



RESEARCH ARTICLE

## Panel Data Analysis of Export Structure and Growth: Case of BRICS-T Countries\*

Necip DÜNDAR<sup>1</sup> , Yüksel BAYRAKTAR<sup>2</sup> 

### ABSTRACT

Realisation of specialisation in areas dominated by technological production structure and the technological level of exported goods are essential determinants of macroeconomic performance. Therefore, the export structure and technological level of exported goods are highly significant. In this study, the relationship between real GDP and exports of goods produced in BRICS-T countries with low, medium, and high levels of skill and technology is investigated. In the panel data analysis using data for the period 1995–2020, the cointegration relationship between the variables was examined, and it was concluded that there is no long-run relationship between real GDP and goods produced in labour-resource intensive, low, medium, and high skill and technology levels of countries. In addition, a causality test using Dumitrescu and Hurlin's (2012) linear heterogeneous model was carried out. The test results showed a unidirectional causality relationship between real GDP and goods with low and high skill and technology but a bidirectional causality relationship between real GDP and labour-resource-intensive goods.

**Keywords:** Export structure, Exports, Real GDP, Technological level, BRICS-T

**JEL Classification:** E60, F10, O50



DOI: 10.26650/ISTJECON2023-1296901

\* Derived from PhD thesis, in Turkish, titled "İhracat Yapısı ve Makroekonomik Performans Arasındaki İlişki: BRICS Ülkeleri ve Türkiye için Parametrik Olmayan Bir Analiz", [Relationship Between Export Structure and Macroeconomic Performance: A Nonparametric Analysis for BRICS Countries and Turkey] (Istanbul University Social Sciences Institute, 2020). However, the data and methodology used in this study were not used in the thesis, as mentioned above.

<sup>1</sup>Asst. Prof. Dr., Muş Alparslan University, Faculty of Economics and Administrative Sciences, Department of Economics, Muş, Türkiye

<sup>2</sup>Prof. Dr., Ankara University, Faculty of Political Sciences, Department of Economics, Ankara, Türkiye

ORCID: N.D. 0000-0002-9408-8669;  
Y.B. 0000-0002-3499-4571

### Corresponding author:

Necip DÜNDAR,  
Muş Alparslan University, Faculty of Economics and Administrative Sciences, Department of Economics, Muş, Türkiye  
**E-mail:** n.dundar@alparslan.edu.tr

**Submitted:** 14.05.2023

**Revision Requested:** 10.05.2024

**Last Revision Received:** 10.05.2024

**Accepted:** 20.05.2024

**Citation:** Dündar, N., & Bayraktar, Y. (2024).

Panel data analysis of export structure and growth: Case of BRICS-T countries. *Istanbul İktisat Dergisi - Istanbul Journal of Economics* 74(1), 99-120.

<https://doi.org/10.26650/ISTJECON2023-1296901>



## 1. Introduction

Exports have an influence on macroeconomic performance as a part of economic growth and are typically linked to a number of ideas, including access to international markets, processing of goods to satisfy international consumers' tastes, and development of new networks (Hu and Tan, 2015). Export growth raises national income by enabling the repayment of foreign debt and more effective use of resources. Moreover, exports support imports, which boost the national economy. Developing or developing countries can obtain the latest technologies or ideas through exports that they cannot obtain through their own means (Gylfason, 1997). Moreover, higher export revenue raises imports of intermediate goods, which in turn raises production levels (Awokuse, 2007).

The export structure includes the distribution of goods by commodity groups, including consumption, intermediate goods/raw materials, and investment, as well as changes in market shares by nation, country group, or region. It also considers the distribution of factor use intensity, including labour-intensive, low, medium, or high-technology. On the other hand, it also includes the distribution of goods by industry sectors, including mining, agriculture, food, fuel, and manufacturing. As a result, the export structure can be considered a crucial element in determining the macroeconomic success of a nation.

Thanks to their geographic location and population potential, the BRICS countries are setting the standard for emerging economies internationally and regionally. BRICS has increased its total trade volume and begun to influence global commerce, particularly since the 2000s. BRICS exports, which were over 330 trillion dollars in 1995, rose to 3,494 trillion dollars in 2020, while its imports, which were above 315 trillion dollars, amounted to roughly 2,929 trillion dollars in that year, according to the United Nations UNCTAD data. Furthermore, BRICS exports, which comprised 6.5% of global exports in 1995, increased to approximately 19.8% in 2020. The BRICS countries' share of global imports climbed from 6% to 16.3% within the same period. This shift in foreign trade statistics is a crucial sign of the BRICS' growing influence. Turkey's efficacy in

international trade began to shift in the 1980s by adopting the export-oriented industrialisation model. As a result, Turkey's share of global exports climbed from 0.4% in 1995 to 1% in 2020. Correspondingly, its share of global imports has grown from 0.68% in 1995 to 1.2% in 2020. This paper includes panel data analysis to investigate the link between real GDP (LGDP) and exports of labour-resource intensive, low, medium, and high skill and technology goods (Labour/Low/Medium/High) in the foreign trade of BRICS-T countries from 1995 to 2020.

## **2. Export Structure in the BRICS-T Countries**

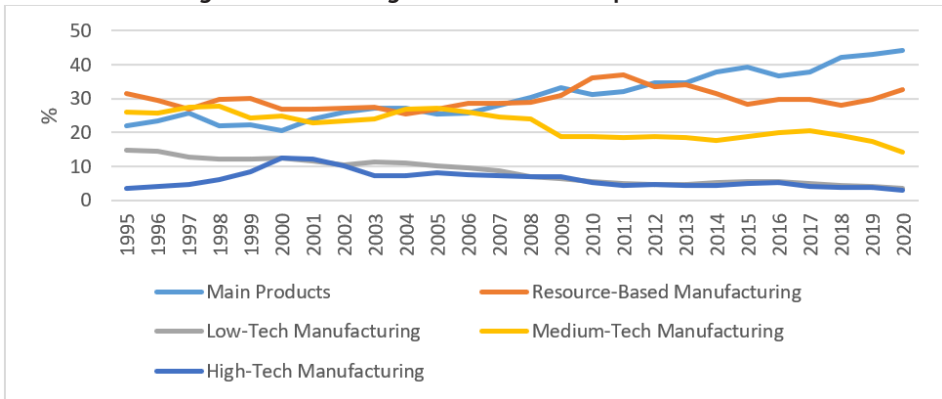
Investors have greater investment potential in developing nations than in developed nations. In this regard, developing nations are undergoing rapid economic expansion. Similarly, the term BRICS is made up of the initials of several nations that are rapidly developing, including Brazil, Russia, India, China, and South Africa. Jim O'Neill, the head economist at Goldman Sachs, first mentioned BRIC in 2001, referring to Brazil, Russia, India, and China (O'Neill, 2001). Features like rapid population growth and high growth rates unite BRIC nations. In 2010, South Africa, a distinct and emerging market, joined the BRICS, making it the BRICS (Khan, Barua & Bhuiya, 2015). Each BRICS nation has a crucial industry-leading or dominating world market. The BRICS countries are characterised by Brazil's dominant position in agricultural production, Russia's richness in mining or subsurface resources, India's low-cost intellectual capital, China's low-cost labour resources, and South Africa's abundant natural resources. South Africa, Brazil, and Russia are raw material suppliers because of their great potential, whereas India and China are suppliers of labour-intensive commodities, manufactured goods, and consumer goods (Chyckalo-Kondratska, Bezrukova & Svichkar, 2017).

Macroeconomic performance during the phase of economic growth is determined mainly by the realisation of specialisation in fields dominated by technological production structures and the technological level of exported products. Specific categories are used to classify the level of technology of exported goods while examining the relevant literature. Lall (2000) was the first to identify the technological level of exported commodities as primary-finished

items made up of raw materials like meat, fresh fruit, cocoa, rice, tea, coffee, coal, timber, and crude oil. These goods are divided into resource-based, low, medium, and high-technology categories.

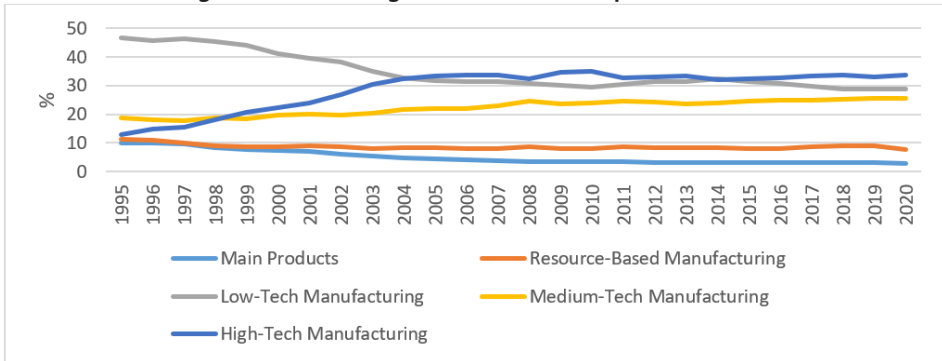
This study examines the export structures of the BRICS-T nations in terms of the technology of the exported items. As noted in Figure 1, a significant portion of Brazil's exports are commodities with primary and resource-based technology levels. When the relevant years are considered, the proportion of primary items climbed from roughly 21% of exports in 1995 to 45% in 2020. Nevertheless, exports of goods manufactured with low technology fell from 14% to 3%, and those manufactured with medium technology fell from 26% to 14%. In addition, the number of products manufactured using high technology has decreased, notably since 2000.

**Figure 1: Technological Structure of Exports in Brazil**



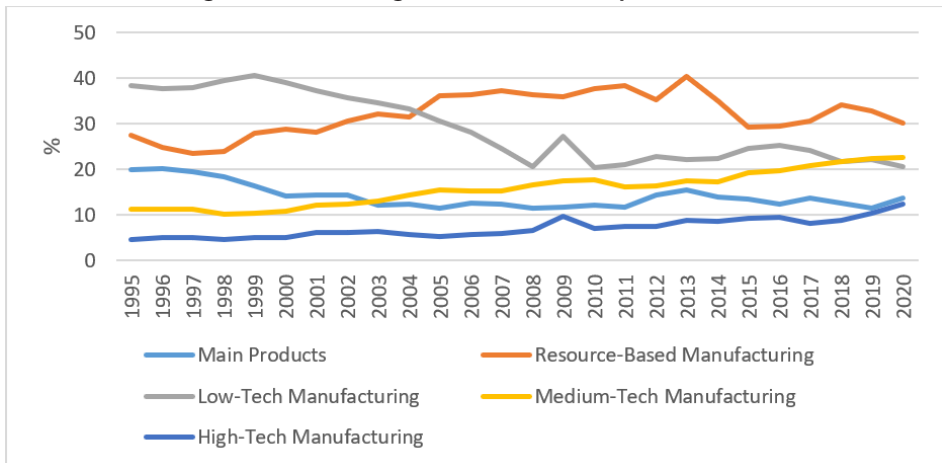
Source: UNCTADSTAT (<https://unctadstat.unctad.org/datacentre/>, 14.07.2022)

Particularly after the 2000s, the importance of high-tech products stands out in China's export structure. Approximately 13% of exports were high-tech products in 1995; by 2020, that percentage was expected to rise to 34%. The weight of resource-based, primary, and low-tech commodities in exports has consistently declined over the years under study. On the other hand, although after the 2000s, exports of medium-tech goods did not grow significantly in proportion, there is still an upward trend.

**Figure 2: Technological Structure of Exports in China**

Source: UNCTADSTAT (<https://unctadstat.unctad.org/datacentre/>, 14.07.2022)

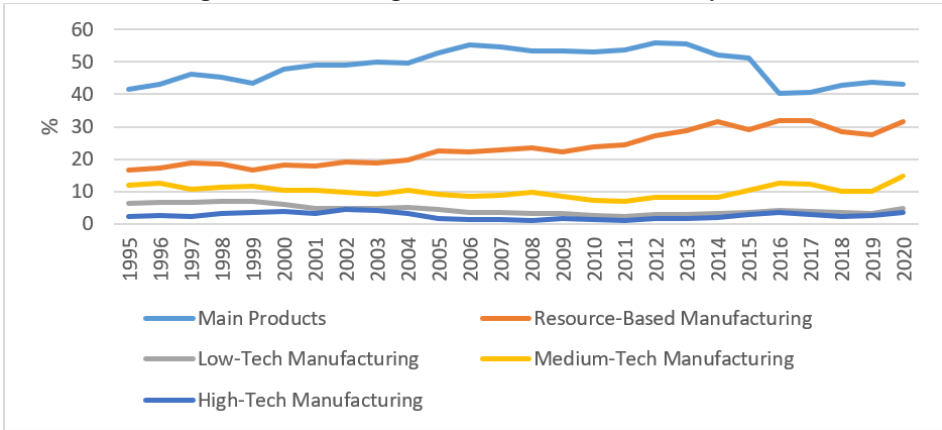
Since the mid-2000s, goods based on natural resources have dominated the technological structure of India's exports. Although the share of low-tech exports has decreased over time, they still constitute more than 20% of all exports. Conversely, exports of goods with medium technology sophistication have increased over time and now constitute more than 20% of total exports. On the other hand, despite a tendency to expand over time, high-tech goods still make up a minor portion of overall exports.

**Figure 3: Technological Structure of Exports in India**

Source: UNCTADSTAT (<https://unctadstat.unctad.org/datacentre/>, 14.07.2022)

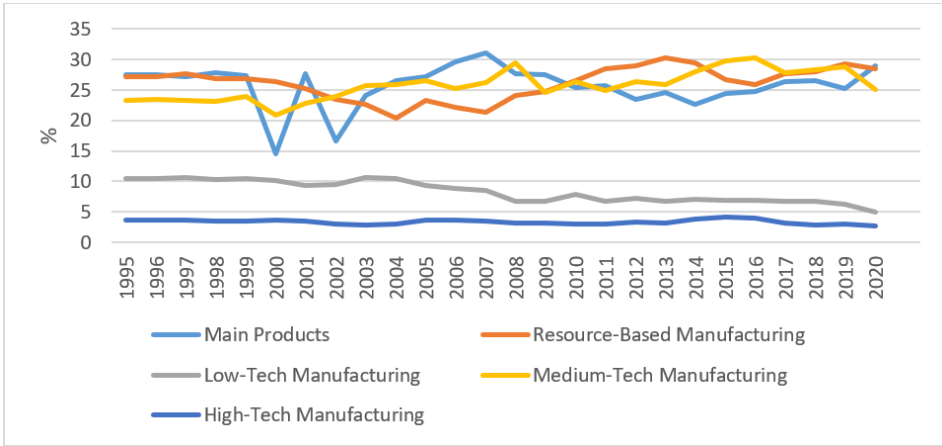
Primary and resource-based products dominate the technological structure of Russian exports. Nevertheless, the weight of low-, medium-, and high-tech goods also tends to increase over the years. However, these commodities constitute a smaller percentage of exports.

**Figure 4: Technological Structure of Russian Exports**



Source: UNCTADSTAT (<https://unctadstat.unctad.org/datacentre/>, 14.07.2022)

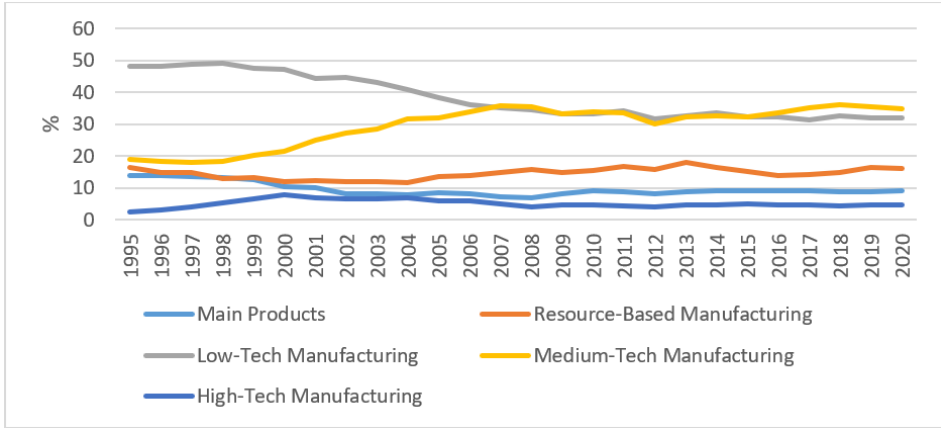
Notably, the percentage of low- and high-tech products in South Africa's exports has declined and remained deficient. However, the share of primary goods based on export resources has usually increased in recent years. On the other hand, since the 2000s, the percentage of medium-tech goods in exports has expanded, accounting for approximately 30% of exports in 2015. However, it has decreased to approximately 25% in recent years.

**Figure 5: Technological Structure of Exports in South Africa**

Source: UNCTADSTAT (<https://unctadstat.unctad.org/datacentre/>, 14.07.2022)

During the study period, Turkey's technological composition of exports showed a notable tendency for a decline in the percentage of low-tech goods exports. In contrast, the percentage of goods produced using medium technology is rising. As a result, the percentage of low-tech goods, which comprised approximately 48% of exports in 1995, fell to approximately 35% in 2020. The percentage of primary and resource-based products has risen since the mid-2000s. Moreover, exports of high-tech goods rose significantly relative to total exports near 2000, reaching 7.8%. It was, however, realised at a deficient level and began to decrease in the following years.

**Figure 6: Technological Structure of Exports in Turkey**



Source: UNCTADSTAT (<https://unctadstat.unctad.org/datacentre/>, 14.07.2022)

### 3. Literature Review

Empirical literature on economic growth and export structure mainly examines the relationship between export diversification, product concentration in exports, product sophistication, or technological structure of exports and growth.

Using data from 1960–1980 and the augmented production function, Fosu (1990) investigated the link between primary and manufactured export goods and growth in less developed countries. The study concluded that primary export goods have little effect on GDP growth, but the manufacturing sector positively affects growth.

Based on data from 1989 to 1991, Mayer and Wood (2001) compared and assessed the export structures of 111 nations from various continents, including South Africa. The study indicates that nations with higher skill levels per worker are more likely to export a larger proportion of their primary goods. Whereas East Asia prioritizes skill-intensive production, South Asia focuses on labor-intensive production.

Using data from 1993 to 2000, Funke and Ruhwedel (2003) investigated the link between export diversification and GDP per capita in 14 Eastern European transition economies. This study finds that high export diversification explains GDP per capita.



Gertler (2006) examined the link between export structure and growth in 22 European Union member countries for 1995–2004 within the framework of the Heckscher-Ohlin model and found a high correlation between the two variables. Guerson, Parks, and Torrado (2007) divided Argentina's exporting nations into two groups and used data for the 1994–2004 and 1960–2004 periods to examine the link between export structure and GDP per capita. According to the study, export structure significantly affects growth.

Hesse (2008) investigated the link between export diversification and growth in GDP per capita for 99 countries using data from 1961 to 2000 using the panel data method. According to the findings, export diversification is crucial for these countries' economic progress and increases GDP per capita.

Sun and Heshmati (2010) used the panel data approach to evaluate the link between trade structure and growth for 31 Chinese provinces from 2002 to 2007. This study confirms that China's trade volume and high-tech trade structure favourably affect its regional productivity.

Basu and Das (2011) used data from 1995–2007 and a nonparametric technique to evaluate the relationship between export structure and growth in 88 developing nations. According to the study, there is a strong link between growth and the export of goods with advanced technology and skill levels.

Lee (2011) performed a cross-country regression analysis for 1970–2004 to quantify the link between export specialisation and growth for 71 countries. According to the study, countries specialising more in exporting high-technology commodities than traditional or low-technology goods typically experience faster economic growth.

Jarreau and Poncet (2012) examined the link between economic performance and export sophistication in Chinese provinces using data from 1997 to 2009 using the panel regression method. According to the study, areas that focus on more complex products experience faster growth.

Aditya and Acharyya (2013) conducted a cross-country analysis of 65 countries using data from 1965 to 2005. Using the dynamic panel approach, this study examines the link between export specialisation and diversity in terms of growth. These results indicate that export specialisation and diversity boost growth.

Kadochnikov and Fedyunina (2013) used data from 2000 to 2008 to apply a simple linear cross-section model to examine the link between export structure and growth in Russia. The findings of this study indicate that diversifying exports is good for economic growth.

Using data from 1995–2010, Altunç and Aydın (2015) used a nonparametric method to investigate the link between export structure and growth for 11 G-20 countries. According to the study, exports of goods with high skill and technology levels are strongly correlated with growth.

Göçgör and Can (2017) examined the link between export product diversification, economic globalisation, and economic growth for 139 countries using data from 1970 to 2010. Cross-country panel data research reveals a link between growth and the diversity of export products. Moreover, it has been found through several robustness tests that export diversification is only positively related to growth in upper-middle economies.

Demir (2018) analysed the relationship between the sectoral structure of exports, technology diversification, and the technological structure of exports with growth in 34 upper-middle-income countries from 1995 to 2015 using the dynamic panel data method. According to the findings, high-tech goods have a major impact on growth, medium-tech goods have limited effects, and low-tech goods have a negative long-term impact.

Erdil Sahin (2019) analysed the link between high-tech exports and Turkey's growth for 1989-2017 by applying VAR analysis and the Granger causality test. According to the study, there is a significant causal link between the export of high-tech goods and growth.

Lazarov (2019) used the Granger causality test and VAR analysis to assess the link between export sophistication and growth in Macedonia from 1995 to 2017. This study finds a strong and statistically significant causal link between export sophistication and growth.

Belkania (2020) analysed the effect of export commodity structure on growth in 11 transition economies from 1997 to 2017 using the panel data method. These findings indicate a significant relationship between the commodity composition of exports and growth.

Dündar (2020) used a nonparametric approach to investigate the link between macroeconomic performance and export structure for the BRICS-T countries from 1995 to 2017. This research highlights a significant relationship between export technology level and macroeconomic performance. In addition, for most countries subject to the analysis, exporting medium-tech goods had a more significant positive impact on GDP per capita.

Akbulut Yıldız and Adıyaman (2021) applied panel data analysis to investigate the relationship between growth and high-tech exports for upper-middle-income nations from 1996 to 2017. The research finds that high-tech goods significantly and positively affect growth in the countries considered.

Considering the related literature, there is a high correlation between export diversity, product sophistication, export structure, and macroeconomic performance. In addition, the technological level of exported items as an export structure generally has a favourable impact on both export level and macroeconomic performance. Unlike previous research, this study uses panel data analysis to assess the link between export structure and growth for BRICS-T countries, focussing on labour-intensive, low-, medium-, and high-tech goods exports.

#### **4. Data and Model Used in the Study**

This study uses the panel data approach to investigate the link between the gross domestic product (GDP) of BRICS-T countries and labour-resource intensive,

low-, medium-, and high-tech export goods. In this study, the annual series of gross domestic product (GDP) and total exports consisting of labour-resource intensive export goods (Labour), low, medium, and high-skill and technology-intensive export goods (Low/Medium/High) obtained from the World Bank and United Nations UNCTAD database for 1995–2020 were used. Table 1 lists all the series used in the model. Due to the limited data for all variables for the BRICS-T countries before 1995, the analysis began in 1995. On the other hand, the fact that the BRICS countries, which comprise approximately 20% of the world GDP, have a high global economic weight and are located in different continents of the world together with Turkey in the context of global representation has been influential in the selection of this sample group.

The analysis uses the GDP logarithm. The Labour/Low/Medium/High variables used to represent the export structure are included as independent factors in the model, whereas the LGDP variable reflecting growth is the dependent variable. The study’s developed model is presented below.

$$LGDP_{it} = B_{0it} + B_{1it}Labor_{it} + B_{2it}Low_{it} + B_{3it}Medium_{it} + B_{4it}High_{it} + \varepsilon_{it} \quad (1)$$

**Table 1: Abbreviation, Variable and Data Sources**

Abbreviation	Variable	Data Source
LGDP	GDP (Constant \$ Prices)	World Bank Indicators
Labour	Percentage of Labour and Resource-Intensive Export Goods in Exports	UNCTADSTAT
Low	Percentage of Low-Skill and Technology-Intensive Export Goods	UNCTADSTAT
Medium	Percentage of Medium Skill and Technology Intensive Export Goods	UNCTADSTAT
High	Percentage of High-Skill and Technology-Intensive Export Goods	UNCTADSTAT

**Note:** \*Stata 15 and Eviews package programmes were used in this study.

## 5. Methodology

Panel data consists of several cross-sectional units (individuals, households, firms, states, and countries) observed over time (Carter Hill, Griffiths & Lim, 2011). Panel data analysis allows for modelling differences between units, revealing dynamic relationships, and using both time and cross-sectional observations. Moreover, panel data enable the generation of more observations, a greater degree of freedom, and a weakening of the linear relationship between explanatory factors, all of which improve the accuracy of econometric estimations (Taş, 2012). These factors influenced how the panel data approach was applied in the study on the link between the gross domestic product and export structure of the BRICS-T countries for 1995-2020. Several presumptions must be verified before conducting panel data analysis. First, unit root tests for each series should be run. When choosing the unit root test to be applied to the series whose stationary value will be determined, cross-section dependence is crucial. If the time dimension of the dataset is larger than the cross-sectional dimension ( $T > N$ ), the Lagrange Multiplier (LM) test developed by Breusch and Pagan (1980) can be used to analyse the cross-sectional dependency between variables. Breusch and Pagan (1980) employed the Lagrange Multiplier (LM) test statistic to determine whether cross-sectional dependence exists.

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho}^{2ij} \quad (2)$$

The symbol  $\hat{\rho}^{2ij}$  in Equation 2 represents the sample estimate of the pairwise correlation of the residuals.

The following hypotheses are evaluated to determine if there is a dependency between the cross-sections:

$H_0$ : The panel shows no cross – section dependency.

$H_1$ : The panel shows cross – section dependency.

The Swamy S test assesses whether the slope coefficients are homogenous, and the results are used to determine the causality tests. (Tatoğlu, 2020). The

parameters are homogeneous according to the test hypothesis  $H_0 = \beta_1 = \beta$ . Equation 3 shows the Swamy S test.

$$\hat{S} = X_{k(N-1)}^2 = \sum_{i=1}^N (\hat{\beta}_i - \bar{\beta})' \hat{V}_i^{-1} (\hat{\beta}_i - \bar{\beta}) \tag{3}$$

Pesaran and Yamagata (2008) extended Swamy's test as the delta ( $\Delta$ ) test. These tests' hypotheses are as follows:

- $H_0: \beta_i = \beta$  Homogeneity exists in the slope coefficients.
- $H_1: \beta_i \neq \beta_j$  Homogeneity does not exist in the slope coefficients.

Pesaran and Yamagata (2008) established the delta and adjusted delta test statistics for equations (4) and (5) to verify the hypotheses mentioned above (Pesaran and Yamagata, 2008).

$$\hat{\Delta} = \sqrt{N} \left( \frac{N^{-1} \hat{S} - k}{\sqrt{2k}} \right) \tag{4}$$

$$\hat{\Delta}_{adj} = \sqrt{N} \left( \frac{N^{-1} \hat{S} - E(\hat{Z}_{it})}{\sqrt{\text{Var}(\hat{Z}_{it})}} \right) \tag{5}$$

Pesaran (2007) provides a simple way to eliminate inter-unit correlation. He conducted a Cross-Sectionally Augmented Dickey-Fuller (CADF) unit root test by combining the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) regression with the cross-sectional averages of the lagged levels and initial differences of individual series. The Im, Pesaran and Shin (IPS) (2003) test's extended cross-section variant, known as the CIPS statistic, is the average of the CADF statistic in equations 6 or 7 (Tatoğlu, 2020).

$$\text{CIPS}(N, T) = t - \text{bar} = \frac{1}{N} \sum_{i=1}^N t_i(N, T) \tag{6}$$

$$\text{CIPS}(N, T) = N^{-1} \sum_{i=1}^N \text{CADF}_i \tag{7}$$

Panel co-integration tests in panel data analysis can be used to determine whether two nonstationary variables have a long-term relationship. Moreover,

second-generation unit root tests are used in cases with an inter-unit correlation, whereas first-generation unit root tests are used in cases without. Gengenbach, Urbain, and Westerlund (2016) developed a panel cointegration test based on error correction using a standard factor structure considering cross-unit correlation, unbalanced panels, and various lag times between units. The error correction model in equation 8 is the basis for this series' second-generation panel co-integration test (Tatoğlu, 2020):

$$\Delta_{y_i} = d\delta_{y,xi} + \alpha_{y_i}y_{i,-1} + \omega_{i,-1}\gamma_i + \vartheta_i\pi_i + \varepsilon_{y,xi} = \alpha_{y_i}y_{i,-1} + g_i^d\lambda_i + \varepsilon_{y,xi} \quad (8)$$

Hypotheses of the test:

$H_0$ : No cointegration relationship exists

$H_1$ : Cointegration relationship exists

Dumitrescu-Hurlin (2012) tests Granger causality against two opposing hypotheses.

$H_0$  = No Granger causality exists between Y and X

$H_1$  = Granger causality from Y to X exists

Dumitrescu-Hurlin (2012) developed the panel *Wald* ( $W_{N,T}^{Hnc}$ ) statistic to test these hypotheses.

$$\text{Wald} (W_{N,T}^{Hnc}) = \frac{1}{N} \sum_{i=1}^N W_{i,T} \quad (9)$$

If the cross-sectional dimension is smaller than the time dimension ( $N < T$ ), Dumitrescu-Hurlin (2012) found  $Z_{nhc}$  ( $Z_{N,T}^{Hnc}$ ) statistics with an asymptotic distribution, and  $Z_{tild}$  ( $Z_N^{Hnc}$ ) statistics with a semi-asymptotic distribution when the time dimension is smaller than cross-sectional dimension ( $N > T$ ). The following equations provide the statistical calculations for these tests.

$$(Z_{N,T}^{Hnc}) = \sqrt{\frac{N}{2K}} (W_{N,T}^{Hnc} - K) \quad (10)$$

$$(Z_N^{Hnc}) = \frac{\sqrt{N} [W_{N,T}^{Hnc} - N^{-1} \sum_{i=1}^N E(W_{i,T})]}{\sqrt{N^{-1} \sum_{i=1}^N \text{Var}(W_{i,T})}} \xrightarrow[N,T \rightarrow \infty]{d} N(0,1) \quad (11)$$

## 6. Findings

Obviously, the dataset used in this research has a time dimension ( $T=26$ ) that is larger than a cross-sectional dimension ( $N=6$ ). According to Table 2, when the Breusch-Pagan LM (1980) test results for the established model are assessed, the probability value is less than 5%. Therefore, the panel does not support the  $H_0$  hypothesis, which states no cross-sectional dependency.

**Table 2: Testing the Model's Cross-Section Dependence**

Test	Statistic
LM	32.37 *

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

Second-generation tests were used for unit root tests because the probability value was less than 5% when the test results for the variables were examined separately.

**Table 3: Testing for Cross-Sectional Dependence on Variables**

Test	Statistic
LGDP	368.7579*
Labour	286.7993*
Low	72.13110*
Medium	143.6862*
High	63.24524*

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

The next step tests parameter homogeneity using the Delta and Delta Adj. tests of Pesaran and Yamagata (2008). Because the parameters are heterogeneous, the null hypothesis  $H_0$ , which claims that the model is homogeneous, is rejected.

**Table 4: Homogeneity Test**

Test	Statistic
Delta	11.272 *
Delta adj.	12.852 *

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



Verifying the series' stationarity before conducting panel data analysis is essential. If it is determined that the variables are not stationary, their differences should be used to make them stationary. To establish the stationarity of the series in this direction, the Im, Pesaran, and Shin (CIPS) Panel Unit Root Test, a second-generation first-group panel unit root test, was applied. The findings of the unit root tests conducted on the constant and constant trend models in the Im, Pesaran, and Shin (CIPS) panel are presented in Table 5.

**Table 5: Im, Pesaran and Shin (CIPS) Panel Unit Root Test**

	Constant	Constant+Trend
LGDP	-1.698	-1.417
Labour	-1.597	-2.170
Low	-1.502	-2.286
Medium	-1.648	-2.087
High	-1.998	-2.708
$\Delta$ LGDP	-2.767*	-2.910**
$\Delta$ Labor	-4.420*	-4.579*
$\Delta$ Low	-4.800*	-5.093*
$\Delta$ Medium	-4.375*	-4.467*
$\Delta$ High	-4.071*	-4.214*

Note: \* and \*\* indicate significance at the 1% and 5% levels respectively.

When the stationarity of the series is tested for the level values of the LGDP, Labour, Low, Medium, and High variables, it can be said that the CIPS test statistics are non-stationary because they are smaller in absolute value than the critical values specified at 90%, 95%, and 99% confidence levels in the constant and constant + trend models. When the differences are considered, it becomes clear that the CIPS test statistic is stationary because its absolute value is more extensive than all the critical values in both models.

**Table 6: Gengenbach, Urbain, and Westerlund Panel Co-integration Test**

	d.y	Coef	T-bar	P-value*
Labour	y(t-1)	-0.308	-2.211	>0.1
Low	y(t-1)	-0.229	-1.425	>0.1
Medium	y(t-1)	-0.246	-1.626	>0.1
High	y(t-1)	-0.209	-1.756	>0.1

Given the panel cointegration test's significance of  $y(t-1)$  and the p-value of more than 0.1, the null hypothesis  $H_0$ -that there is no long-run link between the LGDP and the labour, low, medium, and high variables cannot be rejected. The homogeneity test result reveals that the panel is heterogeneous. Hence, a heterogeneous panel causality analysis needs to be performed. Dumitrescu and Hurlin (2012) conducted a causality test in this situation using the linear heterogeneous model. This study uses the Z-bar test statistic based on the asymptotic distribution results because the time dimension is larger than the unit dimension. As the probability value is less than 5%, the test results in Table 7 show a bidirectional causal relationship between the BRICS-T countries' exports of labour-intensive goods and the LGDP variable. Additionally, a unidirectional causality relationship is found between the LGDP variable and the Low and High variables, which reflect export goods with low and high technology.

**Table 7: Dumitrescu-Hurlin (2012) Causality Test**

	Z-bar	Z-bar Tilde
LGDP $\Rightarrow$ Labour	5.7911*	4.2998*
Labour $\Rightarrow$ LGDP	3.8195*	1.3621
LGDP $\Rightarrow$ Low	7.6655*	1.6530***
Low $\Rightarrow$ LGDP	1.3991	1.0150
LGDP $\Rightarrow$ Medium	-0.7154	-0.7488
Medium $\Rightarrow$ LGDP	-0.4837	-0.5555
LGDP $\Rightarrow$ High	7.8542*	1.7092***
High $\Rightarrow$ LGDP	0.5974	0.3463

Note: \* and \*\*\* indicate significance at the 1% and 10% levels respectively.

## 7. Conclusions and Recommendations

Various advantages exist for developing countries, including abundant natural resources, rapid population growth, cheaper labour, and great potential for profit for investors. Using these advantages, developing countries close the gap with advanced economies by increasing their exports. The technological structure of exports, which refers to the distribution of exported goods based on the intensity of factor use, such as labour-resource intensive, low, medium, or high technology, comes to the fore at this point because it is significant to the level of

macroeconomic performance. As of 2020, the BRICS nations, which comprise more than 40% of the global population and represent over 19.8% of global exports and 16% of global imports, as well as Turkey, were included in the analysis because of their common characteristics. In this study, panel data analysis is used to examine the relationship between real GDP (LGDP) and exports of goods that are labour-resource intensive, low, medium, and high skill and technology goods (Labour/Low/Medium/High) subject to the foreign trade of BRICS-T countries using data for 1995–2020. The study results show that the labour and LGDP variables have a bidirectional causal link. Moreover, it is observed that there is a unidirectional causal link between the LGDP variable and the Low and High variables, which represent export goods with low and high technology.

By considering the results of the panel analysis as a whole, the following conclusions may be drawn: i) The level of national GDP and the technological capabilities of export goods are strongly correlated. ii) An increase or decrease in the economic growth of BRICS-T countries will change the share of labour-resource-intensive export goods. iii) An increase or decrease in the labour-resource-intensive export goods of BRICS-T countries will have a similar effect on the growth of these countries. iv) Changes in the level of national income may affect total exports and accordingly determine the share of labour-resource intensive, low, and high-technology export goods.

The study's findings are consistent with studies by Kunst and Marin (1989), Henriques and Sadorsky (1996), where the export-led export approach is valid, and Awokuse (2003) and Kwan and Kwok (1995), where the growth-led export strategy is correct. Therefore, implementing policies towards high growth targets in BRICS-T countries will increase their export levels. Accordingly, implementing measures that would boost BRICS-T countries' export levels will enhance their growth performance.

The technological structure of exports from all countries, except China, is similar when the BRICS-T countries are examined. These countries' production structures are likely to be dominated by primary, resource-based, and low-tech

goods, and their infrastructure is insufficient to manufacture high-tech goods. To demonstrate stronger growth performances at this point, the BRICS-T countries must try to increase their export structure in terms of technology, sector, product, or market. In this context, they should change their production structure to a high tone with more value added. In addition to the variables included in the analysis within the scope of this study, it is worthwhile to examine the variables that affect the structure of exports by commodity or sector groups. These factors include unit labour costs and product diversity in exports, which include exporting firms or sectors and are primarily based on micro Fundamentals. Similar analyses can also be conducted for other developing countries or country groups.

---

**Ethics Committee Approval:** N/A.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Conception/Design of Study- N.D., Y.B.; Data Acquisition- N.D., Y.B.; Data Analysis/Interpretation- N.D., Y.B.; Drafting Manuscript- N.D., Y.B.; Critical Revision of Manuscript- N.D., Y.B.; Final Approval and Accountability- N.D., Y.B.

**Conflict of Interest:** The authors have no conflict of interest to declare.

**Grant Support:** The authors declared that this study has received no financial support.

---

## References

- Aditya, A. & Acharyya, R. (2013). Export diversification, composition, and economic growth: evidence from cross-country analysis, *The Journal of International Trade & Economic Development*, 22(7), 959-992.
- Akbulut Yıldız, G. & Adıyaman, G. (2021). Yüksek teknolojlili ürün ihracatının ekonomik büyüme üzerindeki etkisi: üst orta gelirli ülkeler için panel veri analizi. *Verimlilik Dergisi*, (3), 249-261.
- Altunç, Ö.F. & Aydın, C. (2015). The Relationship between export structure and economic performance: an amprical analysis for selected G-20 countries. *Uluslararası İktisadi ve İdari İncelemeler Dergisi* ,(14), 423-444.
- Awokuse, T.O. (2003). Is the export-led growth hypothesis: valid for Canada. *Canadian Journal of Economics*, 36(1), 126-136.
- Awokuse, T.O. (2007). Causality between exports, imports, and economic growth: Evidence from transition economies. *Economics Letters*, 94(3), 389-395.
- Basu, S.R. & Das, M. (2011). Export structure and economic performance in developing countries: evidence from nonparametric methodology. *United Nations Conference On Trade And Development, Policy Issues In International Trade And Commodities Study Series*, No.48.
- Belkania, D. (2020). Export structure and economic performance in transition economies. *European Research Studies Journal*, XXIII(1), 476-490.
-

- Breusch, T. & Pagan, A. (1980). The lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies*, 47(1), 239-253.
- Chychkalo-Kondratska, I., Bezrukova, N. & Svichkar, V. (2017). New "stars" of global economy: TICKS comes to replace BRICS. *Journal of International Studies*, 10(3), 24-34.
- Demir, O. (2018). Does high tech exports really matter for economic growth? a panel approach for upper middle-income economies. *AJIT-e: Online Academic Journal of Information Technology*, 9(30), 43-54.
- Dumitrescu, E. & Hurlin, C. (2012). Testing for granger non-causality in heterogeneous panels. *Economic Modelling*, 29(4), 1450-1460.
- Dünder, N. (2020). *İhracat yapısı ve makroekonomik performans arasındaki ilişki: BRICS ülkeleri ve Türkiye için parametrik olmayan bir analiz*, (Yayınlanmamış Doktora Tezi). İstanbul Üniversitesi Sosyal Bilimler Enstitüsü, İstanbul.
- Erdil Sahin, B., (2019). Impact of high technology export on economic growth: an analysis on Turkey. *Journal of Business, Economics and Finance (JBEF)*, 8(3), 165-172.
- Fosu, A. K. (1990). Export composition and the impact of exports on economic growth of developing economies. *Economics Letters*, 34(1), 67-71.
- Funke, M. & Ruhwedel, R. (2003). The export variety and economic growth in east European transition economies. *BOFIT Discussion Papers*, No.8.
- Gengenbach C., Urbain, J. & Westerlund, J. (2016). Error Correction testing in panels with common stochastic trends. *Journal of Applied Econometrics*, 31, 982-1004.
- Gertler, P. (2006). Export structure quality and economic growth. *National Economy Issues, BIATEC*, Vol XIV, 13-17.
- Gözcör, G., & Can, M. (2017). Causal linkages among the product export diversification, economic globalization and economic growth. *Review of Development Economics*, 21(3), 888-908.
- Guerson, A, Parks, J. & Torrado, M.P. (2007). Export structure and growth a detailed analysis for Argentina. *World Bank Policy Research Working Paper*, 1(4237), 1-41.
- Gylfason, T. (1997). Exports, inflation and growth. *IMF Working Paper*, WPI/119.
- Hesse, H. (2008). Export diversification and economic growth. *Commission on Growth and Development Working Paper*, No.21, 1-26.
- Henriques, I. & Sadorsky, P. (1996). Export-Led growth or growth-driven exports. the canadian case. *Canadian Journal of Economics*, 29(3), 540-555.
- Carter Hill, R., Griffiths, W.E., & Lim, G.C. (2011). *Principles of Econometrics*, 4.th Edit., John Wiley & Sons
- Hu, C. & Tan, Y. (2015). Export spillovers and export performance in China. *MPPRA Paper*, No. 67156.
- Im, K., Pesaran, M. H. & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1), 53-74
- Jarreau, J. & Poncet, S. (2012). Export sophistication and economic growth: evidence from China. *Journal of Development Economics*, 97(2), 281-292.

- Kadochnikov, S. & Fedyunina, A. (2013). Export diversification in the product space and regional growth: evidence from Russia", *Utrecht University, Section of Economic Geography*, No. 1327.
- Khan, T. I., Barua, U. & Bhuiya, I.I. (2015). BRICS Economy: an appealing investment opportunity on the international stage. *Journal for Worldwide Holistic Sustainable Development*, 1(3), 15-42.
- Kunst, R.M. & Marin, D. (1989). On exports and productivity: a causal analysis. *Review of Economics and Statistics* 71, 699-703.
- Kwan, A.C.C. & Kwok, B. (1995). Exogeneity and the export-led growth hypothesis: the case of China. *Southern Economic Journal*, 61(8), 1158-1166.
- Lall, S. (2000). The technological structure and performance of developing country manufactured exports, 1985-1998. *QEH Working Paper Series*, No.44.
- Lazarov, D. (2019). Empirical analysis of export performance and economic growth: the case of Macedonia, *International Journal of Trade and Global Markets*. 12(3-4), 381-393.
- Lee, J. (2011). Export specialization and economic growth around the world. *Economic Systems*. 35(1), 45-63.
- Mayer, J. & Wood, A. (2001). South Asia's export structure in a comparative perspective. *Oxford Development Studies*, 29(1), 5-29.
- O'Neill, J. (2001). Building better global economic BRICs. *Global Economics Paper*, No:66.
- Pesaran, M.H. & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, 142(1), 50-93.
- Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross section dependence. *Journal of Applied Econometrics*, 22(2), 265-312.
- Sun, P. & Heshmati, A. (2010). International trade and its effects on economic growth in China. *IZA Discussion Paper*, No.5151.
- Tatođlu, F. Y. (2020), *Panel Zaman Serileri Analizi*, 3.Baskı, İstanbul: Beta Yayıncılık.
- Taş, N. (2012). *Ekonomik değişkenlerin panel veri analizi ile çözümlenmesi*. (Yayınlanmamış Doktora Tezi). İstanbul Üniversitesi Sosyal