularly

the banking sector, and ensure efficiency and transparency in all economic units (TBB, 2008).

As a result of globalisation, innovation, and the expansion of information and technology, the banking industry continues to grow. In June 2022, the Banks Association of Türkiye (BAT) reported 57 active banks in Türkiye, including 35 deposit banks, six development banks, and 16 development and investment banks. The number of staff in deposit, development, and investment banks is 185,566; the total number of branches is 9,753. According to data compiled by the Banking Regulation and Supervision Agency (BRSA), the banking sector's total assets grew to 3,258 trillion Turkish Lira in September 2022. By the end of 2021, the sector's total assets will have expanded by 42.2%, its total loans by 39.5%, and its total securities by 44.4%.

Figure: 1
The Historical Developments of the Banking Sector in Türkiye

(a)   (b)

(c)   (d)

(e)

(f)

(g)

(h)
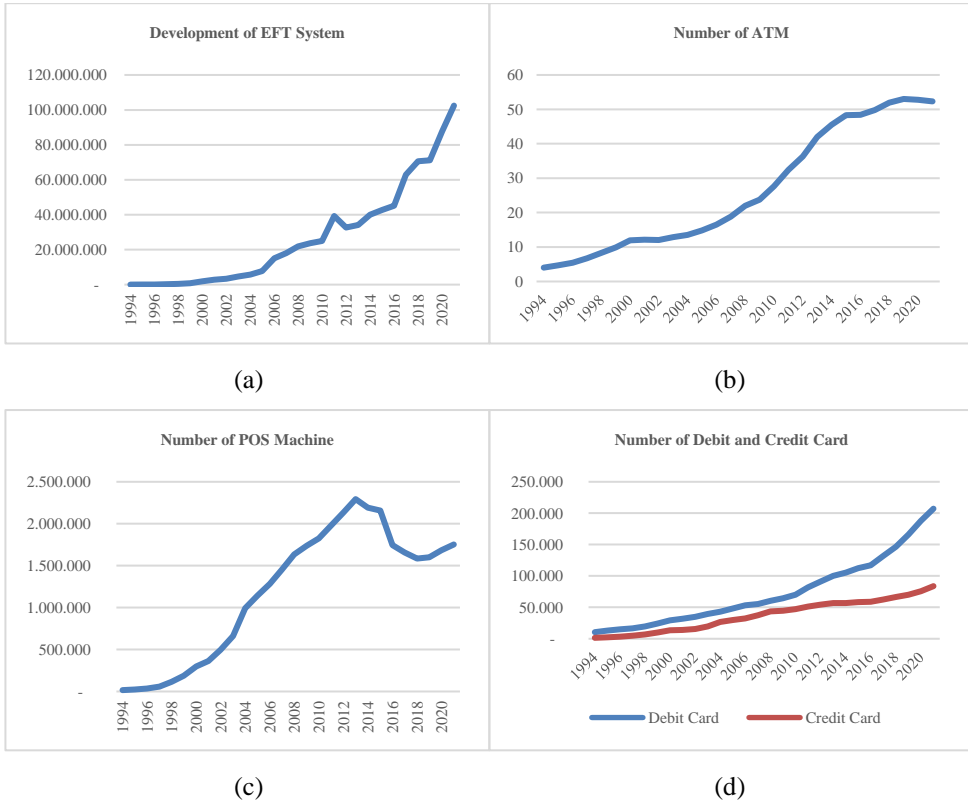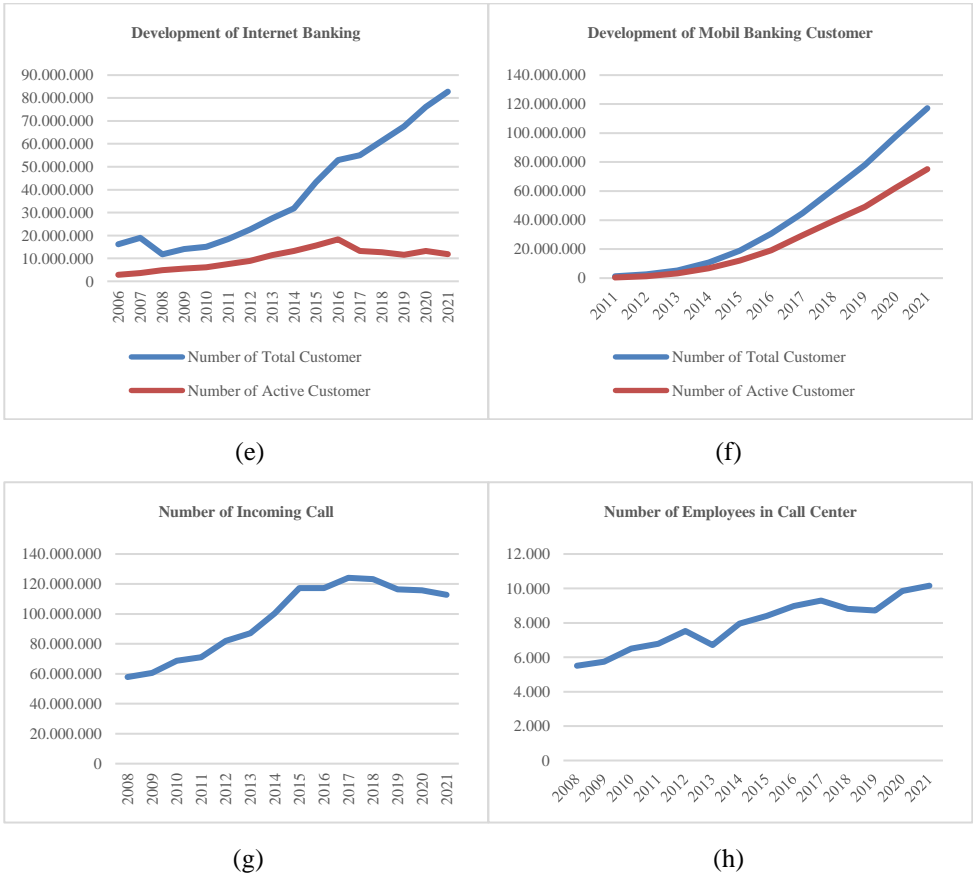
Source: Prepared by the authors.

Figure 1 and Panel (a) demonstrated that the growth of the EFT system in Türkiye increased continuously from 1994 to 2020. Panels (b) and (c) indicate that the number of ATMs and POS is rising. ATMs grew from 4,000 in 1994 to about 52,300 by 2020. This makes it easier for customers to conduct certain banking transactions, such as account controls, without visiting a branch. The increase in the total number of debit and credit cards is illustrated in panel (d). As seen in panel (e), Internet banking is utilised aggressively and intensively as a banking service. As shown in panel (f), mobile banking services began to proliferate in the 2000s, and the number of registered and total active consumers steadily expanded. From 2008 to 2021, the total number of incoming calls and the number of call centre employees went up. This shows that consumers are happy with innovations. As a substantial part of the financial system, the banking sector has come a long way with globalisation and technological development in recent times.

3. Factors Affecting Regional Growth: Theoretical Background

Regional disparities emerge differently in developed countries versus emerging or developing countries. While regional differences tend to be reduced in developed countries, they tend to increase in developing or undeveloped countries (Gündüz, 2006). Moreover, it is unreasonable to assume that all regions within a country are at the same level of development. Numerous regional factors contribute to the differential economic development of different regions. Numerous factors, including geographical conditions, natural resources, population structure, specialisation, productivity, physical and human capital, R&D, infrastructure, and innovation potential, influence the economic success of regions (OECD, 2009). Numerous economic disciplines, including economic growth theory, new spatial economics, and regional economics, examine the notion of regional growth (Capello & Nijkamp, 2009). Explanations based on the literature for regional expansion:

- *The Sectors Theory* states that a region's economic development depends on the sectors and the elastic demand for the goods produced in those sectors. The elasticity of demand for the goods produced is directly proportional to its contribution to economic development. In this context, regional economic development in sector theory, division of labour, specialisation, increases in individual income, and the volume of economic activity (Gündüz, 2006).

- *The Export-Based Growth Theory* indirectly contributes to regional development by raising income, investment, and productivity (Martin, 2005; Taşcı et al., 2011). It is addressed similarly in Kaldor's (1970) Cumulative Causality Theory and the Keynesian Regional Growth Theory, as well as in the export-based growth model. Kaldor argues that the demand for regional exports constitutes regional development. The cumulative consequences of the increase in exports are suggested to be the result of rising returns to scale. In the Keynesian regional growth model, a region's income change is viewed as a function of its exports. As a result, increased exports provide externality and productivity benefits to area economies (Leichenko, 2000).

- *The Development/Growth Pole Theory* demonstrates that not all parts of a country experience economic growth at the same rate and size. The process of development begins in particular regions and subsequently expands to others. Due to their advantageous environment and diversified development opportunities, regions and sectors classified as the development pole (development centre) become economic hubs with more significant economic activity than other regions and sectors. Due to their differences in economic development, these regions or sectors attract more economic activity over time. This trend spreads to the regions or sectors with which they have strong ties (Kaya, 2009).

- *The Evolutionary Theory* emphasises dynamic competitive advantage and a regional economy's adaptation to market shifts, new competitors' emergence, and recent technological development. According to this theory, past innovations and alterations influence the region's current competitive advantage (Martin, 2005).

- *The Institutional Theory* contends that a region's competitive advantage is derived from its institution's riches. Merging institutions for a common purpose creates an atmosphere conducive to regional economic development, from entrepreneurial culture to forms of social capital (Martin, 2005).

The increase in physical fixed capital stock and production capacity as a result of investments; the transfer of know-how through the introduction of new technologies to the region through foreign trade; export revenues; labour flows; human resources and quality; and the financial capacity that enables long-term borrowing (Yeldan et al., 2012). Neoclassical and endogenous growth theories, which are modern growth theories, try to find the most important sources of growth and describe economic growth in terms of per capita income.

Most studies show that financial development is critical in achieving economic growth. In addition, a large spectrum of development economics literature states that capital accumulation is the most important factor underlying economic growth. This view asserts that banks increase domestic savings, attract foreign capital, and cause economic growth (Beck et al., 2000; Valverde et al., 2011; Araç & Özcan, 2014; Wang et al., 2019). Capital accumulation, one of the most critical determinants of economic growth, is based on investment and savings. It is expected that an increase in income will lead to a rise in savings, which will lead to an increase in investments. In his research on savings in Türkiye, Uygur (2012) underlined the role of savings in investment decisions and economic growth. In addition, he noted that Türkiye's inefficient savings are the primary cause of its current account deficit. Capital accumulation, financial innovations, financial development, technological progress, expanding product diversity, and rising production and exports of high-technology items were cited as the most prominent sources of economic growth and expansion. Integration into global markets increased exports and positive externalities, stimulating economic growth and development.

While banks operate in financial intermediation, they attempt to transfer money to more productive sectors. As a result, banks must pay greater attention to selecting financially more robust business models and increasing investments through efficient capital transformation. The earliest assessments of the relationship between financial development and growth are provided by Schumpeter (1911-1934) (Schumpeter, 1911-1934; Kandır et al., 2007). According to Schumpeter (1911), the banking sector financed productive investments, increasing per capita income and the growth rate (Schumpeter, 1911). In his research on Economic Development Theory, Schumpeter (1911) asserts that innovation, particularly financial innovations, fosters economic development. Financial intermediaries transfer idle funds to ventures, which helps the economy grow. Similarly, Schumpeter (1934) demonstrated that the banking sector boosted economic growth due to its role as an underwriter of efficient investments (Schumpeter, 1934; Tsuru, 2000). Schumpeter argues that technological innovation is required for financial intermediaries to contribute to economic growth and development in savings mobilisation, project evaluation, risk management, and transaction facilitation (King & Levine, 1993). (Becsi & Wang, 1997).

Recently, neoclassical and endogenous growth models have studied the relationship between financial innovation and economic growth. Both approaches are applicable for assessing the effects of financial sector innovation on economic growth. However, recent studies indicate that endogenous growth models are ahead (Benhabib & Spiegel, 2000). Since neoclassical growth theory posits that technological development is driven from outside the system, more is needed to answer several fundamental problems regarding the source of long-term economic growth and the causes of income disparities between nations.

Endogenous growth models reject the arguments of the neoclassical growth models entirely. Romer's (1986) "Increasing Returns and Long-Run Growth" and Lucas's (1988) "On the Mechanics of Economic Development" laid forth the principles of endogenous growth models (Grossman & Helpman, 1994). In related models, economic growth will result in the long term, even in the absence of technological development due to positive externalities in production (Schiff, 1999). The basis of their studies indicates that the human capital in R&D units formed new products or production methods (Romer, 1986). Endogenous growth theories refer to the idea that economic growth is intrinsically driven by economic forces functioning within their dynamics, as opposed to external technical breakthroughs uncontrollable by the market mechanism, as in the neoclassical growth models (Grossman & Helpman, 1994). Endogenous growth models assert that banks' screening and monitoring functions, which make it easier, faster, and more efficient for individuals and enterprises to obtain loans, contribute to economic growth (Bencivenga & Smith, 1991).

Although the relationship between financial development and economic growth has been hotly debated for decades, there has yet to be a consensus in the literature on the impact of the financial system on economic growth. Some researchers claim that financial development plays a vital role in the growth process and find that financial development has positive results on economic growth (Schumpeter, 1911; Goldsmith, 1969; McKinnon, 1973; Shaw, 1973; King & Levine, 1993; Levine & Zervos, 1998; Beck et al., 2000; Calderon & Liu, 2003; McCaig & Stengos, 2005; Ang & McKibbin, 2007, Luintel et al., 2008; Valverde et al., 2011; Beck et al., 2012; Motsatsi 2016), some researchers claim that financial development does not play an important role in the growth process and find negative results (Achy, 2004; Chang, 2002; Acaravcı et al., 2009). Besides Müslümov and Aras (2002), Christopoulos and Tsionas (2004), Thangavelu and James (2004), Chang and Caudill (2005), and Aydın and Malcıoğlu (2016), financial growth has been shown to cause economic growth. Liang and Teng (2006), Ang and McKibbin (2007), Odhiambo (2008), Ak et al. (2016), Davarcıoğlu (2016), and Sumarni (2019). Alternatively, studies show bidirectional causality between the two variables (Al-Yousif, 2002; Calderon & Liu, 2003; Pradhan et al., 2013; Dritsakis & Adamopoulos, 2004; Shan & Jianhong, 2006). Few studies have identified a causal link between financial development and economic expansion (Andersen & Tarp, 2003; Lu & Yao, 2009; Chang, 2002; Dawson, 2003; Tang, 2006; Chakraborty, 2010). Finally, Ram (1999) and Halkos and Trigoni (2010) show that the financial system hinders the economic growth process (Ram, 1999; Halkos & Trigoni, 2010).

In this context, for both developing and developed countries, all international, national, and local studies that confirm or reject the relationship between financial markets and the economic growth hypothesis are listed as follows. The relationship between financial development and economic growth has been studied in the literature since Schumpeter (1911) argued that it is critical for economic growth. Technological advancement and an increase in technological advancements aid economic growth. Schumpeter contends that financial development impacts economic growth by supplying sufficient funding to businesses for productive purposes. Following Schumpeter, studies made by Goldsmith (1969), McKinnon (1973), and Shaw (1973) also support this perspective (Bist, 2018).

Goldsmith (1969) looked into the relationship between financial development and economic growth in 35 countries between 1860 and 1963. They found a large and significant relationship between the size of the financial system and economic development. He also underlined the need for a well-functioning banking sector for economic growth. King and Levine (1993) analysed 80 countries between 1960 and 1989 to determine the impact of financial development on economic growth and to evaluate Schumpeter's theory. To assess the level of financial development in the banking sector, they hypothesise that financial services contribute to economic growth by improving capital accumulation and productivity. In addition, they found that the planned financial development component is intimately related to future economic growth rates, physical capital accumulation, and increases in economic productivity.

De Gregorio and Guidotti (1995) explained their investigations using two samples, the first sample (100 countries in the period 1960-1985) and the second sample (100 countries in the period 1990-2000) (Twelve Latin American countries in the 1950-1985 period). They revealed that the effect of financial development on economic growth is mediated through the productivity channel as opposed to the investment channel. They determined that financial development has a substantial impact on economic growth. Demetriades and Hussein (1996) evaluated the relationship between financial development and economic growth in 16 developing countries between 1960 and 1990. They found insufficient evidence that the financial sector is the driving force behind economic development. In the analysis, different results were obtained according to the countries. While financial sector development contributes to economic progress in Honduras, India, Thailand, Korea, Mauritius, and Venezuela, it is the outcome of economic growth in Türkiye, Greece, Costa Rica, Guatemala, El Salvador, and Portugal.

Graff (2002) investigated the relationship between the evolution of financial activity and economic growth from 1970 to 1990. The results indicate that financial advancements contribute to economic expansion. However, it was noted that improvements in the financial sector from 1975 to 1980 had less impact on economic growth. Al-Yousif (2002) investigated the relationship between financial development and economic growth in the economies of 30 developing nations between 1970 and 1999. The results indicate that economic growth and financial development have a considerable mutual influence or that there is bidirectional causation between them. In their 1985-1998 study, Shan and Morris

(2002) studied the relationship between financial development and economic growth for the economies of 19 OECD member countries, China and South Korea. The outcomes of studies vary.

It has been determined that developments in the financial sector have contributed to the expansion of the entire country's economy. In some countries, the expansion of the financial sector generates economic growth, whereas, in other nations, the financial sector has developed due to economic growth. Calderon and Liu (2003) evaluated the relationship between financial development and economic growth for 199 developing and developed nations between 1960 and 1994. The research determined the relationship to be supply-driven for developing countries but demand-driven for developed countries. Taş and Örnek (2003) used quarterly data from 1987 to 2000 to determine the relationship between financial development and economic growth using the Granger causality test and cointegration tests based on an error correction model. They found a long-term relationship between financial development and economic growth. In addition, there is a bidirectional causal relationship between financial development and economic growth.

Aslan and Korap (2006) evaluated the relationship between financial development and economic growth from 1987-2004. The Johansen co-integration and Granger causality are statistically significant and positive in the study. Granger causation is unidirectional, from economic development to financial development. Liang and Teng (2006) evaluated the relationship between financial development and economic growth for the 1952-2001 era of the Chinese economy using a VAR model. They concluded that economic growth causes financial development in a unidirectional manner.

Liu and Hsu (2006) investigated the relationship between economic growth and financial development in Korea, Japan, and Taiwan from 1981 to 2001. Principal component analysis and GMM methods indicate that significant investments drive economic growth in Japan and that movements in the stock market positively impact Taiwan's economic growth performance. Agu and Chukwu (2008) analysed the relationship between financial development and economic growth in the Nigerian banking sector from 1970 to 2005. The analysis indicates a positive relationship between financial development and economic growth. It was concluded that the growth of deposit and loan variables positively impacted economic growth. In other words, a causal relationship was discovered between bank-based financial development and economic growth. Dawson (2008) investigated the relationship between financial development and economic growth in 44 emerging economies between 1974 and 2001. There is a statistically significant positive relationship between financial development and economic growth. Şahin (2017) used panel data to examine the relationship between financial development and economic growth in emerging market economies from 2004 to 2015. He concluded that financial development contributed positively to economic growth.

Bozoklu and Yılancı (2013) used the Granger causality test to examine the relationship between financial development and economic growth in developing countries

from 1988 to 2011. They looked at Brazil, China, Indonesia, the Philippines, South Korea, India, Hungary, Malaysia, Mexico, Egypt, Peru, Chile, Thailand, and Türkiye. Based on the analysis, economic growth is caused by financial development. This shows that improving a country's financial system can help it grow faster. Mhadhbi (2014) used the dynamic panel GMM method to look at the effect of financial development on economic growth in both developed and developing countries and economies from 1973 to 2012. Based on the analysis, it has been decided that lending money to the private sector through the financial system harms economic growth. Güneş (2013) examined the relationship between economic growth and financial development in the Turkish economy from 1988 to 2009. The causality test showed no relationship between financial development and economic growth. Also, one of the analysis results was that the rise in the M2 money supply, often used as a measure of the economy, is not the cause of economic growth. Aydın and Malcıoğlu (2016) analysed the relationship between economic growth and financial development for OECD countries and economies in the 1980-2014 period using the Dumitrescu-Hurlin Panel Causality Test. They found a direction of causality from financial development to economic growth.

Levine and Zervos (1998) investigated the relationship between banking sector development and economic growth in 47 countries from 1976 to 1993. It has been determined that a positive and significant relationship exists between the development of the banking sector and economic growth. In addition, they concluded that the development of bank loans has a strong and positive effect on growth by increasing capital accumulation and productivity. Ahmed and Ansari (1998) found that banking sector development increased economic growth in India, Pakistan, and Sri Lanka from 1973 to 1991. Financial market developments boost economic growth. Odedokun (1999) analysed the relationship between financial development and economic growth for 22 developed and 100 developing countries from 1961 to 1990. It's been shown that financial sector growth stimulates the economy. Beck et al. (2000) intended to determine the relationship between banking sector development and economic growth from 1960 to 1995. A relationship was also found between the growth of the banking industry and the increase in productivity. Results also indicated a correlation between the development of the banking industry and the pace of capital accumulation and savings. They concluded that financial intermediaries significantly and positively impact economic growth.

Long-term estimates show that financial development has a positive and significant effect on economic growth and that financial development and economic growth are cointegrated. Bist (2018) used the panel unit root and panel cointegration methods to determine the long-term relationship between financial development and economic growth in 16 low-income African and African-origin countries from 1995 to 2014. Aydın (2019) used the Westerlund cointegration method to examine the relationship between financial development and economic growth in the fragile five countries (Brazil, Türkiye, India, Indonesia, and South Africa) from 1992 to 2016. The results show a long-term relationship between economic growth and financial development. Also, DOLS and FMOLS panel cointegration estimators showed a long-term relationship between financial development and economic growth that was both significant and positive. Atay (2020) examined the

relationship between financial development and economic growth in Türkiye during the 1961-2015 period using the Granger causality analysis method. A unilateral cointegration of economic growth and financial expansion was determined.

Beck and Levine (2004) examined the relationship between the stock market development, banking sector, and economic growth in 40 countries between 1976 and 1998. The analysis utilising the dynamic panel data GMM approach revealed a significant and favourable association between the development of the banking sector and economic expansion. Christopoulos and Tsionas (2004) analysed the relationship between financial sector development and economic growth in 10 developing economies from 1970-2000. There is no relationship between financial sector development and economic growth in the short term; They found that financial sector development contributes positively to economic growth in the long run. Thangavelu and James (2004) examined the relationship between the Australian economy's financial development and economic growth from 1960-1999. They concluded that economic growth leads to the financial sector's development. Ghirmay (2004) examined the relationship between financial development and economic growth in 13 sub-Saharan African countries. In 12 countries, there is a long-term relationship between financial development and economic growth. In the analysis using the VAR model, the subject of the study was discussed in terms of long-term cointegration and causality.

The difference between the growth of real production and the growth of private credit has shaped economic growth. Ductor and Grechyna (2015) examined the financial development, real sector, and economic growth of 101 developed and developing countries from 1970 to 2010. They found that financial development will only damage growth if there is a direct link between private credit growth and real output growth. Alimi (2015) used an estimated OLS, fixed effect model, and dynamic panel data GMM to examine the relationship between financial development and economic growth in seven Sub-Saharan African countries from 1981 to 2013. The result indicated no statistically significant relationship between financial development and economic growth. This means that financial development does not affect economic growth.

Caporale et al. (2009) looked into the relationship between banking sector expansion and economic growth for the economies of 10 European Union (EU) countries from 1994 to 2007. The developments in the banking sector in these countries are modest, and hence the impact of banking on economic growth is limited. Valverde et al. (2011) analysed the effect of financial innovations in banking on regional growth in 17 of Spain's administrative areas. GMM methods indicate that innovative products and services contribute positively to the growth of the regional gross domestic product, investment, and gross savings and that there is a positive relationship between banking financial deepening and regional growth. Rachdi and Mbraek (2011) examined the relationship between financial development and economic growth for 6 OECD countries and 4 MENA nations between 1990 and 2006. The GMM method indicates a positive, long-term relationship between financial development and economic growth in all countries. Beck et al. (2012) report on financial innovations in the banking sector from 1996 to 2006 covers 32 countries, most of which have high incomes.

The study showed a strong link between increased innovation, growth opportunities for the country, GDP per capita, and capital. Motsatsi (2016) investigated the relationship between innovation and economic growth in the financial sectors of Botswana in South Africa for the period 2006-2014 with the ARDL model. The results showed that the effect of innovation variables on economic growth is positive. So, one of the results was that ATMs and EFTPOS would help the economy grow in rural areas where it is hard to find if policies are implemented to encourage their spread across the country.

4. Data and Methodology

The study aims to reveal the relationship between financial innovation in the banking sector and economic growth for Statistical Region Units Level-1 (12 regions) and Türkiye's 81 provinces. The study used 2010-2021 annual data. Provincial and regional data were derived from the Banks Association of Türkiye and the Presidency of Türkiye, Presidency of Strategy and Budget databases. Models included Arellano-Bond GMM first differences and Pooled Data.

According to the Bank of International Settlements (BIS) Committee on the Global Financial System (CGFS) report, the 2007-08 Global Financial Crisis revealed that banks had significant structural problems, such as capital adequacy and liquidity. The banking industry has adopted various crisis-exit strategies to boost profitability and adhere to legal requirements. In this sense, the global banking sector adopted a variety of structural reforms in the post-crisis period, including the invention of new market, product, and management models that account for the dynamics of the local geography in which they operate, particularly among the five combinations proposed by Schumpeter as the capitalists' and entrepreneurs' crisis-exit strategies. To protect banks from large-scale system risks, the report noted that the effects of structural changes, particularly in the post-crisis period, shaped the majority of banks' international activities geographically over local dynamics in their global strategies. To analyse the relationship between the banking sector's innovative activities and economic growth in Türkiye during the post-crisis period and on a local scale, the research scope and period have been designed accordingly (Buch & Dages, 2018).

Standard GMM, the model eliminates the endogeneity and autoregression issues caused by time series variations, a small number of observation periods, and country-specific effects by incorporating the lagged values of dependent and independent variables as instrumental variables (Joliffe & Cadima, 1996; Beck & Levine, 2000; Liu & Hsu, 2006; Valverde et al., 2011; Rachdi & Mbraek, 2011; Mhadhbi, 2014). This study employs three econometric methods for provinces and regions: Arellano-Bond GMM first differences, OLS, and pooled EGLS (random cross-section effects). When Arellano-Bond GMM panel estimators are compared to OLS, pooled EGLS.

Especially in multivariate analyses where multicollinearity problems are possible, and estimators can produce biased results, methods dating back to Pearson (1901) and Hotelling (1933) form the basis of PCA and facilitate interpretation in large data sets are

utilised. There have been numerous methods to reduce the size of the set. PCA is an adaptive technique based on the eigenvalue/eigenvector problem-solving technique that creates a new index variable from the correlation and covariance matrices uncorrelated but minimises data loss in a linear relationship with the original variables (Joliffe & Cadima, 2016).

Table: 1
Descriptive Statistics

Variable (Log of series)	Obs	Mean	Std.	Min	Max
DEPENDENT VARIABLE					
GDP	972	3.40e+07	1.07e+08	744057	1.52e+09
INDEPENDENT VARIABLES					
INDUSTRIAL	972	17.64463	10.62844	1.3	50.6
ELDERPOP	972	9.725694	3.49751	2.655171	20.13663
URBANPOP	972	73.67135	18.41916	31.96	100
ELECTRIC	972	2763299	4954407	69643	4.04e+07
EMPLOYMENT	972	10425.17	24126.22	18	353908
PATENT	972	76.09568	323.2392	0	3795
INNOVATION VARIABLES					
IDKRD	972	19396.35	91324.25	126	1320830
TKRD	972	21759.13	102057.6	162	1826564
TMVDT	972	2.11e+07	1.13e+08	161210	2.30e+09
TNKRD	972	2.43e+07	1.11e+08	183473	2.02e+09
ATM	972	503.0473	1274.563	16	11933
UYEIS	972	32982.56	112187.8	683	2069772
POS	972	33008.73	111930.4	727	2078544
BKK	972	1191489	3967039	11649	5.98e+07
TSMVDT	972	1.26e+07	6.09e+07	102139	1.25e+09
BSS	972	139.677	381.5067	8	3520
TKPALCK	972	862133.7	4082224	3303	6.70e+07

Table 1 shows descriptive statistics results. In 2021, R&D expenditure in Türkiye approached 82 million, with the highest level in Istanbul (TR1), West Anatolia (TR5), and East Marmara (TR4) regions (3 regions totalling 64 million) and the lowest level in Northeast Anatolia (TRA), East Black Sea (TR9), Middle East Anatolia (TRB), and Southeast Anatolia (TRC) regions (TÜİK, 2022). One of the other relevant indications is the number of patents granted in Türkiye in 2021. These patents are prevalent in Istanbul (TR1), West Anatolia (TR5), East Marmara (TR4), and Aegean (TR3) areas (4 regions totalling 6,643), Northeast Anatolia (TRA), Middle East Anatolia (TRB), and East Black Sea (TRB). It was low in the TR9 and Western Black Sea (TR8) regions (Turkish Patent and Trademark Office, 2022).

Level-1 data from 2021 shows that in Northeast Anatolia, 42.6% of the employed population is employed in agriculture, whereas in Istanbul, the figure is only 0.5%. The percentage of employed people working in manufacturing was highest in the East Marmara region (38.9%), while it was lowest in the Northeast Anatolia region (12%). While 67.7% of employers in the Istanbul region are employed in the service industry, only 45.4% of employers in the Northeast Anatolia region are (TOBB, 2022).

Using annual data from 2010 to 2021, the relationship between financial innovations in development and economic growth for 12 regions and 81 provinces in Türkiye was investigated. Because of the large number of financial innovation factors in the banking industry, the multivariate statistical analysis method (PCA) was employed to combine

banking innovation variables into a single dimension. In dynamic models, the link between the lagged value of the dependent variable and the error term causes the least squares estimators to produce biased and inconsistent results. Arellano and Bond (1991) advocated employing lag factors as instrumental variables in dynamic panel data models to overcome these issues. In dynamic panel data, the GMM approach incorporating lagged values helps analyse the dynamic structure of the relationship between economic growth and financial innovation.

For regions and provinces, the Arellano-Bond GMM first differences estimator model:

$$GDP_{it} = \alpha_t + \beta_1 GDP_{it-1} + \beta_2 INDUSTRIAL_{it} + \beta_3 ELDERPOP_{it} + \beta_4 URBANPOP_{it} + \beta_5 ELECTRIC_{it} + \beta_6 EMPLOYMENT_{it} + \beta_7 PATENT_{it} + \beta_8 INNOVATION1_{it} + \beta_9 INNOVATION2_{it} + \beta_{10} INNOVATION3_{it} + \beta_{11} INNOVATION4_{it} + \beta_{12} INNOVATION5_{it} + \beta_{13} INNOVATION6_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{1}$$

The first difference model of the GMM includes GDP (level and ratio) as a dependent variable, the elderly population ratio as an independent variable, the urban population ratio relative to the total population, and the innovation component generated by PCA as a dependent variable.

4.1. PCA Results

PCA, a multivariate statistical tool, was used in the study to reduce multicollinearity between variables, increase the degree of freedom, and solve index weighting problems efficiently. Karl Pearson came up with PCA in 1901, and Hotelling added it in 1933. PCA reduces the number of dimensions in a data set by keeping its variations connected and made up of many variables (Tatldil, 2002). PCA uses linear combinations of several related variables to explain the variance-covariance pattern. In that way, the variables are reduced to fewer numbers. This led the data set of the original p variables to be conveyed and interpreted with fewer new variables, which are linear components of these variables after the transformation (Johnson & Wichern, 2002; Dinçer et al., 2003; Ünsal et al., 2005; Auer & Gervini, 2007).

PCA analysis reproduces new variables under one or more indices without losing information. Geometrically, each principal component spans the same space as the original variables and explains the same amount of variance. Derived variables (components) are orthogonal (new axes are perpendicular to each other). Each derived variable is ranked to include the maximum variance (Wickens, 1995). Manga (2018) employed 27 innovation indicators; Hamamcı and Şahinoğlu (2020) used the PCA approach for 22 emerging market economies' economic growth indicators. Additionally, Ersungur et al. (2007), Karaçoban and Değirmen (2021), Savi (2006), Rodrigues and Lima (2009), Filiz and Emrek (2005), and Savi (2006) all used PCA.

Table: 2
Principal Component Analysis Result for Innovation Data of Regions and Provinces

REGIONS							
Innovation Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Uniqueness
TMVDT	0.8132	0.5506	0.1257	0.0029	0.1401	-0.0088	0.0000
IDKRD	0.8388	0.5417	0.0320	-0.0026	-0.0109	-0.0433	0.0000
TKRD	0.8477	0.5273	0.0411	-0.0007	-0.0181	-0.0301	0.0004
TNKRD	0.8510	0.5242	0.0321	0.0004	-0.0058	0.0033	0.0000
TSMVDT	0.7162	0.6511	0.2505	0.0112	0.0154	0.0027	0.0000
BSS	0.4828	0.8714	0.0123	-0.0826	0.0235	-0.0128	0.0000
TKPALCK	0.8478	0.4954	0.0405	0.0239	-0.0426	0.0882	0.0239
ATM	0.5886	0.7881	0.1223	-0.0549	-0.0689	0.0157	0.0096
POS	0.5194	0.8478	0.0351	0.0935	0.0370	0.0132	0.0000
UYEIS	0.6035	0.7856	0.0685	0.0964	0.0000	0.0092	0.0045
BKK	0.7627	0.6248	0.0551	0.0353	0.0083	0.0176	0.0232
PROVINCES							
Innovation Variables	Factor 1	Factor 1	Factor 1	Factor 1	Factor 1	Factor 1	Uniqueness
TMVDT	0.8239	0.5445	0.1230	-0.0227	0.0151	-0.0427	0.0069
IDKRD	0.7932	0.6012	-0.0592	-0.0174	0.0233	0.0352	0.0037
TKRD	0.8189	0.5693	-0.0555	-0.0223	0.0054	0.0413	0.0000
TNKRD	0.8211	0.5641	-0.0671	0.0216	0.0078	-0.0190	0.0023
TSMVDT	0.8240	0.5321	0.1946	0.0025	0.0028	0.0046	0.0000
BSS	0.5215	0.8416	0.0041	-0.0537	0.0285	-0.0210	0.0157
TKPALCK	0.7946	0.5602	-0.0426	0.0869	0.0169	-0.0013	0.0451
ATM	0.6039	0.7866	0.0234	-0.0030	0.1266	-0.0003	0.0000
POS	0.5325	0.8406	0.0372	0.0480	-0.0535	0.0043	0.0031
UYEIS	0.5928	0.7993	0.0293	0.0556	-0.0379	0.0238	0.0038
BKK	0.7493	0.6422	0.0042	0.0759	-0.0321	-0.0117	0.0191

Source: Authors' calculation using STATA program.

Table 2 displays PCA factor results for each region and province. Using PCA, an innovation variable was added to the model. Thus, characteristics associated with innovation are categorised under six factors. As for the regions, this new variable includes total deposits (TMVDT), non-specialized loans (IDKRD), total loans (TKRD), total cash loans (TNKRD), savings deposits (TSMVDT), number of bank branches (BSS), non-performing loans (TKPALCK), automatic cash machines (ATM), point-of-sale terminals (POS), member merchants (UYEIS), and individual credit cards (BKK). The factor loads derived from the rotation method for regions and provinces are displayed in Table 1. In the dynamic panel GMM and pooled data analyses, the new variable derived from PCA was utilised as the innovation variable. The Stata 14 and Geoda package packages were used to conduct analyses.

5. Results

5.1. GMM Results and Discussion

This study investigated the effects of INDUSTRIAL, ELDERPOP, URBANPOP, ELECTRIC, PATENT, WORK, and INNOVATION on economic growth. The independent variables were the share of industry in GDP (INDUSTRIAL), the proportion of elderly people in the total population (ELDERPOP), the rate of urbanisation in the total population (URBANPOP), annual electricity consumption (ELECTRIC), the number of patents (PATENT), total job placements (EMPLOYMENT), and the innovation variables derived from the factor analysis (INNOVATION). In the model, GDP was the dependent variable.

Table: 3
Arellano and Bond Generalized Moment Estimator Results (Regions)

Variables	Coefficients	Std. Error	Z value	Prob**
URBANPOP	4.143147	1.028474	4.03	0.000
INDUSTRIAL	11.85092	4.012122	2.95	0.003
ELDERPOP	1.396042	.7015961	1.99	0.047
ELECTRIC	-3.697825	1.444648	-2.56	0.010
PATENT	6.669958	2.11723	3.15	0.002
EMPLOYMENT	-1.032869	.4022737	-2.57	0.010
INNOVATION1	-2.31196	.7661186	-3.02	0.003
INNOVATION2	-2.33616	.7387953	-3.16	0.002
INNOVATION3	.4468946	.1445147	3.09	0.002
INNOVATION4	.4122705	.1302376	3.17	0.002
INNOVATION5	-.2156182	.0823255	-2.62	0.009
INNOVATION6	-.2811693	.0918908	-3.06	0.002

Source: Authors' calculation using STATA program.
*Notes: ** (two levels stars) indicates %95 Confidence Level.*

In Table 3, the urban population, innovation, the ratio of the elderly population to the total population, the ratio of the urban population to the total population, the share of industry in GDP, the total number of patents, the total electricity consumption, the total job placement and innovation variables are statistically significant. The coefficient signs of total electricity consumption, total job placement and four innovation variables were negative.

Table: 4
Arellano and Bond Generalized Moment Estimator Results (Provinces)

Variables	Coefficients	Std. Error	Z value	Prob
URBANPOP	.711029	.0268174	26.51	0.000
INDUSTRIAL	-.4901647	.0189342	-25.89	0.000
ELDERPOP	.3050913	.0269131	11.34	0.000
ELECTRIC	.893395	.0095081	93.96	0.000
PATENT	.0241293	.004441	5.43	0.000
EMPLOYMENT	.1614249	.0057432	28.11	0.000
INNOVATION1	.0428025	.0033212	12.89	0.000
INNOVATION2	-.0700935	.004296	-16.32	0.000
INNOVATION3	-.0049244	.0024786	-1.99	0.047
INNOVATION4	-.0110619	.0040634	-2.72	0.006
INNOVATION5	.0123044	.0020141	6.11	0.000
INNOVATION6	-.0271024	.0038558	-7.03	0.000

*Source: Authors' calculation using STATA program.*

In Table 4, the innovation variable, the ratio of the elderly population to the total population, the ratio of the urban population to the total population, the share of industry in GDP, the total number of patents, the total electricity consumption, the total job placement and innovation variables are statistically significant. The industry share in GDP and the coefficient sign of the four innovation variables were negative.

5.2. Pooled Data Results and Discussion

The most important empirically relevant finding is that the industry's contribution to the GDP is statistically significant. However, in some regions and provinces, this relationship is negligible. This unanticipated occurrence may have been caused by variables reflecting the service sector. Similarly, even though the urban population and the elderly population are supposed to be statistically insignificant, the results for some regions and

provinces were in the opposite direction. This situation may have arisen because the ratios of urban and older populations to the total population are simultaneously found in the same regression model. Urban and elderly people may have opposite effects in establishing differences between target regions and provinces regarding the type of financial innovation in the banking sector. Industrialisation and urbanisation are used interchangeably in the growth, development, and modernisation literature. Literature predicts that industrialisation and urbanisation will increase simultaneously, yet in Türkiye, industrialisation is increasing slower than urbanisation. However, despite the ongoing migration of the rural unemployed population, employment prospects could be more efficient. People prefer urban poverty over poverty in rural areas. In this sense, urbanisation has become a type of migration, except in the West, which is the product of industrialisation and agricultural modernisation. Consequently, even though the urban population is growing relative to the population at large, this development needs to achieve its primary objective regarding economic growth (see Appendices A1 and A2).

Figure: 2
Topological maps of variables for Regions and Provinces
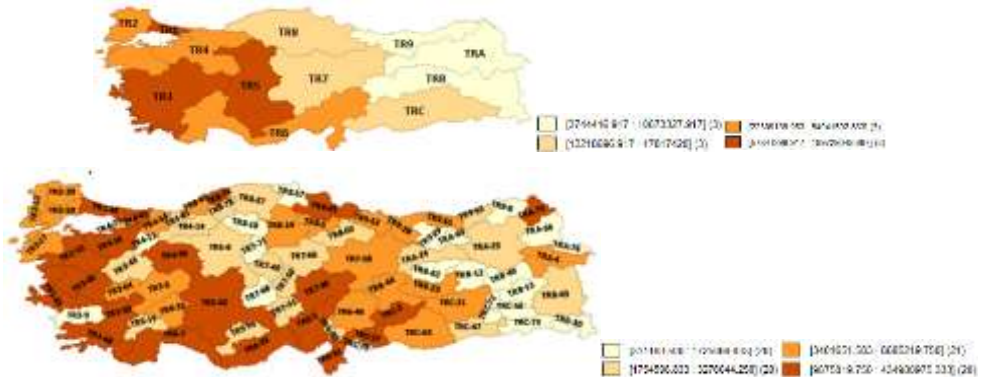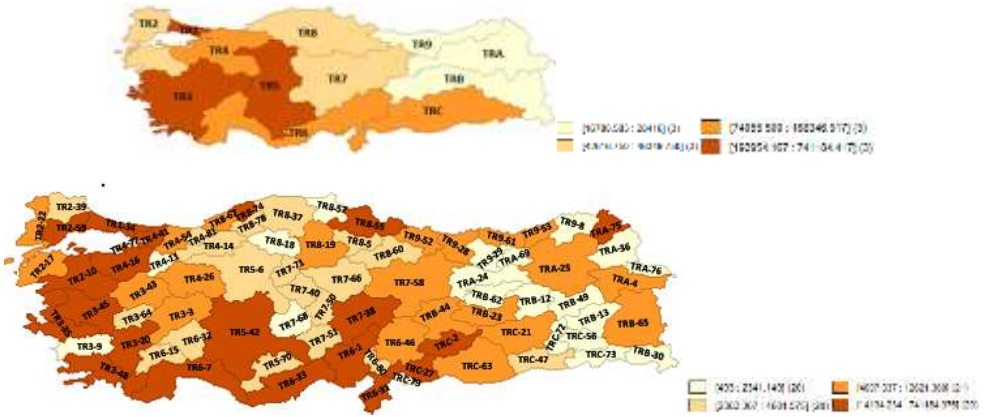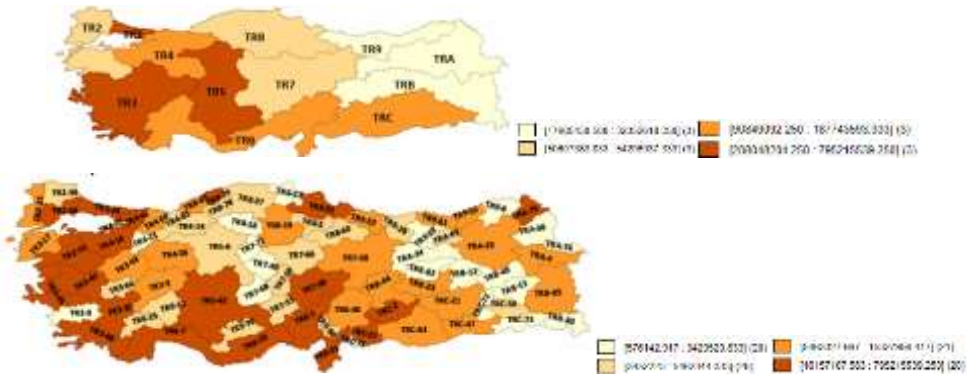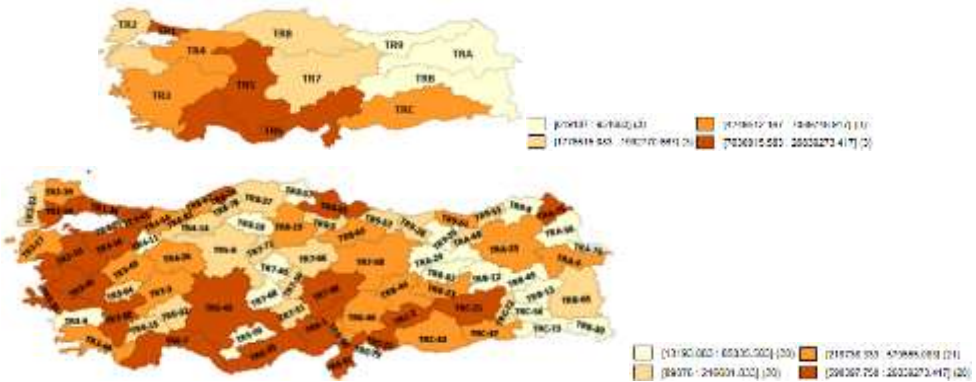**GDP**
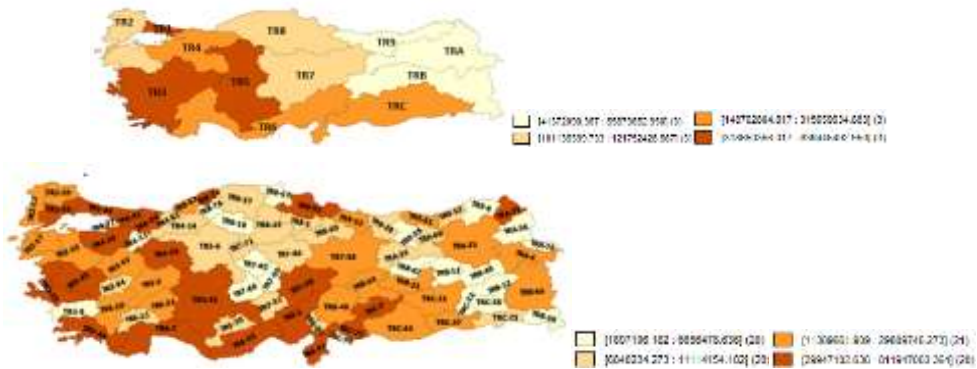
Share of Industry In GDP
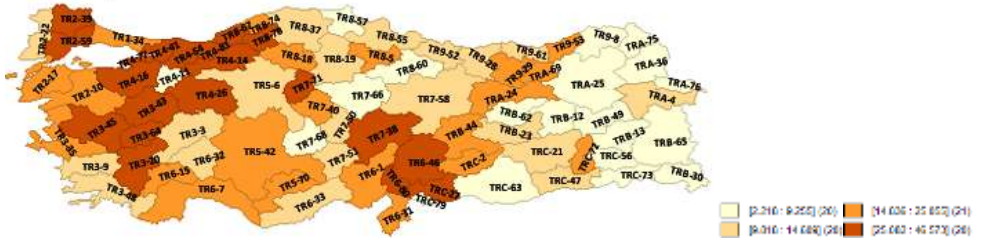
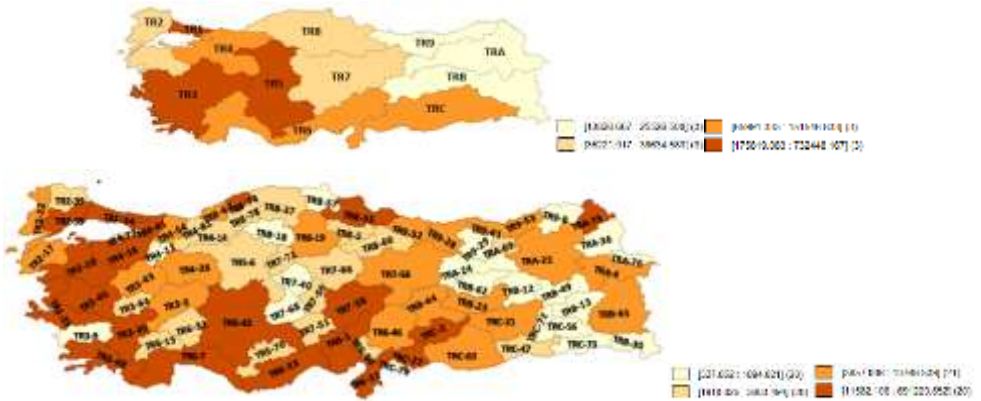**Total Deposits**

Saving Deposits

Total Loans

Total Cash Loans

Non-performing Loans

Non-specialized Loans

Number of Bank Branches
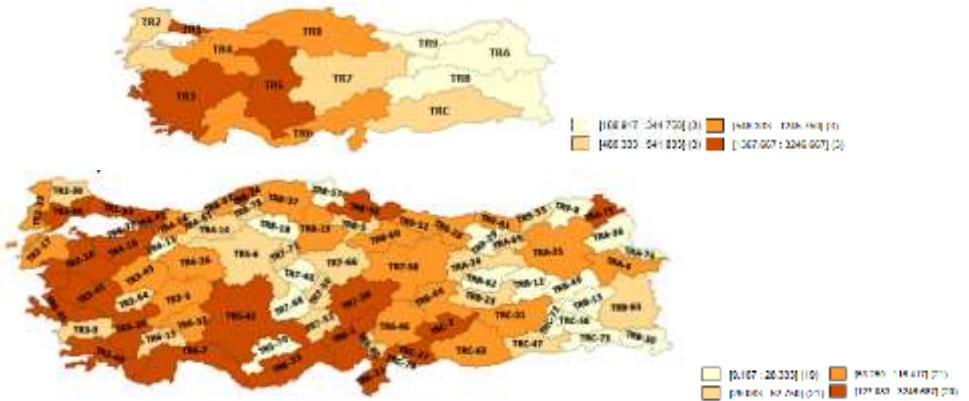
Number of ATM
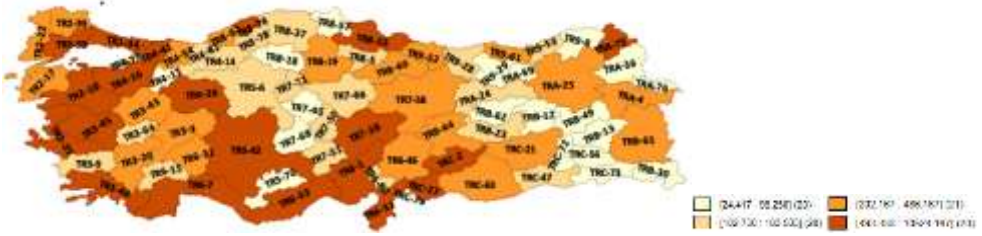
Number of POS

Number of Member Merchants

Number of Individual Credit Cards
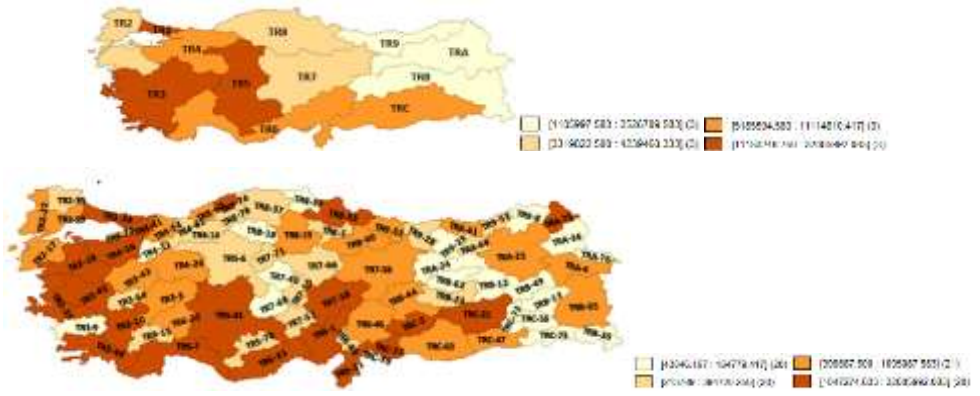
Urban Population
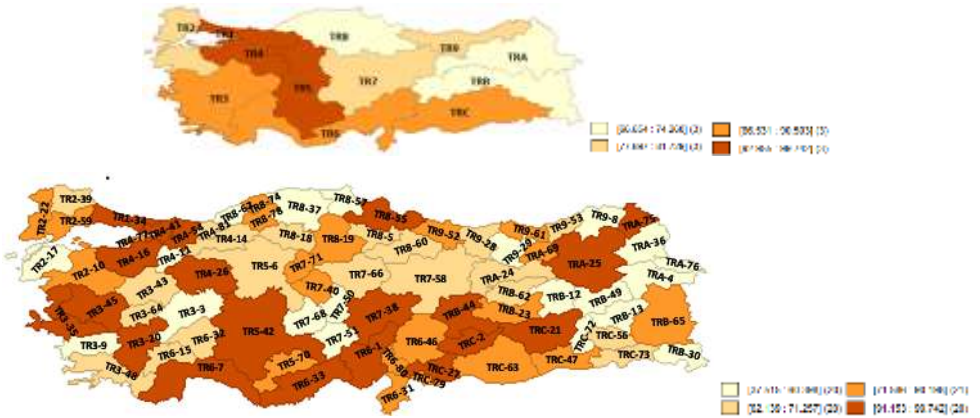
Elder Population

Number of Patents

Electric

Employment

Source: Authors create using the GeoDa package program.
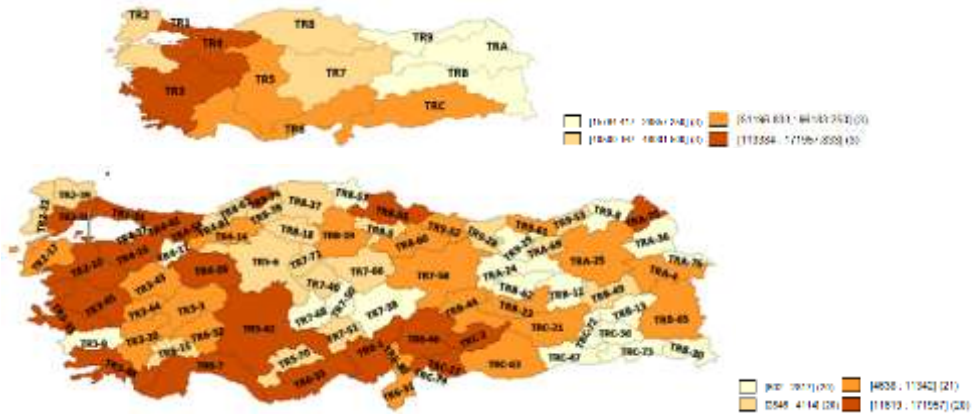
Figure 2 indicates that Türkiye's east and west regions, based on the distribution of financial goods, services, and the GDP level, reveal substantial differences between the two regions. Istanbul, the Aegean, and Western Anatolia significantly contribute to the GDP variable. The highest concentrations of total loans, total deposits, savings deposits, nonperforming loans, and bank branches are in Istanbul, the Aegean, and Western Anatolia. In the Istanbul, Aegean, and Mediterranean regions, the number of ATMs, POSs, member enterprises, and individual credit cards are much higher than in the Northeast, Middle East, and Southeastern Anatolia regions. On a provincial-regional level, it is observed that nonperforming loans, loans, the number of bank branches, the number of ATMs, the number of POS, the number of member firms, and the number of individual credit cards overlap. These results indicate that innovative financial advancements stimulate one another; an innovative process in one province or region stimulates growth and development in another province or region. However, excessive and unsupervised loan and credit card use has a negative impact on provincial and regional NPLs (Non-Performing Loans).

Regionally, there is a negative relationship between unemployment and electricity consumption. East Black Sea, Northeast Black Sea, and Middle East Anatolia have the greatest unemployment rates, but power usage is the lowest. In Istanbul, Agea, and East Marmara regions, unemployment is the lowest, and electricity consumption is the highest. Istanbul, East Marmara, and West Anatolia rank first in total patents, followed by the West Marmara, Agea, and Mediterranean regions. The East Black Sea, Northeast Black Sea, and Middle East Anatolia regions have the lowest number of patents. The conclusions are backed up by the fact that the areas around the East Black Sea, Northeast Black Sea, and Middle East Anatolia had the lowest values for all variables except for the number of people living in cities and the number of older people.

While the urban population is greater in Istanbul, Eastern Marmara, and Western Anatolia, the elderly population is greater in Western Marmara, Western Black Sea, and Eastern Black Sea. Although financial innovations are low in the provinces of Van, Erzurum, Mardin, and Sanliurfa, it is evident that resources are being transferred into investments in these provinces. Consequently, loan utilisation in the Southeastern Anatolia region is relatively lower than investment and financial innovations, which are relatively high and intensive in the western region and its provinces, and funds are transferred to the eastern regions and provinces, where state-funded investments and government incentives contribute to the development of these regions. Konya, Antalya, Mersin, Adana, Kayseri, and Ankara are cities with dense urban populations, a high proportion of young residents, and several financial innovations. In certain regions (TRA, TRB, and TRC), the young people are concentrated, urbanisation is limited, and investment levels are high. Many colleges generate a young, low-cost labour force in the corresponding regions and provinces. Total credit and nonperforming loans are spatially correlated on a regional scale. Regionally, total credit and nonperforming loans are found to be spatially connected. This is an indicator of household and business debt in Türkiye. Households and businesses utilise credit for consumption and investment, and the elasticity of borrowing enables consumers to consume at the current time rather than save. Nonetheless, it demonstrates that individuals have negative expectations regarding continuing their wages and wealth; hence, they face greater default risk. These findings support those of Schumpeter (1911), Goldsmith (1969), McKinnon (1973), Shaw (1973), King and Levine (1993), Levine and Zervos (1998), Beck et al. (2000), Calderon and Liu (2003), Valverde et al. (2011), and Mercan and Peker (2013), Motsatsi (2016), and Sağlam and Sönmez (2017).

6. Conclusion

Using the PCA method, this study grouped several innovation-related variables into a single component. As a result, we depicted the relationship between financial innovations and economic growth for Türkiye Statistical Region Units Level-1 (12 regions) and 81 provinces from 2010 to 2021. Therefore, following a factor analysis of 12 innovation-related factors for the banking industry, the innovation variable is introduced into the Arellano-Bond GMM first difference technique and pooled data analysis. According to the Arellano-Bond GMM first differences estimator, the financial innovation variable is a significant and positive predictor for regions and provinces. The pooled data evaluated the GDP as both a level and a ratio. The innovation variable was determined to be substantial and positive in 8 regions and 51 provinces based on the GDP. Based on the GDP ratio, the innovation variable is significant and positive in 4 regions and 31 provinces.

Globalisation, technology, and innovation-driven changes in products and services have hugely affected the economies of some regions and provinces. These results support Schumpeter's view and endogenous growth theories. A well-functioning and designed financial system and the banking sector are not only limited to the role of intermediary function between the savings of households, firms, and investors but also have great

importance in terms of economic growth with their loans and innovative products and services.

Regional development has been gaining importance for both developed and developing countries. The main objective of politicians should be to increase the welfare of society and ensure and sustain economic growth and development. In this sense, the fact that countries are particularly strong in finance and banking will bring about a strong economy. However, factors such as insufficient natural resources, unfavourable geographical conditions, distance to the market and energy, infrastructure problems, incentives, and tax reductions, lag behind rapid technological improvements and cause differences in the economic growth and development of countries among regions and provinces. One of the main goals of policymakers who want to achieve sustainable growth and development should be to close the regional development gap as much as possible.

Accelerating regional university establishment and R&D studies to produce a skilled workforce will promote development and innovation. Promoting R&D and innovative ideas needs infrastructure. R&D-based public-private cooperation, financial innovation, new industry clusters, well-organized industrial zones, regional destinations, sectoral concentrations, university-industry cooperation, entrepreneurial development, and policy implementation and strengthening are needed. It boosts R&D research in innovative product and service processes and regional growth. The government should encourage R&D in three main ways: R&D expenditure, tax incentives, and patents.

Policies that establish, support, and control financial and legal mechanisms to reduce regional economic and social development differences should be prioritised in our country. It is also a significant endeavour to build financial destinations like the Istanbul Finance Centre, develop and monitor financial technology and innovations, and expand investments to establish a financial identity and attract international money and capital. Identifying locations with too few bank branches and ATMs and taking action is crucial. As in the 2007-2008 global financial crisis, borrowers and lenders with asymmetric information must prevent an adverse selection dilemma and moral collapse in loan markets. These consequences lead to sunk costs and non-performing loans in nations like Türkiye with low savings rates. The results show that banks should strengthen their capital adequacy ratio and credit rationing mechanism.

The globalisation of financial markets, the rapid technological advancement, the benefits of the digitalisation era, and the rapid adaptation of financial markets provide some good externalities for clients but complicate financial information. Financial literacy training reduces this complexity, gives them financial market and product experience, and helps them make budgeting decisions. Financial literacy initiatives that affect elementary and high school students saving patterns and government tactics like channelling domestic savings into productive investments are crucial to removing impediments to sustainable growth and development in countries, regions, and provinces. Future research should investigate

regional growth and financial innovation by including firms and entrepreneurial characteristics in a more comprehensive structure.

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Appendix

Table: A1 (a)
Pooled EGLS (Cross-section random effects) Results of Provinces

Variable	Coefficient	Std. Error	t-Statistic	Prob. **
C	5.798067	0.197211	29.40034	0.0000
ELDERPOP	-0.136109	0.038640	-3.522474	0.0004
URBANPOP	0.059362	0.036343	1.633392	0.1027
PATENT	0.008125	0.007420	1.094993	0.2738
INDUSTRİAL	-0.033590	0.024371	-1.378294	0.1685
ELECTRİC	0.213679	0.029423	7.262322	0.0000
EMPLOYMENT	0.017961	0.003710	4.840720	0.0000
INNOVATION1	0.316869	0.009385	33.76305	0.0000
INNOVATION2	0.232628	0.011549	20.14213	0.0000
INNOVATION3	-0.006020	0.004155	-1.448710	0.1478
INNOVATION4	0.025710	0.004399	5.844707	0.0000
INNOVATION5	0.038035	0.003114	12.21544	0.0000
INNOVATION6	0.002747	0.004237	0.648369	0.5169

Random Effects (Cross)					
Province	Coefficient	Province	Coefficient	Province	Coefficient
ADANA	-0.062856	ADIYAMAN	-0.025264	AFYONKARAHISAR	0.015836
AKSARAY	0.028350	AMASYA	0.004532	ANKARA	0.066223
ANTALYA	-0.055419	ARDAHAN	0.011795	ARTVIN	0.025035
AYDIN	-0.084814	AGRI	0.020774	BALIKESIR	0.004916
BARTIN	-0.064185	BATMAN	0.028166	BAYBURT	0.061960
BILECIK	-0.010795	BINGOL	0.086427	BITLIS	0.016809
BOLU	0.045544	BURDUR	-0.004060	BURSA	0.051297
DENIZLI	-0.079086	DIYARBAKIR	0.023661	DUZCE	0.006118
EDIRNE	-0.073206	ELAZIG	-0.028548	ERZINCAN	0.096951
ERZURUM	-0.014351	ESKISEHIR	0.011666	GAZIANTEP	-0.090487
GIRESUN	0.002305	GUMUSHANE	0.032414	HAKKARI	0.089591
HATAY	-0.121894	ISPARTA	-0.018754	IGDIR	0.048389
KAHRAMANMARAS	-0.051296	KARABUK	-0.147257	KARAMAN	0.042881
KARS	0.007684	KASTAMONU	0.039317	KAYSERI	0.026293
KILIS	-0.018518	KOCAELI	0.059217	KONYA	0.040331
KUTAHYA	0.041826	KIRKLARELI	-0.052044	KIRIKKALE	-0.006397
KIRSEHIR	-0.050878	MALATYA	-0.099762	MANISA	0.061057
MARDIN	0.080534	MERSIN	0.021507	MUGLA	-0.091880
MUS	0.142077	NEVSEHIR	-0.082936	NIGDE	-0.007036
ORDU	-0.001004	OSMANIYE	-0.131193	RIZE	-0.040677
SAKARYA	0.023064	SAMSUN	-0.010528	SIIRT	-0.055103
SINOP	0.029099	SIVAS	0.041766	TEKIRDAG	0.026528
TOKAT	0.009369	TRABZON	-0.003442	TUNCELI	0.046406
USAK	-0.036976	VAN	-0.004097	YALOVA	-0.071981
YOZGAT	0.028499	ZONGULDAK	-0.099626	CANAKKALE	-0.028070
CANKIRI	0.016220	CORUM	-0.016101	ISTANBUL	0.133727
IZMIR	0.028852	SANLIURFA	-0.025244	SIRNAK	0.140751

Effects Specification		
	S.D.	Rho
Cross-section random	0.047510	0.4635
Idiosyncratic random	0.051119	0.5365
Weighted Statistics		
R-squared	0.939689	Mean dependent var	2.187991
Adjusted R-squared	0.938866	S.D. dependent var	0.258623
S.E. of regression	0.057864	Sum squared resid	2.946406
F-statistic (prob)	1142.579 (0.00)	Durbin-Watson stat	1.328903
Unweighted Statistics		
R-squared	0.970416	Mean dependent var	7.158415
Sum squared resid	6.337550	Durbin-Watson stat	0.617824

Correlated Random Effects - Hausman Test			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	255.664699	12	0.0000

Cross-section random effects test comparisons			
Variable	Fixed	Random	Var(Diff.)	Prob.
ELDERPOP	1.106800	-0.136109	0.014550	0.0000
URBANPOP	0.031175	0.059362	0.000316	0.1128
PATENT	0.001280	0.008125	0.000007	0.0084
INDUSTRIAL	0.208515	-0.033590	0.001078	0.0000
ELECTRIC	0.503379	0.213679	0.000888	0.0000
EMPLOYMENT	0.013690	0.017961	0.000001	0.0000
INNOVATION1	0.188123	0.316869	0.000211	0.0000
INNOVATION2	0.153004	0.232628	0.000405	0.0001
INNOVATION3	-0.006963	-0.006020	0.000015	0.8094
INNOVATION4	0.025823	0.025710	0.000014	0.9760
INNOVATION5	0.028114	0.038035	0.000005	0.0000
INNOVATION6	0.004295	0.002747	0.000008	0.5828

*Notes: ** (two levels stars) indicates %95 Confidence Level.*

Table: A1 (b)
Panel Least Squares (Cross-section random effects) Results of Provinces

Variable	Coefficient	Std. Error	t-Statistic	Prob.**
C	2.613421	0.309681	8.439086	0.0000
ELDERPOP	1.106800	0.126662	8.738213	0.0000
URBANPOP	0.031175	0.040457	0.770574	0.4412
PATENT	0.001280	0.007861	0.162872	0.8707
INDUSTRIAL	0.208515	0.040895	5.098838	0.0000
ELECTRIC	0.503379	0.041880	12.01961	0.0000
EMPLOYMENT	0.013690	0.003856	3.549957	0.0004
INNOVATION1	0.188123	0.017289	10.88123	0.0000
INNOVATION2	0.153004	0.023202	6.594455	0.0000
INNOVATION3	-0.006963	0.005706	-1.220314	0.2227
INNOVATION4	0.025823	0.005796	4.455390	0.0000
INNOVATION5	0.028114	0.003833	7.333826	0.0000
INNOVATION6	0.004295	0.005088	0.844102	0.3989

Effects Specification			
Cross-section fixed (dummy variables)			
R-squared	0.990242	Mean dependent var	7.158415
Adjusted R-squared	0.989119	S.D. dependent var	0.490062
S.E. of regression	0.051119	Akaike info criterion	-3.011022
Sum squared resid	2.090495	Schwarz criterion	-2.511698
Log likelihood	1437.421	Hannan-Quinn criterion	-2.820205
F-statistic (prob)	882.3893 (0.00)	Durbin-Watson stat	1.423895

*Notes: ** (two levels stars) indicates %95 Confidence Level.*

Table: A2
Pooled EGLS (Cross-section random effects) Results of Regions

Variable	Coefficient	Std. Error	t-Statistic	Prob.**
ELDERPOP	0.382558	0.105572	3.623670	0.0004
URBANPOP	0.788754	0.166722	4.730963	0.0000
L_PATENT?	0.176569	0.047755	3.697374	0.0003
INDUSTRIAL	-0.662251	0.080755	-8.200712	0.0000
ELECTRİC	0.840394	0.052090	16.16139	0.0000
EMPLOYMENT	0.150978	0.051156	2.951340	0.0037
INNOVATION1	0.046512	0.018177	2.558922	0.0116
INNOVATION2	-0.065507	0.017649	-3.711588	0.0003
INNOVATION3	-0.020386	0.011272	-1.808624	0.0728
INNOVATION4	0.008656	0.007417	1.167038	0.2453
INNOVATION5	0.027593	0.008502	3.245433	0.0015
INNOVATION6	-0.014029	0.008489	-1.652700	0.1008
R-squared	0.966757	Mean dependent var		8.140046
Adjusted R-squared	0.963987	S.D. dependent var		0.428030
S.E. of regression	0.081227	Akaike info criterion		-2.103471
Sum squared resid	0.870923	Schwarz criterion		-1.855986
Log likelihood	163.4499	Hannan-Quinn criterion		-2.002907
Durbin-Watson stat	1.010862			
Pooled Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.787173	1.293859	1.381274	0.1698
ELDERPOP	1.685333	0.461750	3.649881	0.0004
URBANPOP	-0.090042	0.149045	-0.603856	0.5471
PATENT	-0.021387	0.034053	-0.628045	0.5312
INDUSTRIAL	0.914534	0.180658	5.062227	0.0000
ELECTRİC	0.512509	0.160498	3.193247	0.0018
EMPLOYMENT	0.052680	0.034264	1.537475	0.1268
INNOVATION1	0.033599	0.054717	0.614044	0.5403
INNOVATION2	-0.044945	0.077237	-0.581918	0.5617
INNOVATION3	0.009617	0.015763	0.610099	0.5429
INNOVATION4	0.012366	0.007531	1.642137	0.1032
INNOVATION5	-0.038885	0.009623	-4.040742	0.0001
INNOVATION6	0.021260	0.005916	3.593719	0.0005

Fixed Effects (Cross)					
Istanbul	0.808391	TR2-West Marmara	-0.699439	TR3-Agea	-0.152932
TR4-East Marmara	-0.221515	TR5-West Anatolia	0.333209	TR6-Mediterranean	0.090292
TR7-East Anatolia	-0.237924	TR8-West Black Sea	-0.369227	TR9-East Black Sea	-0.369227
TRA-Northeast Black Sea	0.204644	TRB-Middle East Anatolia	0.327658	TRC-Southeast Anatolia	0.286070

Effects Specification			
Cross-section fixed (dummy variables)			
R-squared	0.991640	Mean dependent var	8.140046
Adjusted R-squared	0.990037	S.D. dependent var	0.428030
S.E. of regression	0.042723	Akaike info criterion	-3.317161
Sum squared resid	0.219028	Schwarz criterion	-2.822192
Log likelihood	262.8356	Hannan-Quinn criterion	-3.116033
F-statistic (prob)	618.8612 (0.00)	Durbin-Watson stat	1.528755

*Notes: ** (two levels stars) indicates %95 Confidence Level.*