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Unravelling The Loan-growth Nexus: A Technology Intensity Based Analysis

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Abstract This study examines the relationship between short and medium-long-term loans used by the manufacturing industry sectors in Turkey, classified by their technology intensities, and the industrial production index for each technology intensity. The analysis employs monthly data from 2005 to 2022. This study differs from other studies in the literature by classifying manufacturing industry sectors according to their technology intensities and examining the effects of short- and medium-long-term loans on the sectoral industrial index in line with this classification, using multidimensional homogeneous and heterogeneous panel data methods. The empirical findings indicate that both short and medium-long-term loans have a significant positive effect on the industrial production index across all technology levels for the entire panel. The results based on the technology intensity classification indicate that in the high-tech sectors, short-term loans have a stronger positive impact on the industrial production index than medium- to long-term loans. For medium-high technology sectors, medium-long-term loans have a greater positive effect. Similarly, medium-long-term loans show a stronger positive impact on the medium-low and low technology sectors compared to short-term loans.

Keywords Loans · Economic growth · Asymmetric information · High-tech manufacturing industry · Industrial production index · Multidimensional heterogeneous panel data

JEL Classification O14 · B26 · O32 · L6 · C33

Author Note This article, derived from the author's PhD thesis titled "Analysis of the Loan-Growth Relationship by Technology Intensity in Manufacturing Industry with Multidimensional Heterogeneous Panel Data Models" completed at Istanbul University.

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Schumpeter, while evaluating the economic structure as an evolutionary process, offers a perspective consistent with the historical analysis of the great waves of technology. In fact, important technological developments such as the invention of the steam engine in the 18th century, the invention of electricity in the 19th century and the emergence of information technologies in the 20th century support Schumpeter's evolutionary view (Akcigit & Nicholas, 2019, p. 617). Since the 1990s, the technology revolution, called the 3rd industrial revolution, has played an important role in the development of high-tech industries. During this period, R&D investments have become a key factor in the development of countries. This is because through R&D investments, firms can increase their productivity and reduce their costs by producing innovations that can provide additional benefits in the production process. As a matter of fact, many manufacturing firms operating in developed countries invest a large amount of capital in R&D to maintain and improve their competitive structure (Tsai & Wang, 2004, p. 1555). In theory, this situation has been modelled by Schumpeterian endogenous growth theorists. In these models, R&D is recognised as an important input that enables firms to gradually strengthen their competitive advantage as it improves their technological capabilities (Schoenecker & Swanson, 2002, p. 37). R&D-based technological innovations are fundamental to long-term growth and international competitive advantage. Promoting these innovations is challenging, but it must be done. Holmstrom (1989) makes a convincing case that the innovation process is lengthy, idiosyncratic, and fraught with uncertainty and risk. Given these inherent challenges, it is crucial to examine the role of short- and medium-long-term loans in R&D projects and their impact on the economy. This approach offers a fresh perspective on an important topic. Pioneering empirical studies in the literature have demonstrated that banks have a positive impact on sustainable growth through their lending activities. However, these studies often neglect sectoral effects and technological innovations.

For ideas based on R&D and technological innovation, which constitute the source of growth in industrialised economies, to be transformed into practice, Schumpeter, who is the inspiration of endogenous growth theorists, explained that the use of money as capital has key importance for the emergence of innovative production processes and that money is an integral part of the economic system with the integration between the monetary and real aspects of the economic system (Messori, pp. 173-174). In this context, Schumpeter, who thinks that the distinctive feature of the capitalist system that distinguishes it from other systems is the loan creation process, sees loans as an element that creates purchasing power for entrepreneurs (Aghion & Festré, 2017, p. 38; Festré, 2002, pp. 455-456). Schumpeter's view is tested by examining the impact of loans on manufacturing industries classified by technology intensity.

Theoretical Framework

Since the emergence of capitalism, economic growth has been a central topic in the economic literature. Although classical economists have addressed the issue of growth from different perspectives, they have argued that a steady state in an economy is inevitable. The neoclassical approach is based on a similar scenario. In the neoclassical approach, which was the mainstream approach pioneered by Solow until the end of the 1980s, the source of growth was capital accumulation. In this approach, technological progress is an exogenous variable with unknown origins and effects on growth. Nevertheless, positive deviations in long-run growth are realised because of technological progress. The inclusion of technological innovations, which are the source of cross-country growth differences that invalidate the convergence hypothesis proposed by the neoclassical model, in the growth model started in the late 1980s with the endogenous growth theories led by Romer (1986). Focusing on the mechanisms that drive the real economy, endogenous growth

theories provide a rich theoretical framework to analyse the reasons behind cross-country differences in growth and development. In models based on indirect technological development, which constitute the first tier of endogenous growth theories, technological innovations are realised through economic factors other than technology. The second group, Schumpeterian endogenous growth models based on R&D, inspired by Schumpeter's vision of creative destruction, differs from the models based on indirect technological development in that it recognises that technology is produced through an R&D sector independent of the production sector. If the technology produced by the R&D sector is aimed at diversifying existing goods, in other words, increasing the product range, "horizontal innovation" is in question, and if it is aimed at increasing the quality of existing goods, "vertical innovation" is in question. While Romer (1990) model is included in the horizontal innovation-based R&D model, Grossman and Helpman (1991) and Aghion and Howitt (1992) models, which are more related to Schumpeter's vision of "creative destruction", are included in the vertical innovation-based R&D models (Maré, 2004, pp. 11-13).

For technological innovations modelled as endogenous growth based on R&D to be realised by entrepreneurs, they must have sufficient financial means. Schumpeter explained this situation through the necessity of the integration of innovative real production processes and monetary processes. Schumpeter, who argued that innovative investments can be supported especially through loans, argued that the role of savings in innovative initiatives is relatively insignificant and that entrepreneurs who focus on innovative activities do not have to have the necessary financial resources to realise their projects (Croitoru, 2012, p. 142). Schumpeter, who inspired many studies in the context of growth theory, did not develop any model explaining the process of technological development in his studies. In this context, King and Levine (1993), who took their motivation from Schumpeter, is one of the most important studies supporting Schumpeter's view by empirically demonstrating the effects of financial development on positive growth in their seminal article "Finance and Growth: Schumpeter May Be Right". With this study, the Schumpeterian theory became a theory associated with the loan-growth relationship.

The beginnings of studies in the literature on Schumpeter's views on the relationship between credit and growth date back to the 19th century. The first work in this field was "Lombard Street" written by Bagehot (1873), one of the most versatile intellectuals of England. Bagehot (1873), arguing that money is undoubtedly the most important element representing economic power, stated that the UK has arguably the largest monetary accumulation in the world and that providing loans to local entrepreneurs can contribute to growth, just as the UK provides financial support by lending to large investments such as railroads in undeveloped countries. With this view, Bagehot provided an important perspective on how banks can contribute to economic growth. In fact, in the following periods, it has been accepted by many economists that banks and various financial intermediaries undertake tasks such as ensuring the efficient distribution and supervision of the funds required for the financing of projects, minimising the asymmetric information problem, and that economic growth will be achieved by directing the funds allocated for investment to productive and innovative areas (Becsi & Wang, 1997; Capasso, 2004; Levine, 1997; Levine et al., 2000).

However, asymmetric information, which is frequently observed in loan markets where the financial system is inefficient, prevents the transfer of funds to the appropriate place and prevents the financing of innovative investments. The asymmetric information problem, which leads to adverse selection and moral hazard problems in loan markets, causes banks to increase their tendency to lend to high-risk projects or borrowers to enter into high-risk projects that increase the probability of default after receiving a loan (Mishkin, 1991). According to Stiglitz and Weiss (1981), market imperfections arising from asymmetric information leading to loan rationing restrict banks' lending to high-tech sectors, especially those involving intensive R&D investments. This has a negative impact on R&D projects, affecting firms' marginal financing costs and the probability of success. Information required by banks to reduce asymmetric information may

include firms' marginal financing costs, probability of success, and future returns to innovation projects. However, the details of many innovation projects are not shared with banks to prevent the leakage of confidential production information of the firm in the sector to its competitors. This creates a constraint that limits the ability of the high-tech sectors to implement R&D projects (Xin et al., 2019, p. 843). In low-tech sectors with relatively less R&D intensity, there is no significant constraint on the use of long-term loans as the risk of loan non-repayment is lower. As a result, the existence of imperfections in loan markets makes it difficult for high-tech sectors with high return potential but also high risk to implement R&D projects.

Literature Review

The relationship between financial development and economic growth has long been discussed and analysed in the economic literature. However, when the effectiveness of credit policies, sectoral differences and long-term effects are considered, the relationship becomes more complex. To analyse this complex structure by taking loan maturities into account, this study is important in terms of analysing the impact of short- and long-term loans used by R&D-based sectors classified according to technology intensity on the economy and bringing a new perspective to the literature.

In the context of the relationship between financial development and growth, one of the most prominent studies in the literature is that of King and Levine (1993). While analysing the relationship between financial development and economic growth with data from 80 countries, they found that financial development has a strong relationship with economic growth, capital accumulation and efficiency of capital allocation. Ceylan and Durkaya (2010) examined the relationship between credit and growth in Turkey and found a unidirectional causality relationship between credit and gross domestic product. Stolbov (2017) evaluated the relationship between credit and GDP growth in 24 OECD countries and found that credit use causes economic growth in some countries. Mercan (2013), analysed the positive and significant effects of credit volume on economic growth in Turkey eventually. The analysis showed that credit can have positive effects on economic growth eventually.

It has also been investigated that the relationship between credit and economic growth may lose its impact after a certain point. Beck et al. (2014) argue that credit growth can boost economic growth up to a certain point, but after this point, credit loses its significant impact on growth. Ho and Saadaoui (2020), on the other hand, argue that there is an inverted L-shaped relationship between credit and economic growth for ASEAN countries and that credit growth loses its positive effect on short-term economic growth after a certain threshold point. Bui (2020) states that credit growth has an inverted-U-shaped effect on economic growth, emphasising the negative effects of credit growth on growth after a certain level. Leitão (2012), on the other hand, finds that bank lending has a negative impact on growth, suggesting that credit growth does not always support economic growth.

Sectoral studies have revealed that the impact of credit on growth varies across sectors. Girma and Vencappa (2015) and Anwar (2015) examined the relationship between credit and growth in various sectors in India and found that bank credit has a positive impact on sectoral growth. Girma and Vencappa (2015)find that bank and non-bank sources of finance positively affect firm-level productivity growth, with bank credit having a higher impact on the growth of manufacturing firms than non-bank sources of finance. Anwar (2015) found that loans to agriculture, industry and services have a statistically significant and positive impact on the output of each sector. Similarly, Toby and Peterside (2014) and Majeed and Iftikhar (2020) analysed the impact of sectoral credit on economic growth in Nigeria and Pakistan. Toby and Peterside (2014) examined the role of banks in financing the agricultural and manufacturing sectors in Nigeria and found that commercial bank lending has a weak positive relationship with the agricultural sector's contribution to GDP but a strong positive relationship with agricultural income. Majeed and Iftikhar (2020) find that credit

to the private sector has a positive but statistically insignificant effect on economic growth, and by sector, the agricultural sector is negatively affected by agricultural credit, while the industrial sector is positively affected by credit.

The impact of bank loans on technology and innovation is also discussed. Demmou et al. (2019) and Shakib et al. (2023) assessed the relationship between financial access and innovation and emphasised the positive effects of loans on innovative activities. Demmou et al. (2019) found that access to finance and financial development are more important for productivity growth in sectors where intangible assets are more intensive. Shakib et al. (2023) showed that credit market deepening stimulates innovation in all regions. Ang and Madsen (2012) and Xin et al. (2017) show that long-term credit stimulates innovation. Ang and Madsen (2012) found that innovative production is higher in countries where the use of credit and venture capital is higher. Xin et al. (2017) found that industries that are more dependent on external financing exhibit higher levels of innovation in provinces where long-term bank loans have a larger share in China. Ayyagari et al. (2011) and Qi and Ongena (2020) examined the effects of bank loans on the introduction of new technologies. Ayyagari et al. (2011) found that access to bank loans has a positive effect on the introduction of new products and technologies. Qi and Ongena (2020) showed that problems in accessing credit are a major barrier to innovation, especially in advanced and hard-to-reach innovation.

However, there is also negative evidence on the relationship between credit and innovation. Brown et al. (2017) and Dabla-Norris et al. (2012) report a weak or negative relationship between credit growth and innovation. Brown et al. (2017) found a positive relationship between the share of high-tech sectors in GDP and the growth rate, but failed to find any relationship between credit growth and high-tech sectors. Dabla-Norris et al. (2012) found that the impact of financial sector development on innovation and productivity is weak. Hsu et al. (2014) and Cecchetti and Kharroubi (2019) argue that credit markets have negative effects on high-tech-intensive industries. Hsu et al. (2014) found that industries that are more dependent on external finance and have higher technology intensity exhibit significantly higher innovation in countries with more developed equity markets than credit markets. Cecchetti and Kharroubi (2019) show that there is a negative relationship between credit growth and the growth rate of output per worker, and that credit growth drives firms towards lower-return projects over time.

In conclusion, the effects of credit on economic growth and technological innovation are complex and multidimensional. These effects can vary widely by country, sector and type of credit. Therefore, policy-makers should carefully consider sectoral differences, long-term effects and possible consequences on innovative activities when setting credit policies. Moreover, balanced and sustainable credit policies should be developed to avoid the negative effects of credit growth on economic growth and innovation after a certain level.

Data and Methodology

The purpose of this study was to determine the relationship between the loan used by manufacturing industries classified by technology intensity and the industrial production index in Turkey. Accordingly, the study uses monthly data sets covering the period between 2005 and 2022. The OECD (Organisation for Economic Cooperation and Development) report "Categorisation of Manufacturing Industries according to their R&D Intensity" under the title "ISIC REV.3 Technology Intensity Definition" has been used to create the classification of manufacturing industries according to technology intensity. According to the technology (R&D) intensity, manufacturing industries are analysed in four different technology dimensions: high technology industries, medium-high technology industries, medium-low technology industries, and low technology industries. The data on the variables of each sector under these four technology levels were obtained from datasets prepared specifically for that sector.

The classification based on the data obtained for Turkey is shown in Table 1.

Table 1

Classification of the manufacturing industry sectors by technology intensity

High Technology Industries	Medium-High Technology Industries	Medium-Low Technology Industries	Low Technology Industries
Electrical and Optical Equipment	Motor and Other Vehicle Manufacturing	Main Metal Industry	Textile and Textile Products
Communication	Machinery and the Equipment Industry	Rubber and Plastic Industry	Paper Raw Materials and Products Industry
	Chemical Products Industry	Nuclear Fuel-Petroleum and Coal Industry	Wood and Wood Products
	Manufacturing Industry Not Elsewhere Classified		Leather and Leather Products

In the model, the sectoral industrial production index is used as the dependent variable and short- and medium-long-term cash bank loans are used as independent variables. Short- and medium-long-term cash loans used on a sectoral basis were obtained from the Banks Association of Turkey database, while sectoral industrial production index data were obtained from the Turkish Statistical Institute database. (Since the data for some sectors in the classification are combined with other sectors in the database, only those sectors for which independent data are available are considered in the study) Explanations about the variables are given in Table 2.

Table 2

Explanations of the variables

Variables	Variable type	Abbreviation	Unit
Industrial Production Index	Dependent	indpx	Index
Short-Term Cash Loans (logarithmic)	Independent	lnscl	The turkish Lira
Medium-Long Term Cash Loans (logarithmic)	Independent	lnmlcl	The turkish Lira

Econometric analyses based on panel data generally use data with one unit and one time dimension. However, these models may be insufficient to meet the analysis requirements in some cases. Today, increased access to data has made it possible to construct "Multidimensional Homogeneous Panel Data Models" that include more than one unit and/or more than one time dimension instead of a single time or a single unit dimension. Multidimensional panel data models include more than one unit and/or time dimension. This situation provides an advantage in terms of reaching more detailed results since the effect of each dimension related to the variables examined can be modelled (Yerdelen Tatoğlu, 2016, p. 299). The reason for using multidimensional homogeneous panel data in this analysis is that there are three dimensions in the model, two unit and one time, both the technology dimension and the sectoral dimension. Since the two-unit dimensions are nested within each other in the analysis, the multidimensional nested model is valid.

On the other hand, panel data models are usually estimated with the assumption that the slope parameter is constant. However, this assumption is often not realised and Heterogeneous Panel Data Models have been developed in which the slope parameter varies across units or both units and time in addition to the fixed parameter. The fact that there are two units and one time dimension in the model allows the use of the Multidimensional heterogeneous panel data method as well as the Multidimensional homogeneous panel data method. The reason for applying this method is that the analysis allows the effects of short- and medium-long term credit utilisation to be analysed separately at all technology levels: high, medium-high, medium-low and low technology levels. As a result, the main reason for choosing multidimensional

homogeneous and heterogeneous panel data methods is that they allow for a more detailed and in-depth analysis of the relationship between credit growth and technology.

The multidimensional homogeneous and heterogeneous panel data models based on the dataset and the variables are presented in equations 1 and 2, respectively.

$$\mathbf{indpx_{ijt}} = \beta_0 + \beta_1 \mathbf{lnscl_{ijt}} + \beta_2 \mathbf{lnmlcl_{ijt}} + \mu_i + \gamma_j + \lambda_t + \mathbf{u_{ijt}} \quad (1)$$

$$\mathbf{indpx_{ijt}} = \beta_{0i} + \beta_{1i} \mathbf{lnscl_{ijt}} + \beta_{2i} \mathbf{lnmlcl_{ijt}} + \mathbf{u_{ijt}} \quad (2)$$

In model number one, i denotes the manufacturing industry sectors, j denotes the technology level and t denotes the time dimension. The model considered is a three-dimensional nested panel data model with two unit and one time dimension. The hypotheses of the study are given below.

Main hypothesis: Short-term and medium-long-term loans used by manufacturing industries according to technology intensity have a positive effect on the sectoral industry index.

H1: Short-term cash loans used by high-tech industries have a positive effect on the industry index.

H2: Medium-long-term cash loans used by high-tech industries have a positive effect on the industry index.

H3: Short-term cash loans used by medium-high technology industries have a positive effect on the industry index.

H4: Medium-long-term cash loans used by medium-high technology industries have a positive effect on the industry index.

H5: Short-term cash loans used by medium-low technology sectors have a positive effect on the industry index.

H6: Medium-long-term cash loans used by medium-low technology sectors have a positive effect on the industry index.

H7: Short-term cash loans used by low-technology sectors have a positive effect on the industry index.

H8: Medium-long-term cash loans used by low-technology sectors have a positive effect on the industry index.

Findings

In the first stage of analysis, to determine the appropriate homogeneous model, the statistical significance of each effect is tested with the LR test. The test results are presented in Table 3.

Table 3

LR test results

Basic hypothesis	LR test statistics
H_0: $\sigma_\mu = \sigma_\gamma = \sigma_\lambda = 0$	2042.69*
H_0: $\sigma_\mu = 0$	1715.64*
H_0: $\sigma_\gamma = 0$	128.19*
H_0: $\sigma_\lambda = 0$	1093.17*

Note: *, showed significance at the 1% level
**, showed significance at the 5% level

Since all effects are statistically significant because of the LR test, it is decided that it is appropriate to analyse using the three-dimensional, three-effects panel data method. Then, the classical model without

all three effects, the three-effect random effects model was estimated by the Maximum Likelihood Method and the three-effect fixed effects model was estimated by the Least Squares with Shadow Variables Method.

Table 4

Tests results

	POLS	Random Effects	Fixed Effects
lnscl	3.039*	10.864*	6.373*
lnmlcl	11.468*	11.726*	11.503*
constant	-228.04*	-407.219*	-276.3*
R^2	0.43		0.77
Hausman test	167.27*		

Note: *, showed significance at the 1% level
**, showed significance at the 5% level

According to the estimation results of the three-dimensional model with the POLS, random effects, and fixed effect models, all parameters are statistically significant. According to the results of the Hausman (1978) test conducted to determine whether the three-dimensional model should be estimated with the fixed effects assumption or the random effects assumption, the H_0 hypothesis is rejected and it is concluded that the random effects estimator is inconsistent and the fixed effects estimator is consistent and valid. After determining that the fixed effect assumption is valid because of the Hausman test, deviation tests were conducted on this model. Accordingly, the average variance inflation factor (VIF) value was calculated to test whether there is multicollinearity (MCL) in the model. In addition, Breusch and Pagan (1979)/ Cook and Weisberg (1983) Heteroskedasticity test and Wooldridge (2002) autocorrelation test were performed as deviation tests from the assumption appropriate for the model established within the scope of the multidimensional panel data model. The results are presented in Table 5.

Table 5

Heteroskedasticity, autocorrelation, and multicollinearity

	x^2/ F	p value	Results
Breusch-Pagan/Cook-Weisberg Testi	1082.93	0.000	Heteroskedasticity exists
Wooldridge Testi	50614	0.006	Autocorrelation exists
Mean VIF		4.61	No Multicollinearity

The results of the tests for deviation from the assumption indicate that there is no multicollinearity, but there is heteroskedasticity and autocorrelation. In the presence of heteroskedasticity and autocorrelation, the results of the fixed effects regression estimation with Robust Standard Errors are given in Table 6.

Table 6

Regression Estimation Results with Robust Standard Errors

Independent Variables	Coefficients	Standard Error	P>|z|
lnscl (β1)	6,373	1179	0.000
lnmlcl(β2)	11503	1279	0.000
constant (β0)	-276.3	31568	0.000

According to the estimation results, for the entire panel, a 1% increase in short-term cash loans increases the industrial production index by 0.06%. On the other hand, a 1% increase in medium-long-term loans increases the industrial production index by 0.1%.

In the second stage of the analysis, the multidimensional model was estimated with the heterogeneous panel data model to determine whether there are separate effects of the four dimensions of technology intensity. First, homogeneity tests were conducted for the panel. First, homogeneity was tested with Swamy's S test and Pesaran and Yamagata's Δ test.

Table 7

Homogeneity tests

	Statistics	**p value**
Swamy's S test	χ^2_9	0.000
Pesaran ve Yamagata's Δ test	Delta = 136.415	0.000
	Delta (adj) =136.805	0.000

According to the results of both Swamy's S test and Pesaran and Yamagata's Δ test, the null hypothesis is rejected, and it is concluded that the slope parameters are heterogeneous. When the slope parameters are heterogeneous but not correlated across units, we estimate the slope parameters using the Mean Group (MG) Estimator proposed by Pesaran and Smith (1995) and Swamy's Random Coefficients (RC) models developed by Swamy (1971). The most used test to test for the existence of cross-sectional dependence is the Breusch Pagan LM test in Table 8.

Table 8

Breusch-Pagan cross-sectional dependence test

	Statistics	**p value**
Breusch-Pagan LM Testi	χ^2_6= 472.401	0.000

The test results show that there are cross-sectional dependence. Accordingly, the SUR estimator was used in the presence of both heterogeneous and cross-sectional dependence. The results are given in Table 9.

Table 9

SUR estimator results

	Independent Variables	**SUR**
High-Technology Industries	lnscl	26.268*
	lnmlcl	7.481*
	constant	−641.207*
	R^2	0.65
	χ^2	786.86*
Medium-High Technology Industries	lnscl	9.272*
	lnmlcl	12.583*
	constant	−400.531*
	R^2	0.77
	χ^2	1356.56*
Medium-Low Technology Industries	lnscl	−2.462
	lnmlcl	11.879*
	constant	−122.139*
	R^2	0.58
	χ^2	516.50*
Low-Technology Industries	lnscl	4.681*
	lnmlcl	9.932*

	Independent Variables	SUR
	constant	−240.064*
	R^2	0.67
	χ^2	905.24*

Note: *, showed significance at the 1% level
**, showed significance at the 5% level

Since the number of units in the model is small, it is appropriate to use the SUR estimator. According to the results of the SUR, each 1% increase in short-term cash loans used by high-tech industries increases the industrial index of high-tech industries by 0.26%, while each 1% increase in medium- and long-term cash loans increases it by 0.07%. When medium-high technology industries are analysed, each 1% increase in short-term cash loans used by these industries increases the industrial index of medium-high technology industries by 0.09%, while each 1% increase in medium- and long-term cash loans increases by 0.12%. When we look at medium-low technology industries, the effect of short-term cash loans used by these industries on the industrial index of medium-low technology industries is statistically insignificant, whereas each 1% increase in medium- and long-term cash loans increases the industrial index by approximately 0.12%. When we look at low-tech industries, each 1% increase in short-term loans used by these industries increases the industrial index by 0.04%. Each 1% increase in medium- and long-term loans increases the industrial index by approximately 0.1%. Therefore, all hypotheses except hypothesis H5 are accepted.

The parameter estimates from the seemingly unrelated regression (SUR) are combined with the mean group approach of Pesaran and Smith (1995) to obtain valid results for the whole panel (Yerdelen Tatoğlu, 2023, pp. 75-79). The estimation results for the entire panel are given in Table 10.

Table 10

SUR estimator results for the whole panel

Independent Variables	$\hat{\beta}$	Variance	Standard error	t
lnscl	9.44	37.29	6.106	1.54
lnmlcl	10.468	1.3	1.142	9.16

According to the results, the effect of short-term loans on the industrial production index is insignificant according to the t-statistic for the whole panel, regardless of the sector. On the other hand, the effect of medium- and long-term loans on the industrial production index is statistically significant and has a positive sign. It is found that a 1% increase in medium- and long-term loans increases the industrial production index by 0.1%. The cross-sectional dependence matrix of the residuals obtained from the SUR estimator is presented in Table 11.

Table 11

Cross-sectional dependence matrix

	u_1	u_2	u_3	u_4
u_1;	1.0000			
u_2;	0.1273	1.0000		
u_3;	−0.0115	0.4669	1.0000	
u_4;	0.1169	0.5098	0.7652	1.0000

In the inter-unit correlation matrix in the table, u_1 represents high technology sectors; u_2 represents medium-high technology sectors; u_3 represents medium-low technology sectors and finally u_4 represents low technology sectors. When the matrix is analysed, it is seen that there is a correlation of more than 76%

between the error terms of the models established for medium-low technology sectors and low technology sectors. This is followed by a correlation of over 50% between the error term for medium-high technology sectors and low technology sectors and over 46% between the error term for medium-high technology sectors and medium-low technology sectors. On the other hand, the matrix shows a very low correlation between the high-tech sectors and other sectors.

Conclusion

Over the past 200 years, the global economy has undergone continuous technological transformation. Research and development (R&D) activities during this period have advanced the global technology frontier, becoming a fundamental determinant of the growth process. While R&D-based technological innovations are known to play a crucial role in achieving long-term growth and international competitive advantage, fostering these innovations presents a challenging process due to the high degree of uncertainty and risk of failure inherent in R&D. The literature has often overlooked the impact of short- and medium-long-term loans on sectors based on their tangible and intangible asset intensities. In this context, this study provides a new perspective to the literature by examining the use of short- and medium-long-term loans in sectors according to their technological intensity and its reflection on the economy. The analyses reveal that the impact of short- and medium-long-term loans on the industrial production index is significant and positive for the entire multidimensional homogeneous panel. On the other hand, the impact of medium and long-term loans on the industrial production index is found to be stronger than that of short-term cash loans. The general results of the multidimensional heterogeneous SUR estimator for the entire panel indicate that while an increase in medium-long-term loans raises the industrial production index, an increase in short-term loans has an insignificant effect on the industrial production index.

When the analysis is refined with the SUR estimator to observe the effects based on technological intensity separately, it is observed that in the high-tech sectors, an increase in short-term cash loans has a significantly higher positive effect on the industrial production index than medium-long term loans. In the medium-high technology sectors, both short-term and medium-long-term loans have a positive effect on the industrial production index, but the effect of medium-long-term loans is higher. In the medium-low technology sectors, the effect of short-term loans is insignificant, but the effect of medium-long-term loans is similar to that in the medium-high technology sectors. In the low-tech sectors, both short-term and medium-long-term credits increase the industrial production index, but the effect of medium-long-term credits is stronger than that of short-term credits. The main reason for the different effects of short- and medium-long-term credits on the industrial production index based on technological intensity is thought to stem from the asymmetric information problem in financial markets. The problem of asymmetric information, where credit seekers possess more information about their ability and intention to repay the loan than the banks, reduces the efficiency of financial markets. Interest rates are a key factor influencing the magnitude of the asymmetric information problem in credit markets. When a firm's projects cannot be classified by the bank due to the presence of asymmetric information, the bank sets high interest rates, which reduces the probability of loan repayment.

The significantly stronger positive impact of short-term cash loans on the industrial production index in high-technology sectors compared to medium-long-term loans stems from the perception of high-risk projects in these sectors by banks. This reluctance to offer long-term loans is due to the lack of substantial collateral and the low perceived probability of stable cash flow in these sectors. High-technology firms engaging in R&D investments are more likely to default if the research project fails. Consequently, while it is possible to use the project as collateral for the loan, the value of the collateral becomes insignificant in the event of default. This often hinders the development of high-risk, high-reward R&D projects within

the country. Conversely, low-technology sectors, possessing more tangible assets, are deemed less risky by banks and are more likely to secure long-term loans. In the medium-high-technology sectors, the positive impact of both short-term and medium-long-term loans on the industrial production index is close, with medium-long-term loans having a higher effect. Despite the R&D-intensive nature of these sectors, their outputs are more tangible compared to high-technology sectors, making them more likely to provide collateral and be perceived as lower risk by banks. This allows these sectors to obtain medium- to long-term loans at lower costs. Similarly, the impact of medium-long-term cash loans on the industrial production index in the medium-low-technology sectors is close to that in the medium-high-technology sectors. Finally, in the low-technology sectors, the impact of medium- to long-term loans on the industrial production index is stronger than that of short-term loans. As the output becomes more tangible, firms can obtain longer-term loans at lower costs, leading them to prefer long-term loans, which in turn has a greater impact on the industrial index.

Another significant finding is the strong correlation between the medium-low-technology and low-technology sectors, indicating that the industrial productions of these two sector groups move closely together. This suggests that investments in new technologies in one sector increase demand in the other sector. This high correlation also indicates a complementary relationship between sectors with similar levels of technological intensity. The use of products produced in the medium-low and low-technology sectors as raw materials in other sectors, along with similarities in the number of firms, number of employees, value-added per employee, and export ratios, results in these two technology groups moving closely together. Additionally, there is a notable relationship between the medium-high-technology and low-technology sectors, as well as between the medium-high-technology and medium-low-technology sectors, similar to the reasons stated above, particularly due to sectoral complementarities. This is evident from the industrial production indices of the sectors that feed into each other. A final significant finding is the lack of a strong correlation between the high-technology sectors and the other three technology levels. Due to the nature of their outputs, the high need for R&D investment, and factors such as the small number of firms, these sectors in Turkey are relatively unaffected by other sectors.

This result, which supports Schumpeter's argument that credit positively affects economic growth, is also generally supported by Ceylan and Durkaya (2010), Mercan (2013) and Stolbov (2017). This result, which supports Schumpeter's argument that credit positively affects economic growth, is also generally supported by Ceylan and Durkaya (2010), Stolbov (2017) and Mercan (2013). On the other hand, the study is supported by the studies of Demmou et al. (2019), Shakib et al. (2023), Ang and Madsen (2012), Xin et al. (2017), Ayyagari et al. (2011)and Qi and Ongena (2020), which conclude that bank credit has a positive effect on innovative production. On the other hand, these results differ from the studies by Brown et al. (2017), Dabla-Norris et al. (2012), and CecchettiCecchetti and Kharroubi (2019), as they find a positive relationship between loans and innovative industries.

The research shows that strengthening the financial system is critical to stimulate credit growth and economic growth in Turkey and other developing countries. Improving financial intermediation services will help technology-intensive sectors to access the resources they need more easily. This supports Schumpeter's argument that monetary processes in an economy are a critical factor affecting real processes. Governments should develop policies that encourage technology-intensive sectors and R&D activities, enabling firms to increase their innovation capacity and contribute to economic growth. At the same time, a balanced and strategic approach to resource allocation should be adopted, considering the sectoral differences in credit growth. In this direction, policies should be developed to support sectors with high technological intensity with both short-term and medium-long-term loans. These policies will increase technological innovation in the country through financial systems and ensure sustainable economic growth.

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