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RESEARCH ARTICLE

Recalculation of Manufacturing Industry Production Function with Trade Openness and Human Capital: Multi-Dimensional Panel Data Application

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Abstract

The manufacturing industry plays a key role in ensuring long-term and sustainable economic development. Although the impact of the service and information technology sectors on economic growth has increased recently, reindustrialization trends have appeared especially in developing and underdeveloped countries. Studies on the manufacturing industry have started to gain importance again within the scope of reindustrialization. In this context, the production functions of the manufacturing industry started to be recalculated and the factors affecting the manufacturing industry became the field of study again. In particular, global trade has become one of the dominant issues in terms of the manufacturing industry. This study aims to calculate the manufacturing industry production function of 40 countries for the period of 2000-2014. While making this calculation, it is aimed to see the effect of trade openness and human capital on manufacturing industry production. For this purpose, multidimensional panel data analysis was used and the Cobb-Douglas production function was calculated. As a result of the analysis, it has been found that labor, exchange rate, trade openness, and human capital have a positive effect on manufacturing industry production.

Keywords

Manufacturing Industry, Cobb-Douglas Production Function, Multidimensional Panel Data Analysis, Trade Openness, Human Capital

Introduction

Industrialization is the process of producing goods and services with the extensive use of existing resources. The manufacturing industry plays a key role in ensuring long-term economic development (Szirmai, 2009). It prevents the increasing population from accumulating in agriculture and thus enables the increase in production and therefore the national income. The increase in national income creates a source for new investments. This development manifests itself not only in the impact on GDP but also in the increase in the diversity of manufactured goods (Sutikno & Suliswanto, 2017). Kaldor (1966), one of the first authors to

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examine the effect of the manufacturing industry on economic growth in detail, stated in his first law that the engine of growth is the manufacturing industry. Based on Kaldor's second law, there is an increase in the productivity of workers by learning the work they do with industrial growth. This also supports economic growth. Similar results were obtained in other studies examining the relationship between the manufacturing industry and economic growth (Libanio & Moro, 2006; Su & Yao, 2016; Karami, Elahinia, & Karami, 2019; Ughulu, 2021).

The recent increase in the impact of the service sector on economic growth compared to the agriculture and industry sectors has started discussions that industrialization is no longer the driving force of the economy, and this situation is also reflected in the economics literature (Lee & McKibbin, 2014). However, the spread of trade on a global scale has also affected industrial production. With the increase in production, especially in the trade of intermediate goods, the economics literature has started to develop in this field. However, it has been determined that the studies pay attention to trade openness and the effects of import and export are examined separately and are very limited. Withal, examining human capital and trade together is important to reveal the importance of human capital along with trade in order to ensure the industrial development of especially underdeveloped and developing countries with low human capital.

Recent re-industrialization trends have made it necessary to reconsider the subject with new data and to make the evaluation by considering income groups. The intensification of the literature in recent years indicates increasing interest. However, in the literature review conducted within the scope of this study, it appeared that the effects of trade openness on the manufacturing industry were not widely examined. In addition to trade openness, the effect of manufacturing industry imports and exports on manufacturing industry production should be examined specifically. It is also important to examine the difference in this effect in various income groups. The present study aimed to fill this gap in the literature. This study aims to calculate the Cobb-Douglas production function for the manufacturing industry with the data of 40 countries in various income groups for the period 2000-2014 and to examine the effects of trade openness and manufacturing industry imports and exports in manufacturing industry production with multidimensional panel data analysis. The fact that a detailed study of the world was not done for this period in previous studies, the analysis of countries by dividing them into income groups, and the use of multidimensional panel data analysis are the original points of the study. The next sections will be the theoretical framework, analysis, discussion and then the conclusion section.

Theoretical Framework

The rapid development in the service, and information, and communication sectors and their contribution to economic growth has recently led to a debate that these fields have replaced the manufacturing industry. The view that the new engine of growth is the service sector has come to the fore (Maroto-Sánchez & Cuadrado-Roura, 2009; Lee & McKibbin, 2014). For this reason, it has started to be discussed to what extent a country should develop its manufacturing industry at the stage of development. Although the place of the manufacturing industry has become a controversial issue recently, the manufacturing industry continues to maintain its importance, especially in middle-income countries. There are various reasons for this situation. The manufacturing industry affects the service sector both in the short and long term, a development in the manufacturing industry causes the service sector to develop as well. In addition, compared to other sectors, the manufacturing industry is the sector that supports investment and technology accumulation the most. In addition, the manufacturing industry is the area that makes the most important contribution to the development of human capital in middle-income countries. Therefore, the manufacturing industry still forms the basis of economic growth in low- and middle-income countries (Su & Yao, 2016). On the other hand, the fact that the manufacturing industry is the sector that accumulates the most physical capital causes it to benefit more from economies of scale. Economies of scale are achieved by both decreasing fixed costs and increasing efficiency. In addition, the fact that it is connected with other sectors ensures that an increase in output in the manufacturing industry is reflected in other sectors, which creates a multiplier effect. Therefore, the manufacturing industry still maintains its importance in terms of development (Haraguchi, Cheng, & Smeets, 2017).

The manufacturing industry, along with the use of natural resources, is one of the most important supporting forces of growth, especially in underdeveloped countries. In addition, the manufacturing industry, which is one of the most important areas that bring foreign currency returns to the national economy, is the primary driving force of innovation (Dadush, 2015). Although global industrial growth increases global welfare, it has different effects on every economy. While industrial growth in developed countries increases productivity by producing new technologies, it also creates positive externalities in climate and environmental conditions. In developing countries, production is an important tool that creates more added value than traditional fields, helps to increase employment and welfare levels with new technologies, and reduces poverty. Value added is accepted as an important indicator of industrial development, which is found by subtracting all inputs from all outputs of a sector (Facevicova & Kynclova, 2020). Figure 1 shows the development of industrial added value over time by income groups. When examining Figure 1, the left axis is for high, upper middle and lower middle-income countries and the right axis is for low-income countries. The reason for the division of the axes is that the added values of the low-income countries are not visible in the figure because it is quite low compared to other income groups. Although fluctuations in the low and lower-middle-income groups remain the same, the industrial value-added is quite low. The fastest growth has been experienced in the upper-middle-income group. Value-added, which followed a relatively horizontal course in upper-middle-income group countries until the early 2000s, has increased rapidly since this period and approached the high-income group. In the emergence of such a course, it is of great importance that countries became an investment focus of companies with international capital with the liberalization movements experienced in these countries. Although a similar course is followed in low-middle-income countries, the incomplete environment of investment conditions in these countries prevents industrial development. The gap between low-income and high-income countries is widening day by day, and this is also seen in the growth rates of countries (Correa & Kanatsouli, 2018). The abandonment of labor-intensive production in the manufacturing industry, especially in developed and developing countries, does not mean that the manufacturing industry has lost its importance. The increase in the productivity of labor provides the acceleration of economic growth. The rapid increase in labor productivity has played an important role in the rapid growth of countries such as South Korea, Taiwan, Singapore, and Hong Kong (Tregenna, 2011).

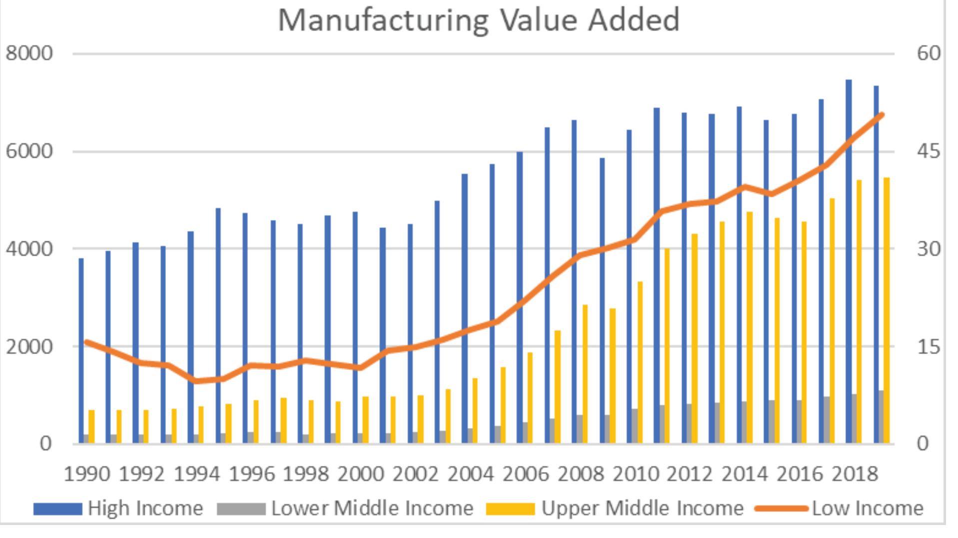

Figure 1. Manufacturing Value Added

Source: UNIDO

According to the neo-classical view, the income levels of countries with similar technological opportunities will converge over time. The high marginal productivity of capital in low-income countries will ensure convergence to high-income countries in the long run. However, on a global scale, it is seen that poor countries do not show such a development, except for some East Asian countries. This situation arises from the unique political, institutional, and other characteristics of the country. For this reason, it is not possible to talk about an unconditional convergence (Rodrik, 2013). This is illustrated in Figure 1 by the fact that the industrial value-added of low-income countries does not converge with high-income countries over time.

The manufacturing industry is one of the most important tools that provide income by creating employment, increasing resource efficiency, and making countries competitive in international trade, thus increasing welfare (Jenkins & Sen, 2006). However, this is not always sufficient to improve the industrial competitiveness of the country on a global scale. The Competitive Industrial Performance (CIP) index prepared by UNIDO shows the success of a country in producing and selling industrial products in the domestic and foreign markets. Thus, it reveals its industrial competitiveness comparatively. When calculating the CIP index, six primary indicators are considered: industrial value-added per capita, industrial exports per capita, industrialization intensity, export quality, country-specific impact on world industrial value-added, and country-specific impact on world industrial exports. The high value of these indicators increases the CIP index value, which indicates that the country's industrial competitiveness is high. The CIP index is widely used to compare neighboring countries. Because these countries can often be commercial partners or competitors. These countries may have similar socio-economic structures, use the same currency, and have similar cultural heritage (Correa & Todorov, 2020). The heat map in Figure 2 shows the distribution of the CIP index. According to the figure, it is seen that industrial competitiveness is concentrated in North America, Europe, and East Asia. The countries with the lowest level of competitiveness are concentrated on the African continent. Industrial agglomeration is important in terms of specializing in the labor force, gathering more resources, increasing competition among entrepreneurs, creating economies of scale, creating positive externalities, and spillover knowledge and technology in the region (Li, 2020). For this reason, industrial production concentrated in certain regions develops the region by feeding itself. It is easily seen from the heat map that dark and light-colored countries are concentrated in certain regions, indicating that industrial agglomeration is valid for North America, Europe, and East Asia.

Since the Industrial Revolution, the manufacturing industry has been of great importance for developed countries to achieve their current success and for some developing countries to converge to the developed country category, although the number is small. However, in the last few decades, developed countries have become deindustrialized and the number of people working in the industrial sector has decreased continuously in these countries. Moreover, this situation has occurred in underdeveloped and developing countries since the 1980s. The deindustrialization experienced by these countries has a detrimental effect on economic growth (Rodrik, 2015). This deindustrialization process harbors dangers such as reducing the rate of economic growth, increasing inequalities, causing the destruction of quality jobs, and hindering the accumulation of human and physical capital. Therefore, various steps need to be taken to reverse this process, especially in developing and underdeveloped countries. It is normal to see asymmetries in this reversal phase. Thus, the size of deindustrialization and the size of reindustrialization may not be the same (Tregenna, 2011). The share of employment in the manufacturing industry, and the share of the manufacturing industry in GDP which are the indicators of deindustrialization, are widely used in the literature (Dasgupta & Singh, 2007;

Tregenna, 2011; Krawczyński, Czyżewski, & Bocian, 2016). Figure 3 shows the distribution of the share of employment in the industry in total employment by income groups. From the beginning of the 2000s, it is seen that this share has increased in all income levels other than the high-income group. Even if this increase is not very evident yet, it may be an indicator of reindustrialization. Also, this process is likely to be slower than the deindustrialization process.

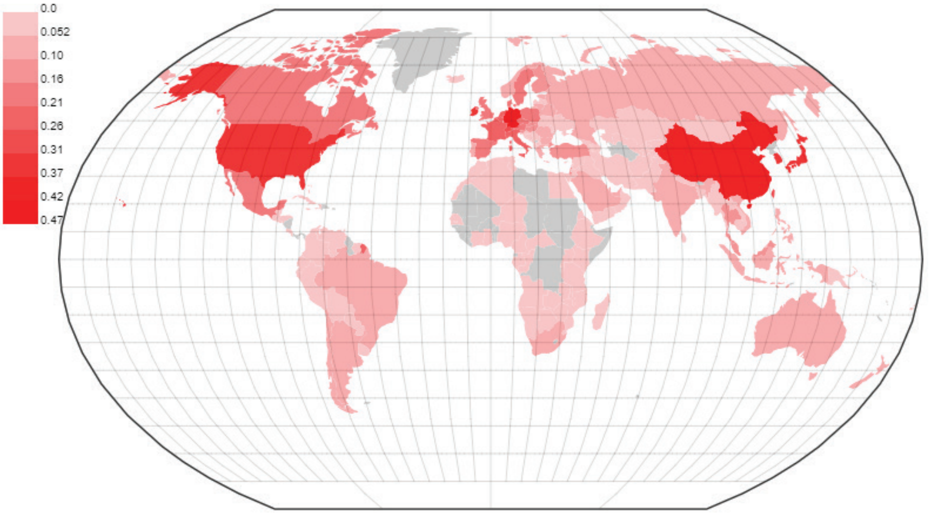

Figure 2. 2018 CIP Index Heat Map

Source: UNIDO

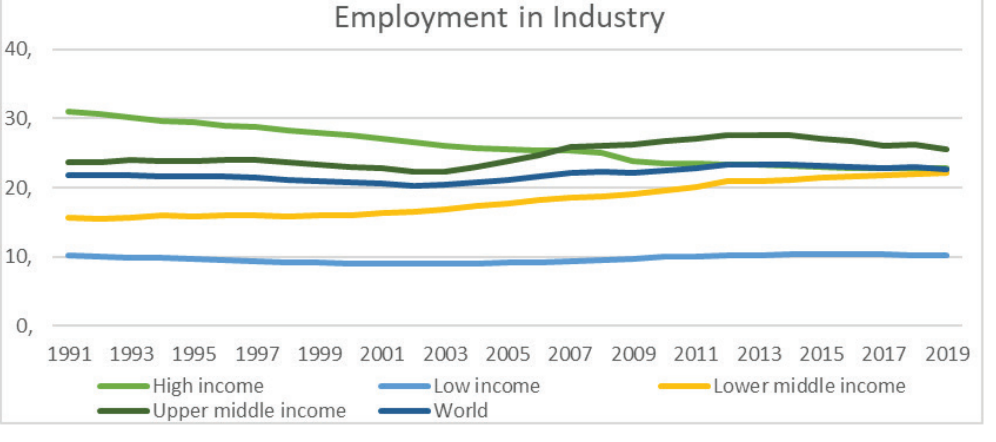

Figure 3. Employment in Industry (% of Total Employment)

Source: World Data Bank

The fact that industrialization gained importance again after the 2000s necessitated recalculation of the factors affecting industrialization and the production functions of the manufacturing industry as of this period. When the field of economics is examined, it is seen that the production function is calculated for various periods and regions. However, some of these studies examined the economy in general and did not specifically cover the manufacturing industry (Willman, 2002; Hájková & Hurník, 2007; Khatun & Afroze, 2016; Aslan, Menegaki, & Tugcu, 2016; Aquino & Ramírez-Rondán, 2020; Tripathi & Inani, 2020). Some of them comprise studies on industry on a country or regional basis (Khalil, 2005; Böhringer, Moslener, Oberndorfer, & Ziegler 2012; Hossain, Basak, & Majumder, 2013; Šipikal, Širaňová, & Némethová, 2017; Gajdzik, 2020).

To increase the competitive pressure, efforts to increase profitability by reducing costs, and to increase efficiency, companies have started to carry out their production in different countries, considering the cost elements in the production stages. This situation is affected by the foreign trade structure of the countries as well as their geographical locations (Saygili, Cihan, Yalcin, & Hamsici, 2010). In this context, especially intermediate goods are constantly subject to foreign trade. This outsourcing has brought specialization and integration into international production. While this situation pushes countries to remove trade barriers and integrate into the global economic system, it has allowed developing countries to converge with developed countries. Access to new technologies, opening up to international markets, and gaining knowledge enable this convergence (Landesmann, & Stöllinger, 2019). For this reason, foreign trade is of great importance for the manufacturing industry, and the development of the manufacturing industry through comparative advantages through foreign trade enables especially developing countries to converge with developed countries. For this reason, a series of studies have been carried out to determine the effects of foreign trade on the manufacturing industry.

When the literature was examined, it was realized that the effects of trade openness on the manufacturing industry were analyzed. Some of these studies only dealt with certain country groups (Tahir, Estrada, Khan, & Afridi, 2016; Sade, Esther, Oladipo, & Adedokun, 2021). However, there are also studies examining the effects of trade openness on the added value of the manufacturing industry in certain country groups (Azolibe, 2021). Apart from these, the effects of trade openness on growth have been frequently studied in the literature (Dumitrescu & Hurlin, 2012; Banday, Murugan, & Maryam, 2021). Although the effect of trade on the manufacturing industry is examined within the scope of these studies, this approach includes a holistic perspective. However, if imports consist mainly of consumer goods that can discourage domestic production, trade is likely to adversely affect domestic production (Ndikumana, 2000). For this reason, it is important to analyze the effects of manufacturing industry imports and exports on production separately. However, when the literature is examined, it has appeared that such studies are quite limited. Some of these studies focused on exports and technology imports without concentrating on manufacturing industry imports and exports and examined the impact of technology imports on the manufacturing industry (Rjiesh, 2018). In addition, the effects of manufactured input imports on production were also examined (De Souza & Gómez-Ramírez, 2018). Furthermore, there are a limited number of country-based studies. In some of these studies, manufacturing industry production was not focused on, and the effect of America's import of manufactured goods from China on the number of people working in the manufacturing industry in Mexico was examined (Mendoza Cota, 2016). The present study aimed to fill this gap in the literature.

Human capital, another variable used within the scope of the study, is frequently used in the literature. In particular, the relationship between human capital and growth has been frequently studied in the literature (Li & Wang, 2016; Yang & Zhao, 2020). However, some studies reveal company-based analysis (Hsu & Chen, 2019). In addition, by examining the relationship between human capital and technology, it has been determined that while the increase in human capital causes a decrease in low-tech industries; it creates an increase in the share of medium and high-tech industries (Zhou, 2018). Human capital is represented by many different variables in the literature. In some studies, the average year of education (Ismail, 2006; Yang & Zhao, 2020), the index value calculated by the authors from the average school year (Kartal, Zhumasheva, & Acaroglu, 2017), and a variable calculated over the relationship between worker income and health-education (Brock & German-Soto, 2013) are used to represent human capital. Within the scope of the current study, the Human Capital Index was used by considering human capital with a holistic approach. HCI measures the productivity of a child born today as a future employee, based on the criteria of full health and complete education, by calculating the contribution of health and education to worker productivity. Therefore, the index consists of four major components: the three major determinants of human capital (education, health, and employment) plus the factors such as regulations and infrastructure that allow these three major determinants to transform into greater returns (World Economic Forum, 2013).

Analysis

Data

Production, in its simplest sense, is the conversion of factors of production into goods and services in a certain period. The production function shows the relationship between these factors and the amount of production. The most important estimation step in nonlinear production models is the correct estimation of the parameters of the dependent and independent variables. The most frequently used nonlinear models can be listed as Cobb-Douglas, CES, and Translog production functions (Mahaboob, Ajmath, Venkateswarlu, Narayana, & Praveen, 2019). The production function of Cobb-Douglas (Cobb & Douglas, 1928), which is one of the most frequently used of these functions, is also used in the literature for the manufacturing industry (Hossain, Basak, & Majumder, 2013; Peter, 2017; Kumar, Sankaran, Arjun, & Das, 2019). In the study conducted by Hossain, Bhatti, and Ali (2004), it was decided that the Cobb-Douglas production function is the most appropriate function for the manufacturing industry by making comparisons between various production functions. Several studies in the literature reach similar results (Miller, 2008; Aiyar & Dalgaard, 2009).

4 different Cobb-Douglas production function was established within the scope of the research. These functions can be listed as follows:

Model 1

$$lnq=\beta_0+ \beta_1\, lnk+ \beta_2\, lnl+ \beta_3\, open+ \beta_4\, lnexc \quad (1)$$

Model 2

$$lnq=\beta_0+ \beta_1\, lnk+ \beta_2\, lnl+ \beta_3\, open+ \beta_4\, lnexc+ \beta_5\, hc \quad (2)$$

Model 3

$$lnq=\beta_0+ \beta_1\, lnk+ \beta_2\, lnl+ \beta_3\, mexp+ \beta_4\, mimp+ \beta_5\, lnexc \quad (3)$$

Model 4

$$lnq=\beta_0+ \beta_1\, lnk+ \beta_2\, lnl+ \beta_3\, mexp+ \beta_4\, mimp+ \beta_5\, lnexc+ \beta_6\, hc \quad (4)$$

lnq= log of gross production by industry (reel value)

lnk= Log of reel capital stock

lnl= Log of number of employees

mexp= Manufactures exports (% of merchandise exports)

mimp= Manufactures imports (% of merchandise imports)

lnexc= Official exchange rate

hc= Human capital index

open= Trade openness

The data used in calculating manufactures export-import, exchange rate, human capital, and trade openness data were obtained from the WB-World Development Indicator database. The trade openness was calculated in accordance with the literature as follows. Real values are used during this calculation (Managi, Hibiki, & Tsurumi, 2009; Brueckner and Lederman, 2015):

Trade openness= $\frac{(Import+Export)}{GDP}$

The data of the manufacture production, capital stock, and labor used in the study were obtained from the WIOD (World Input-Output Database)-Socio-Economic Accounts (2016) database. Manufacturing industry data consists of 18 sub-sectors. The data used in the study was obtained by collecting these sub-sectors. The data set published by WIOD covers only the period 2000-2014. For this reason, the data set used in the analysis includes a 15-year time series. The WIOD input-output table consists of datasets from 42 countries according to the ISIC Rev 4.0 industry classification standard. Taiwan and China were excluded from the analysis due to the lack of data. In addition, the WIOD data set offers specific series for each sub-sector within the manufacturing industry. In this way, it provides the opportunity to find detailed data for various sub-sectors (Dietzenbacher, Los, Stehrer, Timmer, & De Vries, 2013). The descriptive statistics of the variables are as given in Table 1.

Table 1
The descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
lnq	5.68	1.36	3.26	9.79
lnk	9.48	0.05	8.30	9.66
lnl	3.00	0.71	1.28	4.65
open	0.88	0.48	0.20	3.23
mexp	68.12	20.01	11.58	97.43
mimp	69.04	9.43	38.53	86.94
lnexc	0.51	0.95	-0.30	4.07
hc	3.10	0.44	1.78	3.73

Model and Results

Multidimensional panel data analysis was used within the scope of the study. This quite new method was applied for the first time in the study of Baltagi, Song, and Jung (2001). When panel data models are examined, it is generally seen that the effect of the unit dimension is more weighted than the time dimension. In this case, it is appropriate to use two units and a one-time effect in multidimensional panel data models (Tatoğlu, 2016). Multidimensional panel data models can be created nested and non-nested. The advantage of nested models is that they provide a detailed analysis by covering the effects of groups such as country-city, country-income, as well as time effects. Non-nested models are generally applied in the gravity model (Tatoğlu, 2017). Multidimensional panel data models are estimated with the assumption of fixed and random effects. Multidimensional models estimated with fixed effects assumption are analyzed with shadow variable least squares estimator and within-group estimator. In the random-effects model, generalized least squares and maximum likelihood methods are applied (İsabetli & Tunalı, 2018).

In this study, two units, income group, and country, and a time dimension were used. Countries are classified according to low, lower-middle, upper-middle, and high-income groups in accordance with the list prepared by WB. Since there is no country in the low-income group in the dataset used in this study, countries are classified into three groups. The models of the study, which were analyzed with the multidimensional nested panel data method, were established as follows:

Model 1

$$lnq_{ijt}=\beta_0+\beta_1 \, lnk_{ijt}+\beta_2 \, lnl_{ijt}+\beta_3 \, open_{ijt}+\beta_4 \, lnexc_{ijt}+\mu_i+\gamma_j+\lambda_t+u_{ijt} \quad (1)$$

Model 2

$$lnq_{ijt}=\beta_0+\beta_1 \, lnk_{ijt}+\beta_2 \, lnl_{ijt}+\beta_3 \, open_{ijt}+\beta_4 \, lnexc_{ijt}+\beta_5 \, hc_{ijt}+\mu_i+\gamma_j+\lambda_t+u_{ijt} \quad (2)$$

Model 3

$$lnq_{ijt}=\beta_0+\beta_1 \, lnk_{ijt}+\beta_2 \, lnl_{ijt}+\beta_3 \, mexp_{ijt}+\beta_4 \, mimp_{ijt}+\beta_5 \, lnexc_{ijt}+\mu_i+\gamma_j+\lambda_t+u_{ijt} \quad (3)$$

Model 4

$$lnq_{ijt}=\beta_0+\beta_1 \, lnk_{ijt}+\beta_2 \, lnl_{ijt}+\beta_3 \, mexp_{ijt}+\beta_4 \, mimp_{ijt}+\beta_5 \, lnexc_{ijt}+\beta_6 \, hc_{ijt}+\mu_i+\gamma_j+\lambda_t+u_{ijt} \quad (4)$$

Here i shows the unit size of the countries, j shows the country groups classified according to income groups, and finally, t shows the time dimension. μ_i is the country effect, γ_j is the income group effect, and λ_t is the time effect. First of all, the significance of each effect individually and together was tested with the LR test. Altogether, in paired or individually set LR tests, the hypotheses are that the standard errors of the unit effects are equal to zero. The LR test results are as given in Table 2.

According to the LR test result, all H_0 hypotheses were rejected for all models. It has been revealed that the country and income group effects are significant and the two-unit panel data methods are appropriate in the analysis process of the model. Then, the models were estimated with fixed and random effects. Estimation results are given in Table 3 and Table 4.

Table 2
LR Test Results

Null Hypothesis	**LR Test Statistics**			
	Model 1	**Model 2**	**Model 3**	**Model 4**
$H_0=\sigma_\mu=\sigma_\gamma=\sigma_\lambda=0$	1772.81*	1640.22*	1847.46*	1703.39 *
$H_0=\sigma_\mu=\sigma_\gamma=0$	1104.63*	1353.54*	1103.16*	1328.87*
$H_0=\sigma_\mu=\sigma_\lambda=0$	1770.62*	1640.22*	1847.40*	1703.39*
$H_0=\sigma_\gamma=\sigma_\lambda=0$	312.30*	161.06*	309.19*	144.63*
$H_0=\sigma_\mu=0$	1104.62*	1349.22*	1103.16*	1324.25*
$H_0=\sigma_\gamma=0$	201.24*	64.82*	205.31*	62.03*
$H_0=\sigma_\lambda=0$	58.84*	49.04*	93.40*	48.52*

Note: * indicates significance at the 1% significance level.

Table 3
Fixed Effects Estimation Results

Shadow Variable Least Squares Estimator				
	Model 1	**Model 2**	**Model 3**	**Model 4**
lnk	0.02	0.02	0.03	0.02
lnl	0.92*	0.88*	0.78*	0.75*
open	0.08*	0.07**		
lnexc	0.81*	0.79*	0.77*	0.74*
hc		0.31*		0.32*
mimp			0.01*	0.01*
mexp			-0.001	-0.001
cons	2.23*	1.35**	2.06*	1.16**
F-test	4131.00*	4187.43*	4782.80*	4886.20*
R^2	0.9977	0.9978	0.9981	0.9981
Within Group Estimator				
lnk	0.04	0.02	0.03	0.02
lnl	0.76*	0.94*	0.83*	0.95*
open	0.08*	0.08*		
lnexc	0.67*	0.68*	0.63*	0.67*
hc		0.25*		0.20*
mimp			0.005*	0.004*
mexp			0.002*	0.003*
cons	4.10e-07	4.79e-07	4.42e-07	4.91e-07
F-test	8865.85*	7363.67*	8077.34*	6891.60*
R^2	0.9835	0.9841	0.9855	0.9859

Note: * and ** indicate significance at the 1% and %5 significance level, respectively.

When Table 3 and Table 4 are examined, it has been determined that all three models are significant as a result of the F statistics and Wald test of the models. However, the shadow variable least squares estimator variable is not preferred because it causes a loss of degrees of freedom by adding a shadow variable to the model and the limitations of the specifications it allows. In addition, the shadow variables of nested units drop of the model because of multicollinearity. For this reason, the results are not different from the two-dimensional panel (Tatoğlu, 2018: 300). Therefore, the shadow variable least squares estimator variable results are not consistent. For these reasons mentioned above, within-group estimators were preferred. When the results of the within-group estimators are examined, it is seen that the explanatory power of all models is quite high (For model 1 and 2 it is 98%, for model 3 and 4 it is almost 99%). What all models have in common is that the capital stock is meaningless. This may be because countries from different income groups are evaluated together. The change in the marginal effect of capital stock in different income groups may have rendered the variable meaningless. All variables except capital stock were found to be significant. In addition, the coefficient of labor in all models is quite high compared to other variables. The data used in this study includes the entire manufacturing industry. If the sub-sectors of the manufacturing industry are examined, the elasticity of labor may change. However, in parallel with the current study in the literature, it has been determined that labor flexibility is higher for different

Table 4
Random Effects Estimation Results

Maximum Likelihood Estimator				
	Model 1	**Model 2**	**Model 3**	**Model 4**
lnk	0.01	0.01	0.01	0.01
lnl	1.03*	0.98*	0.90*	0.89*
open	0.08*	0.07**		
lnexc	0.87*	0.85*	0.84*	0.83*
hc		0.33*		0.31*
mimp			0.008*	0.007*
mexp			-0.0002	0.0001
cons	1.82*	1.15**	1.92*	1.10**
Wald	981.36*	1060.29*	1053.49*	1146.00*

Note: * and ** indicate significance at the 1% and %5 significance level, respectively.

countries. (Hossain & Al-Amri, 2010; Hassine, Boudier, & Mathieu, 2017; Song & Son, 2020). Therewithal, looking at Figure 3, it is seen that the rate of labor in industrial production has increased. This supports the positive effect found in the analysis.

Within the scope of the study, two different methods were used to represent the trade. The first of these is trade openness. The trade openness values in Models 1 and 2 were found to be significant at 1%, and the coefficient of trade openness in both models was found to be 0.08. Trade openness is a frequently used indicator of the literature. Especially in developing countries, the positive effects of trade on the manufacturing industry have been revealed in many studies. This shows that the traditional misconception about the harmful effects of trade on domestic industries is not valid (Tahir, et al., 2016; Sade, et al., 2021). Competition caused by trade causes productivity gains (Chikabwi, Chidoko, & Mudzingiri, 2017), forcing firms that want to export more to increase productivity. Thanks to trade, access to technology, economies of scale, and spillover effects occur. In addition, the opportunity to access fore-ign markets provides an increase in productivity. Although the goods coming from foreign countries force the domestic companies, the efficient management skills, on-the-job training programs, increased competence, etc. that come to the country thanks to these companies, improve the domestic companies (Wong, 2006). In the 3rd and 4th models, imports and ex-ports of the manufacturing industry are used, not trade openness to represent trade. Although both variables have a significant and positive effect, they have very small coefficients. In both models, the share of manufactured goods exports in total goods exports and the share of ma-nufactured goods imports in total goods imports have a very low impact on the manufacturing industry. Although this situation seems to be a contradictory result with the high coefficient of the trade openness variable, even if there is no export and import of manufactured goods, the trade-in other fields may feed the manufacturing industry by feeding the manufacturing industry sideways. This situation can be explained by the development of the financial system thanks to the development of foreign exchange inflow and outflow, the increase in the invest-ments of the trading countries in the relevant country, the increase in the demand of households as a result of the increase in the income of the countries engaged in foreign trade, and the increase in the production industry indirectly by the development of trade areas other than the manufacturing industry. Since it is not possible to prove these relationships within the scope of the current analysis, additional analyses can be made in future studies in this context.

Another important variable handled within the scope of the analysis is human capital. In the 2nd and 4th models where human capital is included, the coefficients of the variable were found to be positive and significant as 0.25 and 0.20, respectively. This result shows parallelism with the literature (Ismail, 2006; Ciccone & Papaioannou, 2009). Although the exchange rate has very close coefficients in all models within the scope of the current analysis, it positively affects the manufacturing industry. This result is in parallel with the literature (Sade, et al., 2021). Accordingly, it shows that if the value of the domestic currency decreases compared to the foreign currency, exports become cheaper and imports become more expensive, and thus domestic manufacturing companies will be encouraged to produce more for export and will always increase their productivity (Azolibe, 2020).

Discussion

It is widely accepted in the literature that the manufacturing industry is the main factor in ensuring sustainable growth (Luken & Castellanos-Silveria, 2011; Wang, Wang, & Dai, 2018). However, in terms of development, the transition of production from labor-intensive systems to capital-intensive and technology-intensive systems is important (Li, Xue, & Huang, 2018). The efficiency of labor and capital increases the productivity of the sector and raises income. For this reason, investments in new technologies are very important in terms of increasing the added value of both labor and capital (Novotná, Leitmanová, Alina, & Volek, 2020). Labor-intensive industries are especially vital for job creation. However, to benefit from economies of scale and price competition, it is tried to increase capital intensity through technological developments in industries. However, this may lead to a decrease in employment, especially among unskilled workers (Das & Kalita, 2009). In the post-industrial era, more production was made with fewer workers than in the Fordist mass production era, and the marginal productivity of workers was lower than technological progress. Especially medium-skilled white and blue-collar workers have been replaced by technology (Acemoglu & Autor, 2010; Tüzemen & Willis, 2013).

Although the service, information, and finance sectors have gained importance around the world recently, the weakness in virtual economies has brought them closer to mainstream growth models. This situation has developed the trend of re-industrialization with high technology and added value. In this process, competition is not applied to costs and prices, but by technological development (Hu & Hu, 2013). In addition, with the re-industrialization process, the demand for educated workers is increasing, which reduces unemployment among individuals with high human capital. Increasing the added value of workers and adapting them to work with new technologies can be achieved through wage policy (Scott, 2006; Moore & Shute, 2012). Therefore, human capital is one of the major strengths for high-tech companies to maintain their competitive advantage in the knowledge economy (Chen & Chien, 2011). Governments should implement optimal industrial policy to support human capital development in industry, reducing the opportunity cost of human capital to zero and the probability of human capital leaving the community to zero. Mutual trust and cooperation, which are the biggest determinants of human capital, need to be implemented with active industrial policies (Hsu & Chen, 2019). However, technological developments and the use of technological products in the manufacturing industry increase the productivity of workers. Using robots in the industry allows for the improvement of product quality and the expansion of product variety (Jungmittag & Pesole, 2019). In the increasingly competitive environment created by globalization and the rise of information technology in the 2000s, the value creation activities of countries have radically differentiated and led to various advances. For this reason, Germany first developed the concept of Industry 4.0 to bring itself to a new and privileged position. This concept refers to the combination of many technological innovations that are expected to significantly change the manufacturing industry. Thanks to technologies such as robotics, artificial intelligence, cloud computing, and big data analysis, it is aimed to connect the entire industry by integrating both the physical and virtual worlds. This is expected to change all production systems (Aydın, 2018).

The center-periphery relationship that emerged because of globalization after the Industrial Revolution is one of the reasons for commercial growth. This situation has led to the emergence of today’s developed and developing country distinction. Especially the deindustrialization movements experienced in the 19th century push the developing countries to be cautious. However, one of the biggest results of participating in trade is to reduce costs first and then to provide convergence (Baldwin, Martin, & Ottaviano, 2001). Especially in developing countries, starting from the baby industry thesis, newly developing industries were protected and trade was limited and these industries were supported by the state. In the current study, it has been determined that the negative impact of foreign trade on the manufacturing industry is not valid in the selected countries. Although most of the countries in the current study are developed countries, similar results were obtained for developing countries (Dodzin & Vamvakidis, 2004).

Conclusion

The relationship between industrial production and international trade has been frequently examined and various theories have been put forward. Especially the baby industry theory has been respected for a long time and countries have protected their newly developing industries against the harmful effects of trade according to theory. Nevertheless, almost all countries that do not want to lose the superiority of being the first country to enter the market, especially with globalization, have started to trade rapidly. In addition, the effects of imports and exports on industrial production have also been discussed separately. However, the economic literature has not yet formed a consensus on this issue. On the other hand, within the scope of the literature, it is accepted that the effect of human capital generally affects positively industrial production, as in economic growth.

As a result of the analysis made within the scope of the current study, it was determined that trade openness, exports, imports, and human capital positively affect industrial production. This result shows that the theories stating that trade has harmful effects on production are not valid for the countries covered in the analysis. On the other hand, the human capital variable meets the expectations. It would be appropriate to implement policies to increase trade and disseminate education programs that can be applied to the general population in order to increase trade and develop human capital in the countries mentioned.

The strongest aspect of the study is that, thanks to the data set used, the number of people working and the amount of capital in that industry were used as variables, and the general capital level and the number of employees in the country were not used as in most of the literature. Thus, the coefficients obtained as a result of the analysis really reflect the manufacturing industry, not the entire country. Although the present study fills an important gap in the literature, it has several limitations. First of all, the study includes only a 15-year data set. Secondly, it does not cover recent developments. Therefore, it is planned to conduct another study with a different data set to examine the recent developments.

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Appendix

List of the countries: Australia, Austria, Belgium, Canada, Switzerland, Cyprus, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Croatia, Hungary, Ireland, Italy, Japan, Republic of Korea, Lithuania, Latvia, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Sweden, United States, Bulgaria, Brazil, Indonesia, Mexico, Russian Federation, Turkey, India.