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E-mail: eab@mail.ege.edu.tr

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Volume 24 • Number 1 • January 2024

Cilt 24 • Sayı 1 • Ocak 2024

Contents

EGE AKADEMİK BAKIŞ / *EGE ACADEMIC REVIEW*

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The Significance of Participation in the Global Production Network to Economic Development: An Econometric Analysis of BRICS+T Countries

Şahin NAS[1], Seyit Ali MİÇOOĞULLARI[2], Maya MOALLA[3]

ABSTRACT

With globalization, the international fragmentation of production (IFP) splits the production process of final goods and services into several stages undertaken in different countries integrated into global production networks. BRICS + T countries have rapidly participated in the (IFP) process, especially after the 2000s. The main purpose of this paper is to analyze the nexus between BRICS+T countries' participation in the global production networks and their economic development. As an indicator of this participation, the vertical specialization rate had been calculated utilizing OECD Input-Output Tables. Subsequently, the development index was calculated utilizing economic-technological and cultural-institutional indicators published by World Bank. The vertical specialization's impact on development was estimated utilizing the CS-ARDL estimator. The results revealed that while vertical specialization has a statistically significant positive impact on development in the short term, a positive but not statistically significant impact was recorded in the long term. Konya's (2006) causality test was performed to examine the causal relationship among the selected variables. The results revealed a one-way causality from development to vertical specialization in China and Turkey and a one-way causality from vertical specialization to development in Brazil. No causality relationship could be detected in other countries included in the analysis.

Keywords: Economic Development, Vertical Specialization, Globalization, Input-Output Models, BRICS+T, CS-ARDL.

JEL Classification Codes: C01, C67, F02, F63, F60

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INTRODUCTION

Globalization has led to the free movement, transfer and flow of increasingly integrated goods, services, production factors, technological accumulation and financial resources among countries. It can be defined as the articulation of national economies with the world markets (Şenses, 2004; Şubaşat, 2004; Şenses, 2009; Yeldan, 2016). The development trends in the world economy are characterized by the rapid augmentation of globalization, especially after 1980 (Şenses, 2004: Şenses: 2009: Rodrik 2011: Yeldan, 2016). Along with the globalization trends, an important loss of development policies had been experienced in the world economy during the post-1980 period. However, during the pre-1980 period, development and industrial policies come to the forefront, especially in developing countries. The interpretation of such policies may be that the developing countries that attained their independence after World War II sought to close the growing gap with the developed ones (Keyder, 2004). The developed countries are characterized by self-sustaining growth, structural change in production, technological innovation, social, political and institutional innovation, and improving people's living conditions (Myrdal, 1974). In the aftermath of 1980, the world economy has undergone major changes such as replacing the policies of import substitution and inward-looking industrialization and development strategies, that had been applied during the period from 1945 to 1970, with those of outward growth and liberalization (Şenses, 2004: Şenses: 2009: Rodrik 2011: Yeldan, 2016). Furthermore, developments in international trade had been experienced in the post-1980 period. Moreover, international trade has grown faster than income and global production in the post-1980 period compared with the previous one (Tekin-Koru, 2020). According to Tekin-Koru (2020: 55), the ratio of international trade to the gross world product has doubled since the liberalization of international trade after 1980. One of the most significant economic reasons for international trade growth and development is the decrease in the costs of information and communication technologies, transportation, and trade during that

[1] Şırnak University, Faculty of Economics and Administrative Sciences, Department of Management Information Systems, snas@sirnak.edu.tr

[2] Kilis 7 Aralık University, Vocational School of Social Sciences, Department of Foreign Trade, s.alimicoogullari@kilis.edu.tr

[3] Mersin/Turkey, mayamoalla@hotmail.com

period. This matter led to fragmenting the production of goods and services between countries vertically and increasing firms' participation in the global value chains and global production networks (Tekin-Koru, 2020). Similar to Tekin-Koru (2020), Amador and Cabral (2009; 2016) stated that international trade experienced fairly strong growth and underwent major changes in the post-1980 period. Trade integration into the world economy has encouraged companies to develop new production strategies. The companies' new production strategies include benefiting from the internal local advantages such as low labor cost and proximity to the market and fragmentation of the production of goods and services into two or more stages that can be performed in different countries (Clark, 2010; Hess & Yeung, 2006). Bialowas and Budzynska (2022) also emphasized that the international fragmentation of the production process is one of the most significant trends in the modern world economy. Therefore, international trade is referred to as the multiple cross-border goods flow process which increasingly depends on the exchange and intermediate input goods rather than the production of final goods and services (Bialowas and Budzynska, 2022). Thus, economic globalization has recently been characterized by the fragmentation of international production. Fragmentation of the production process relates every country or every region to the world economy (Duan et al., 2018; Greffi and Wu, 2020; Antràs, 2020). Thus, an organization that produces goods and services across multiple geographical locations for worldwide markets emerges, and accordingly, a global production network is formed within the global economy (Coe & Yeung, 2015). The international fragmentation process of production or global production network (Coe, Dicken & Hess, 2008; Yeung, 2015) is associated with trade in intermediate inputs across borders and integration of the imported intermediate inputs with export-oriented production (Greffi, 2015). Similarly, the global production network is a network process in which the production, distribution and consumption of goods and services become interconnected with the global economy, and this framework allows for geographical variation in producer-consumer affairs (Henderson et al., 2002). Global production networks, that emerged and rapidly expanded after 1980, not only integrate global production into structures that blur traditional organizational barriers but also integrate national economies (or parts of such economies) in ways that have immense implications for national development (Dicken & Hassler, 2000). The matter connects countries or regions through commercial interdependence (Amador and Cabral, 2009). Greffi (2015) argues that some countries, in particular emerging market economies, play a significant role in the international fragmentation of production. With this respect, the main motivation of this paper is to investigate the extent to which countries' participation in the global production network affects their development. Hence, the research question of this paper is investigating the nexus between the participation of BRICS (Brazil, Russia, India, China, and South Africa) and Turkey in the process of fragmentation of international production and the development of these countries, especially after the important role they played in the world trade (Greffi, 2005) with the acceleration of globalization since the 2000s. To achieve our goal, the BRICS and Turkey's vertical specialization rate, which measures the rate of participation in the international production process, had been calculated utilizing OECD Input-Output Tables. Subsequently, the development of these countries had been calculated using various economic-technological indicators (industrialization, life expectancy and total patent applications) and cultural-institutional indicators (control of corruption, government effectiveness, political stability and absence of terrorism, regulatory quality, rule of law and accountability). An econometric analysis of panel data had been utilized to investigate the impact of vertical specialization on BRICS+T countries' development during the period of 1995-2018. The method of obtaining the data employed in the empirical analysis can make a significant contribution to the development of the literature. In another aspect, the study is expected to contribute to the literature by providing an econometric analysis of the nexus between countries' development and their participation in the global production network. To the best of our knowledge, the literature on global production networks generally analyzes the positions of countries in global production networks and to what extent they participate in these networks. This paper not only estimates the participation of BRICS+T countries in global production networks but also sheds light on how these countries' participation in global production networks affects their development. This research also provides the historical development of the dependent variable means economic development. Furthermore, the HIY method proposed by Hummels, Ishii & Yii (1998; 2011) had been applied to I-O tables to calculate the explanatory variable means vertical specialization. This paper is made up of four sections. The first section includes the introductory part. In the second section literature review is structured. The third section includes data, methodology and findings. The fourth section is about evaluating the results and conclusion.

LITERATURE REVIEW

The acceleration of the process of liberalization and globalization in the post-1980 period has been accompanied by significant changes in the structure and nature of international trade characterized intrinsically by the international fragmentation of production. In this sense, one of the most striking features of the post-1980 period is the geographic and organizational fragmentation of the production of goods and services. The most important reason for this is the search for not only capital but also cheap labor, especially by transnational companies. By developing their employability skills and new resources, companies continue to finance their activities and gain competitive power. (Coe et al., 2010; Coe & Hess, 2013; Neilson, Pritchard & Yeung, 2014). The process that started after 1980 gained an important dimension in the 1990s. In the 1990s, global production was further fragmented and spread over a wider geography. From this period onwards, global production networks have become an important determinant of the world economy (Coe & Yeung, 2015; Hess & Yeung, 2006; Yeung & Coe, 2015). Other important factors that accelerated and expanded globalization and global production networks were digitalization, e-commerce, and information and communication technologies. These factors have become natural elements of global production networks (Coe & Yeung, 2019; Henderson et al., 2002). Dicken & Hassler (2000) state that Indonesian performance in long-term global production networks slightly improves production. At the same time, they state that global production networks have a positive effect, especially on knowledge and technology acquisition. However, despite these positive features, Dicken & Hassler (2000) state that global production networks create negative effects in times of crisis, thus, Indonesian ready-made garment manufacturers have become increasingly dependent on US and European markets. Therefore, Dicken & Hassler (2000) and Henderson et al., (2002) argue that longer-term position within global production networks depends on developing an even stronger and deeper production base of technology and skills. Coe, Lai & Wójcik (2014) state that global production networks are managed by firms rather than official institutions. However, companies that are included in this network are at risk of being affected by foreign currency, interest rates, and contracts. According to the authors, this situation aggravates the negative effects of financialization. Coe, Lai & Wójcik (2014) and Coe et al. (2010) argue that global production networks can cause income inequality between regions. Neilson, Pritchard & Yeung (2014) and Coe & Yeung (2015) emphasize that after the 1980s, global production networks become more intense, especially in sectors such as clothing, electronics, consumer goods, and automotive assembly. The authors state that developed countries (especially the USA) shift their production in these sectors to lower-cost developing countries. In this sense, similar to Coe, Lai & Wójcik (2014), Nelison, Pritchard & Yeung (2014) argue that global production networks manufacture global debt and imbalance conditions. Likewise, Yeung (2014) and Coe et al. (2010) state that the leading firms in developed countries make the firms of developing countries dependent on them through global production networks, and the interests of these companies may not be fully consistent with national development. In other words, local firms act in the interests of multinational firms. However, Yeung (2014) argues that participation in the global production network leads East Asian countries to achieve significant gains, especially in the field of ICT. The rapid rise in the global economy seen not only in the rise of China and Asian tiger economies but also in Brazil and India associated with the new forms of state involvement, most notably China's tentacular Belt and Road Initiative have created strong geographical shifts in terms of production (Coe & Yeung, 2019). Despite the gains that had been achieved from the global production networks, Yeung (2021) related socioeconomic inequalities to global production networks. After explaining the development and effects of the global production networks, their emergence can be summarized as follows: The international fragmentation of production occurs when the production process of a particular good or service is fragmented into two or more stages that can be performed in different countries or regions. Put differently, each country specializes in a different stage of the production process of a good or service. Such transformation in international trade creates a strong economic dependency between the countries specialized in different stages of the production process (Henderson et al., 2002; Hummels, Ishii & Yi, 2001; Alexander, 2012). The interpretation of such economic dependency entails utilizing the imported intermediate inputs to produce goods and services and then exporting the obtained final products to the countries specialized in any stage of the production process of those goods and services. This gradual process continues until the produced goods and services reach the final consumer. In the literature, this gradual production process that takes place in international trade is defined as vertical specialization (Coe & Yeung, 2015; Hummels, Ishii & Yii, 1998; Hummels, Ishii & Yii, 2001; Lamonica, Salvati &

Carlucci, 2020). Hummels, Ishii & Yi (1998; 2001) stated that three conditions must be held for vertical specialization to occur: firstly, a certain good should pass through two or more sequential stages. Secondly, two or more countries must provide value-added to the production process of that good. Finally, at least one country should use imported intermediate inputs in the production process and export some of the output (Chen, Kondratowicz & Yi, 2005; Dağıstan, 2009). In general, input-output tables are used to measure vertical specialization in the literature (Duan, et al., 2018). The works of Hummels, Ishii & Yi (1998; 2001) became the pioneering research that calculated vertical specialization rates utilizing input-output tables. In their work, the authors emphasized that global trade became increasingly integrated and economically interdependent. They revealed that vertical specialization increased significantly in Europe and East Asia during the period from 1968 to 1990. Similar to the conclusions obtained by Hummels, Ishii & Yi (1998; 2001), Chen, Kondratowicz & Yi (2005) also stated that the world's vertical specialization showed an increasing trend during the period from 1968 to 1998. Their results revealed that the vertical specialization rate was higher in small countries such as Denmark and the Netherlands compared with the large ones such as the USA, Japan, and Australia. Examining a similar period (1967-2005) to the aforementioned three studies, Amador and Cabral (2009) concluded that vertical specialization had generally increased in the world. Moreover, their results revealed that vertical specialization was higher in Asian countries. Dean, Fung & Wang (2011) and Yang et al. (2011) argued that the participation of the Chinese economy in global production activities has increased continuously in the 2000s. Along with China, Yang et al. (2015) stated that vertical specialization increased drastically in the world during the period from 1995 to 2005. Amador, Cappariello and Stehrer (2015) postulated that the Eurozone owes much of its economic weight to the global value chains. They revealed that its vertical specialization has increased significantly, except for the 2009 crisis period. Solaz (2018) demonstrated that during the period from 1995 to 2011, vertical specialization has generally increased worldwide except for Russia and Canada. Yu and Luo (2018) concluded that vertical specialization had increased in countries worldwide world including Canada and Russia. Their results revealed that the country with the lowest vertical specialization was Brazil but that with the highest one was South Korea. Furthermore, they claimed that the manufacturing industry's vertical specialization was higher than the total economy's one. Yin and Liu (2019) argued that vertical specialization had increased in high-tech sectors in China during the period from 1992 to 2009. They demonstrated that the vertical specialization rate in these sectors was higher than that in the medium- and low-tech sectors. Pahl and Timmer (2019) analyzed a large group of countries and revealed that participation in global production networks had rapidly increased during the period from 1970 to 2013 and especially after 1980. Constantinescu, Mattoo & Ruta (2019) revealed that vertical specialization across the world had increased till the 2000s. Although the vertical specialization rate decreased after 2000, it showed an increasing trend until the 2009 global financial crisis. Constantinescu, Mattoo & Ruta (2019) argued that till 2000 the vertical specialization rate in the manufacturing industry was below that of the total economy, but it exceeded the total vertical specialization rate after 2000. Similar to Pahl and Timmer (2019), Pedilla et al. (2019) also stated that vertical specialization in the world economy follows a continuously increasing trend. Lamonica, Salvati & Carlucci (2020) utilized the WIOD to calculate the vertical specialization covering 40 countries during the period from 1995 to 2011. The results revealed that during the period from 1995 to 2011, the vertical specialization remained stable in Bulgaria, Cyprus, and Indonesia. Moreover, it decreased in Canada, Estonia, Malta, Portugal and Russia. In general, the world economy has become more dependent in the post-1980 period and this process has accelerated especially after the 2000s. With this respect, Xiao et al. (2020) emphasized that the fragmentation process of production changed the nature of international trade. They argued that almost more than two-thirds of today's world trade crosses the border of at least one country before production takes its final form and this process takes place through the global production networks. Literature review showed that participation in global production networks has increased in the world economy in the post-1980 period and especially after the 2000s. The policies that had been applied after 1945 such as import-substitution, inward-looking and industrialization strategies had been replaced with outward, export-oriented strategies and integration into global production the matter which increased the interdependence between countries. Chang (2016) and Chang and Grabel (2016) defined the period of 1945-1975 as the world's golden age, especially for the developing countries which implemented intensive industrialization, import substitution and inward-looking policies the matter that played a significant role in achieving economic growth. It had been argued that open and outward-oriented policies became the engine of economic growth and development in the post-1980 period. Gereffi (2015) argues that participation in global production networks is significant for economic development. According to Gereffi (2015), joining global production networks increases investments in connecting (either constructing or developing) economies' physical infrastructures such as seaports, canals, airports, roads and information and communication technologies. Olczyk and Kordalska (2017) and Goldar et al. (2020) provide empirical evidence that export performance has been positively affected by vertical specialization and thus the inclusion in global value chains drives export growth. Participation in global production networks increases productivity (Constantinescu, Matooo & Ruta, 2019) and affects foreign direct investment positively (Martinez-Galan and Fontoura, 2019). Moreover, Pahl and Timmer (2020) affirmed that participation in global production networks affects firm productivity strongly and positively but does not affect job creation positively. They revealed that it affects productivity positively in developing countries. Furthermore, participation in global production networks stimulates economic growth (Jangam and Rath, 2021) and positively affects total factor productivity and firm productivity in the manufacturing industry (Banga, 2021). Orhangazi (2020) states that in the global value chain system, the developed countries specialize in stages that require higher technology due to their qualified workforce and capital structures, on the contrary, the developing countries specialize in labor-intensive and low-tech stages of the production process and, in such manner, a significant portion of the produced value flows to developed countries. Orhangazi (2020) emphasizes that the income gap between developed and developing countries will keep widening even if the developing countries make progress thanks to their global value chains. Put differently, a disparity among countries in the levels of economic development will occur as the level of vertical specialization increases in the long run. However, the capacity to produce and export is increasingly dependent on imports. Similar to Orhangazi (2020), Bakır et al. (2017) emphasize that the global value chains constitute a dual structure of "centralized economies" and "factory economies". In the process of fragmentation of international production, a significant portion of the produced value flows to the "centralized economies" since these economies specialized in industrial production that requires qualified labor and high technology; however, the labor-intensive and low-tech industrial production is transferred to the "factory economies". Accordingly, the "factory economies" cannot close the welfare gap with the "centralized economies". Moreover, Wigley, Mıhcı & Ataç (2018) emphasize that income inequality may increase and the countries may be more sensitive to external shocks in the early stages of integration with the global production network. In general, the literature analyzes the degree of countries' participation in the global production networks, that is, the vertical specialization rate and the direction of participation in the global value chains. With this respect, there are some studies, albeit limited, on the analysis of the extent to which the countries' participation in the global production network affects the macroeconomic indicators such as Olczyk and Kordalska (2017); Goldar et al. (2020); Constantinescu, Matooo & Ruta (2019); Martinez-Galan and Fontoura (2019); Pahl and Timmer (2020); Jangam and Rath (2021) and Banga (2021). It is expected that this work will significantly contribute to the literature since it investigates the effect of vertical specialization on development econometrically.

DATA AND METHODOLOGY

In this research, we tried to investigate the dynamic relationships between economic development and vertical specialization in BRICS-T Countries utilizing annual panel data for the period from 1995 to 2018. Unlike the literature, the dependent variable means the economic development variable had been represented by an index reconstructed by the PCA method (Principal Component Analysis) utilizing 10 different variables. The explanatory variable means the vertical specialization ratio had been calculated utilizing the method of input-output analysis. The fixed capital formation had also been included in the model as a control variable. Institutional quality variables included in the Development Index were obtained from the World Governance Indicators (WGI) published by the World Bank. The sub-data had been obtained from the World Development Indicator (WDI) published by the World Bank. The explanatory variable means the vertical specialization rate was calculated utilizing the OECD input-output tables. The control variable means the fixed capital formation variable was obtained from the World Development Indicator (WDI) published by the World Bank. The structured model is shown in equation (1):

$$DI_{i,t} = \beta_0 + \beta_1 VS_{i,t} + \beta_2 FC_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where DI denotes the development index; VS denotes the vertical specialization rate; FC denotes the fixed capital formation. represents the constant, and represent coefficients of the independent factors. The subscripts i and t represent the horizontal section of countries and the time dimension, respectively. The method used to obtain the data in the empirical analysis of this study will significantly contribute to the development of the literature. Moreover, the historical development of the dependent variable means the economic development DI has been taken into consideration. Furthermore, the explanatory variable means the vertical specialization rate VS was calculated by applying the HIY method proposed by Hummels, Ishii & Yii (1998; 2011) to I-O tables. Let's define the variables we will be working with.

Development Index (DI)

Although the concept of economic growth is used interchangeably with that of economic development, these two concepts are very different. According to the Human Development Report (1996), economic growth is one of the important components of economic development which is the ultimate goal of any economy. Economic growth refers to an increase in the production of goods and services in an economy. Economic development seeks to increase the individuals' life quality in the fields of socioeconomic, cultural, legal and political fields along with providing economic growth (World Development Report, 2013). Therefore, the development indicator cannot be reduced to a single variable and/or parameter. Godo (2005) discusses the concept of development by analyzing the dependency relationship between the cultural and economic subsystems. Whereas the cultural subsystem includes the value judgments and the institutions; the economic one includes technology and production factors. In this research, both the World Development Report's definition of development as the indicator that increases the individuals' life quality, as well as the development of multidimensionality shown in Godo's (2005) study, are taken into consideration. Table (1) represents information about the variables of the DI created by the PCA method. The Indicators of the Development Index in Table 1 indicate that development in this study does not depend solely on economic growth. It encompasses a perspective ranging from concepts including technology, productivity, and production to concepts of sociocultural and institutional quality, and including growth.

Vertical Specialization Rate

The vertical specialization rate in BRICS+T Countries was calculated by applying the HIY method proposed by Hummels, Ishii & Yii (1998; 2011) to I-O tables. The vertical specialization rate shows the extent to which the studied countries participate in the global production process. In short, vertical specialization denotes the rate of imported intermediate goods and services produced for export. Such a rate represents the degree of countries' participation in the global production networks. The main motivation of the work is to investigate how the countries' participation in the global production network affects the development of these countries. To achieve our goal, the vertical specialization rate had been calculated for BRICS+T Countries. The OECD input-output tables of these countries were employed to calculate the vertical specialization rate during the period from 1995 to 2018[1].

Horizontal Section Dependence-Slope Homogeneity

The horizontal section dependence test is critical in the empirical panel data research of countries that have similar economic characteristics such as developing, emerging, and transition ones. An economy is vulnerable to other countries' shocks stemming from the internationalization of trade, financial integration and globalization. Thus, cross-section dependence analysis is required in empirical panel data research. The standard panel data methods assume that there is no dependence between cross-section units and assume that the slope coefficients are homogeneous. Ignoring the cross-section dependency may lead to incorrect inferences (Chudik and Pesaran, 2013). The estimated coefficients may differ between cross-section units. For this reason, the pre-tests of cross-sectional dependence and slope homogeneity will be conducted in the empirical analysis. As a first step, the Pesaran (2004) CDLM and the biased adjusted LM test (Pesaran et al., 2008) were applied. These methods are valid when N>T and T>N. The statistics of these tests are as follows:

$$CD_{LM} = \sqrt{\frac{N}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\,\hat{\rho}_{ij}^{\,2} - 1) \qquad (2)$$

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \frac{(T-k)\hat{\rho}_{ij}^{\,2} - \mu_{Tij}}{v_{Tij}} \qquad (3)$$

Equation 3 and 4, represents the statistical equations of the Pesaran (2004) CDLM and the biased adjusted LM test (Pesaran et al., 2008) respectively. The term $\hat{\rho}_{ij}$ denotes the correlation between cross-sectional units, the term μ_{Tij} denotes the cross-sectional averages and the term V_{Tij} denotes the variance. For both tests, the null and the alternative hypotheses are as follows:

H_0: There is no horizontal section dependence.

H_1: There is a horizontal section dependence.

[1] The calculation method of the vertical specialization rate is given in Appendix-1

Table 1. Indicators of Development Index

	Indicator Name	Explanation	Source
Economic-Technological Indicators	Industrialization	Industry (including construction), value added (% of GDP)	World Bank-World Development Indicators
	Life Expectancy	It shows the number of years a newborn is expected to live if the mortality patterns at the time of its birth remain constant in the future.	
	Per Capita Income	GDP per capita is based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates.	
	Total Patent Applications	Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office.	
Cultural-Institutional Indicators	Control of Corruption	Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	World Bank-Worldwide Governance Indicators
	Government Effectiveness	Government Effectiveness captures perceptions of the quality of public services, and the degree of its independence from political pressures.	
	Political Stability and Absence of Terrorism	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	
	Regulatory Quality	Regulatory quality measures the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	
	Rule of Law	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	
	Accountability	Accountability captures perceptions of the extent to which a country's citizens can participate in selecting their government, as well as freedom of expression, freedom of association, and free media.	

Note: World Bank-World Development Indicators and Governance Indicators https://databank.worldbank.org/source/world-development-indicators# and https://databank.worldbank.org/source/worldwide-governance-indicators respectively obtained from the links.

The homogeneity test is to determine whether a change in one country causes a change in the other countries covered by the panel analysis. Therefore, the countries' economic status is significant. The issue of data homogeneity concerns the shape of the unit root tests to be applied. With this respect, to test the homogeneity/heterogeneity, the Delta test developed by Pesaran and Yamataga (2008) was applied. The hypothesis is as follows

$$H_0: \beta_i = \beta$$

$$H_1: \beta_i \neq \beta$$

The rejection of the null hypothesis indicates the heterogeneity of the slope coefficients. To examine the stability of the data series, the Cross-sectionally Augmented Dickey-Fuller unit root test (CADF) had been applied.

Unit Root Test

It is important to test the stationary of the data series in the econometric analysis to avoid spurious regression results. There are many generations of unit root tests in the literature. Based on the sample size and the power of the test; each unit root test has some advantages and disadvantages (Narayan and Narayan, 2010). Moreover, the existence of the cross-sectional dependency in the panel determines the unit root test to be applied. Since there is a piece of evidence suggesting the presence of cross-sectional dependence between units in the BRICS-T panel; the second generation of the unit root tests that take the cross-sectional dependency into account were utilized. With this respect, the Cross-sectionally Augmented Dickey-Fuller unit root test (CADF) developed by Pesaran (2007) had been applied. It is calculated as follows:

$$\Delta y_i = a_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + \sum_{j=0}^{p} d_{ij}\, \Delta\bar{y}_{t-j} + \sum_{j=1}^{p} \delta_{ij} \Delta\, y_{i,t-j} + e_{i,t} \quad (5)$$

Where; denotes the mean of all N sections at time T. CADF test are used to determine the stationarity of the series of each cross-section, but not the stationarity of the entire panel data. To determine the stationarity of the whole panel, the arithmetic mean of the CADF t statistics had been calculated for each horizontal cross-section. The calculated arithmetic mean represents the statistic of the CIPS (Cross-Sectionally Augmented IPS (CIPS)). The CIPS statistic is computed as follows:

$$CIPS = N^{-1} \sum_{i=1}^{N} CADF \quad (6)$$

The statistics of CADF and CIPS tests obtained utilizing equation 5 and equation 6 had been compared with the values in the study of Pesaran (2007) to decide whether to reject the null hypothesis stating that the series has a unit root or not. If the absolute value of the test statistic is greater than the critical value, then we reject the null hypothesis and conclude that the series does not have a unit root, meaning it is stationary.

Coefficient Estimation: The CS-ARDL Model

In this research, the cross-sectionally augmented autoregressive distributed lag (CS-ARDL) model developed by Chudik and Pesaran (2015) was used to estimate the long and short-run coefficients. The main advantage of the CS-ARDL estimator is that it does not interfere with the consistency of the estimations even if the series are cointegrated and stationary at different levels. Moreover, since the Common Correlated Effects (CCE) approach is implemented in the context of the panel ARDL version means that it is based on the lagged dependent variable and the lagged cross-sectional mean, it considers the cross-sectional dependence (Chudik & Pesaran, 2015). Furthermore, it allows mean group estimations with heterogeneous slope coefficients. The mean-group version of the CS-ARDL model is based on increasing the ARDL estimates of each cross-section with the cross-section means as representative of unobserved common factors and their lags (Chudik et al., 2017). This technique also performs well for the weak externality problem stemming from including the lagged dependent variable in the model. The CS-ARDL estimation is based on the following regression model:

$$y_{it} = \alpha_i + \sum_{l=1}^{p_y} \lambda_{l,i}\, y_{i,t-1} + \sum_{l=0}^{p_x} \beta_{l,i}\, x_{i,t-1} \sum_{l=0}^{p_\varphi} \varphi'_{i,l}\, \bar{z}_{i,t-1} + \varepsilon_{i,t} \quad (7)$$

Where; denotes the lags of the horizontal cross-sectional averages. The following equation is used in the long-run coefficient estimation for the mean group estimation:

$$\hat{\theta}_{CS-ARDL,i} = \frac{\sum_{l=0}^{p_x} \hat{\beta}_{l,i}}{1-\sum_{l=1}^{p_y} \hat{\lambda}_{l,i}}\ , \hat{\theta}_{MG} = {}^{1}/_{N} \sum_{i=1}^{N} \hat{\theta}_i \quad (8)$$

Where; $\hat{\theta}_i$ denotes the predictions for each cross-section. Chudik and Pesaran (2013) suggested that the CCE group mean estimator, with lagged increases, performs well in terms of bias, size, and power. However, the authors observed a negative bias when T<50. To correct for small sample time series bias, Chudik and Pesaran (2015) suggested the recursive mean adjustment (REC) of So and Shin (1999) or the split-panel jackknife of Dhaene and Jochmans (2015). The REC method was preferred in this paper because it gave more consistent results. The REC method is based on the following equations:

$$\hat{y}_{i,t} = y_{i,t} - \frac{1}{t-1} \sum_{s=1}^{t-1} y_{i,s} \quad (9)$$

$$\widetilde{\omega}_{i,t} = \omega_{i,t} - \frac{1}{t-1} \sum_{s=1}^{t-1} \omega_{i,s};\ \omega_{i,t} = (x'_{i,t}, g'_{i,t})' \quad (10)$$

Where $\hat{y}_{i,t}$ and $\widetilde{\omega}_{i,t}$ denote the mean group estimate of the first and second half of the sample, respectively.

The time dimension of this study is 24 (T<50). Therefore, the results of bias correction with the REC method of CS-ARDL estimation will also be reported. After estimating the CS-ARDL model, panel causality analysis was carried out to analyze the long-run causality relationships.

Bootstrap Panel Granger Causality Analysis

The analysis in this work follows the Bootstrap Panel Granger Causality Analysis proposed by Konya (2006). This method considers the seemingly unrelated regression (SUR) model which avoids the problem of cross-sectional dependence. Moreover, this method does not require pre-testing for unit roots and cointegration (Konya 2006; Kar et al, 2011). Konya's (2006) bootstrap panel causality analysis is based on the estimation of the following systems of equations:

$$\mathrm{DI}_{1t} = \alpha_{11} + \sum_{l=1}^{p_1} \lambda_{11l}\mathrm{DI}_{1t-1} + \sum_{l=1}^{p_1} \beta_{11l}\mathrm{VS}_{Nt-1} + \varepsilon_{11t}$$
$$\mathrm{DI}_{1t} = \alpha_{11} + \sum_{l=1}^{p_1} \lambda_{1Nl}\mathrm{DI}_{Nt-1} + \sum_{l=1}^{p_1} \beta_{1Nl}\mathrm{VS}_{Nt-1} + \varepsilon_{1Nt} \quad (10)$$

$$\mathrm{DI}_{1t} = \alpha_{11} + \sum_{l=1}^{p_1} \lambda_{11l}\mathrm{DI}_{1t-1} + \sum_{l=1}^{p_1} \beta_{11l}\mathrm{FC}_{Nt-1} + \varepsilon_{11t}$$
$$DI_{1t} = \alpha_{11} + \sum_{l=1}^{p_1} \lambda_{1Nl}DI_{Nt-1} + \sum_{l=1}^{p_1} \beta_{1Nl}FC_{Nt-1} + \varepsilon_{1Nt} \quad (11)$$

$$VS_{1t} = \alpha_{11} + \sum_{l=1}^{p_1} \lambda_{11l}VS_{1t-1} + \sum_{l=1}^{p_1} \beta_{11l}DI_{Nt-1} + \varepsilon_{11t}$$
$$VS_{1t} = \alpha_{11} + \sum_{l=1}^{p_1} \lambda_{1Nl}VS_{Nt-1} + \sum_{l=1}^{p_1} \beta_{1Nl}DI_{Nt-1} + \varepsilon_{1Nt} \quad (12)$$

$$FC_{1t} = \alpha_{11} + \sum_{l=1}^{p_1} \lambda_{11l}FC_{1t-1} + \sum_{l=1}^{p_1} \beta_{11l}DI_{Nt-1} + \varepsilon_{11t}$$
$$FC_{1t} = \alpha_{11} + \sum_{l=1}^{p_1} \lambda_{1Nl}FC_{Nt-1} + \sum_{l=1}^{p_1} \beta_{1Nl}DI_{Nt-1} + \varepsilon_{1Nt} \quad (13)$$

Where N denotes the number of cross sections (i=1,… ,N); t denotes the period (t=1,…,T) and *l* denotes the length of the delay. If the calculated country-specific Wald test statistics exceed the bootstrap critical value, then the null hypothesis of no causality will be rejected. Since the estimations conducted by this method are specific to a single cross-section, means a single country, it allows for heterogeneous slope coefficients.

Empirical Findings

Within the scope of the empirical model, both cross-sectional dependence and homogeneity are considered to obtain consistent estimates. The results of the CDLM test (Pesaran, 2004), Bias Adjusted LM tests (Pesaran et al, 2008) and the Delta test (Pesaran and Yamagata, 2008) are given in table 2.

studied panel data model. In the analytical process, the econometric techniques that are vigorous to cross-sectional dependence and slope heterogeneity were employed. The results of investigating the stationarity properties of the variables utilizing the CIPS Panel unit root test are given in table (3). Moreover, the results of applying the unit root at the level and first difference taking the constant and the constant plus trend are reported in the table (3).

The DI variable is stationary at the first difference considering both constant and constant-trend models at the 5% significance level. The level value of the VS variable is stationary considering both constant and constant-trend models at a 5% significance level. The FC variable is stationary at the first difference considering the constant model at a significance level of 1% and stationary considering the constant-trend model at a significance level of 10%. To summarise, DI, VS and FC are stationary at I(1), I(0) and I(1) levels, respectively. According to the CS-ARDL approach, the stationarity levels of the variables being I(0) or I(1) do not pose a problem for the next step of the analysis.

The CS-ARDL approach was utilized to calculate the values of long- and short-run coefficients. The CS-ARDL approach handles the issues of cross-sectional dependence and different degrees of stationarity. The CS-ARDL mean group estimator was employed to obtain

Table 2. The Results of Cross Section Dependence and Homogeneity Test

Test	Statistics	Prob.
CD_{LM}	5.865***	0.000
LM_{adj}	5.884***	0.000
$\tilde{\Delta}$	6.399***	0.000
$\tilde{\Delta}_{adj}$	6.982***	0.000

*** denotes that the null hypothesis is rejected at the 1% level.

Table 3. Results of CIPS Panel Unit Root Test

	Level		**First Difference**		**Result**
	Constant	**Constant -Trend**	**Constant**	**Constant -Trend**	
DI	-0.362	-0.830	-2.216**	-2.964**	*I(1)*
VS	-2.473**	-2.898**	-	-	*I(0)*
FC	-1.530	-1.199	-2.710***	-2.820*	*I(1)*

Note: ***, ** and * denote that the null hypothesis is rejected at the 1%,%5 and %10 levels respectively. Constant model's critical values (Pesaran, 2007: 280): %1: -2.60, %5: -2.34, %10: -2.21. Constant plus trend model's critical values (Pesaran, 2007:281): %1: -3.15, %5: -2.88, %10: -2.74. The maximum lag length has been determined according to SIC and the maximum lag length is 3.

Table 4. The results of CS-ARDL

KE = *f* (DUO, SSO)					
	CS-ARDL (2,3,2)			*CS-ARDL$_{REC}$* (2,3,2)	
	Coefficient	t-Statistics		Coefficient	t-Statistics
Short-run					
ΔDI_{t-1}	-0.265*	-1.69		-0.451***	-3.41
ΔVS	1.066	1.26		1.249**	1.94
ΔFC	0.933**	2.24		1.270***	2.56
Long-run					
VS	0.409	0.39		0.095	0.14
FC	0.460*	1.68		0.485**	2.69
Error-correction	-0.823	-5.02***		-0.693	-7.90***
F Stat.		5.28***			4.09***
Adjusted R-squared		0.82			0.79

Note: ***,** and * denote that the null hypothesis is rejected at the 1%,%5 and %10 levels respectively.

the country-specific coefficients on the horizontal cross-section. The optimum lag structure was determined by the F-test methodology of general-to-specific. Moreover, the recursive mean adjustment (REC) developed by So and Shin (1999) was employed to correct for small sample time series bias. The results are summarized in Table 4.

The results revealed that according to the short-term bias correction method (REC), the VS has a positive effect on DI at the 5% significance level. A 1% increase in VS increases DI by 1.24%. The FC variable, which had been added to the model as a control variable, had a positive impact on DI. According to CS-ARDL estimation, a 1% increase in FC increased development by 0.93% at the

Table 5. Results of Konya's (2006) Panel Causality Test

	DI ⇏VS				VS ⇏DI			
	Wald-Stat.	Bootstrap Critical Values			Wald-Stat.	Bootstrap Critical Values		
		%1	%5	%10		%1	%5	%10
Brazil	0.090	3.067	1.660	1.075	2.933*	4.791	3.087	2.353
Russia	1.953	31.27	20.559	16.108	1.489	7.48	4.034	2.798
India	0.210	9.368	6.479	5.309	1.124	15.185	10.033	8.217
China	2.598**	3.176	2.000	1.470	0.064	3.086	1.504	1.059
S.Africa	0.017	20.688	13.658	10.814	3.670	29.486	21.203	17.589
Turkey	4.210*	7.106	4.575	3.429	0.810	4.714	2.393	1.500
	DI ⇏FC				FC ⇏DI			
	Wald-Stat.	Bootstrap Critical Values			Wald-Stat.	Bootstrap Critical Values		
		%1	%5	%10		%1	%5	%10
Brazil	7.686***	3.798	2.763	2.256	1.724	9.279	5.338	3.493
Russia	25.120***	22.179	17.071	14.479	0.513	10.055	5.352	4.267
India	43.587**	57.009	39.126	33.710	0.095	53.802	36.631	28.842
China	10.624**	12.069	10.181	8.945	4.034*	9.128	5.061	3.474
S.Africa	0.826	18.122	13.232	11.329	2.926	28.281	19.673	15.869
Turkey	2.734**	3.637	2.329	1.727	7.822***	5.966	3.927	2.864

Note: ***,** and * denote that the null hypothesis is rejected at the 1%,%5 and %10 levels respectively.

5% significance level. According to the bias correction estimation, a 1% increase in FC increased development by 1.27% at the 1% significance level. The results of the long-run estimation are similar to those of the short run. The impact of fixed capital formation means the control variable, on development is positive and significant in the long run. The impact of vertical specialization on development is positive and significant in the short run but an insignificant positive impact of vertical specialization on development had been accounted in the long run. Finally, the error correction terms of the CS-ARDL and CS-ARDL$_{REC}$ estimates were negative and significant at the 1% significance level. This result revealed a long-run equilibrium process. According to the CS-ARDL estimator, the velocity of the equilibrium is 82.3% per period; and the CS-ARDL$_{REC}$ predicted an adjustable rate being 69.3% per period. In the fourth part of the analysis, the bootstrap panel Granger-causality of Konya (2006) had been employed to investigate the long-term causality relationship. This method was found to be appropriate due to the presence of horizontal cross-sectional dependence and slope heterogeneity in the studied model. Moreover, it gives consistent results regardless of whether the variables are stationary or not. Furthermore, it allows for determining causality for each country in the studied sample separately. The maximum lag level was determined as 3 and the optimum lag order was determined by Schwarz Information Criterion (SIC). Bootstrap critical values are achieved in 10.000 cycles. The results of the bootstrap panel Granger-causality of Konya (2006) are given in table (5).

The results in table 5 revealed that China and Turkey had one-way long-term causality running from development to vertical specialization at the level of significance of 5% and 10%, respectively. Only Brazil had one-way long-term causality running from vertical specialization to development at the level of significance of 10%. A stronger causal link running from development to fixed capital formation had been accounted in the long run. Causality had been reported in Brazil and Russia at the level of significance of 1%. It had been reported also in India, China and Turkey at the 5% significance level. Causality running from fixed capital formation to development had been reported in China and Turkey at the significance level of 10% and 1% respectively. The results revealed a two-way causality between development and fixed capital formation variables in China and Turkey. A long-term consistency had been detected according to the estimation results of CS-ARDL and and those of Granger causality analysis. Based on the estimation results of , vertical specialization affects development positively in the short run but no effect can be reported in the long term. Although a causality running from vertical specialization to development has been detected in Brazil, this relationship is not very strong (10% significance level); the fact that causality could not be detected in other studied countries supports this result.

CONCLUSION

With the acceleration of globalization trends, significant changes have taken place in the structure of world trade. One of the most distinctive features of this change is the fragmentation of the production process of goods and services. In the world economy, instead of producing a final good or service in one single country, more than one country specializes in one or more certain stages of the production process until this good and service take its final form. That is, the international fragmentation process of production or the global production network. Developing countries, in particular, heavily participate in the international fragmentation of production and some of the emerging market economies play a significant role in it. BRICS+T countries have also participated significantly in the global production process, especially after the 2000s. In this paper, the vertical specialization ratio has been calculated to see the extent to which BRICS+T countries participate in the global production network. Moreover, the development index had been calculated utilizing various economic and sociocultural indicators of these countries. Furthermore, the vertical specialization's impact on development in BRICS+T countries was analyzed utilizing the CS-ARDL model. The results revealed a statistically significant positive impact of vertical specialization on development in the short-run. Although vertical specialization has a positive effect on development in the long run, this result is not statistically significant. Finally, Konya's (2006) causality test has been applied for checking the causal relationship among the selected variables. The results revealed a one-way causality running from development to vertical specialization in China and Turkey. A causal relationship running from development to vertical specialization could not be detected in Brazil, Russia, India and South Africa. The one-way causality relationship running from vertical specialization to development was seen only in Brazil, while no causality relationship could be detected in other countries included in the analysis. The results of Konya's (2006) causality test revealed a one-way causality running from development to vertical specialization in China and Turkey. A causal relationship running from development to vertical specialization could not be detected in Brazil, Russia, India and South Africa. The one-way causality relationship running from vertical specialization to development was seen only in Brazil, while no causality relationship could be detected in other countries included in the analysis. Participation in global production networks may not always have positive effects on the country's economy and development. As explained in the literature review, global production networks can lead to inequalities or make a country more vulnerable to crises. In addition, it can make companies dependent on leading companies. The empirical findings obtained in this study show that although the global production network positively affects countries' development in the short run, it does not have a serious effect on the development of countries in the long run. For this reason, to move through participation in global production networks to positions of producing higher value-added, it is necessary to encourage technology, foster innovation, and benefit from the technological innovations that have already been developed and used in developed nations. In addition, the production of technology-based goods and services should be encouraged. Moreover, incentive and orientation policies should be applied to sectors considered important in the global production network process. In this sense, the government can play an active role. The applied policies should deepen benefiting from the knowledge and experience of the leading companies further than being dependent on them. Thus, developing countries come to the stage at which their participation in the global production network becomes not only a determinant of this process but also independent from the developed countries, and as a result, positive effects, in the long run, can be achieved in the developing countries.

Appendix-1: Vertical Specialization's Calculation Method

The vertical specialization of each sector in an economy was calculated by applying the HIY method proposed by Hummels, Ishii & Yii (1998; 2011) to I-O tables. Under the assumption that there are n sectors in the economy, the input-output model is created as follows (Yin and Liu, 2019: 453):

$$\begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} \text{x} \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} + \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} \quad (1)$$

A summary notation for equation (1) is:

$$X.A + F = X \quad (2)$$

To obtain equation (3), we need to isolate the X variable:

$$X = (I\text{-}A)^{-1} + F^{2} \quad (3) \quad (3)$$

Equation (3) symbolizes the equilibrium level of output in an economy consisting of n sectors (Miller and Blair, 2009: 11-15). **X** $nx1$ denotes the output vector, **A** nxn represents the matrix of technical coefficients, **I** nxn represents the identity matrix, **F** $nx1$ denotes the final demand vector and $(I\text{-}A^d)$ nxn represents the Leontief inverse matrix. The technical coefficients matrix (**A**) is made up of the sum of the domestic technical coefficients matrix (A^d) and the imported coefficient matrix (A^m) (Xiao et al., 2020: 543):

$$\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} = \begin{vmatrix} a_{11}^d & \cdots & a_{1n}^d \\ \vdots & \ddots & \vdots \\ a_{n1}^d & \cdots & a_{nn}^d \end{vmatrix} + \begin{bmatrix} a_{11}^m & \cdots & a_{1n}^m \\ \vdots & \ddots & \vdots \\ a_{n1}^m & \cdots & a_{nn}^m \end{bmatrix} \quad (4)$$

A summary notation for equation (4) is:

$$A = A^{d\,+}\, A^m \quad (5)$$

Utilizing the equations derived above, the sectoral vertical specialization rates in an economy can be estimated utilizing the HIY method proposed by Hummels, Ishii, and Yi (2001) (Hummels, Ishii and Yi, 2001: 78-82):

$$\frac{VS_i}{X_i} = \frac{u.A^m.X}{X_i} \quad (6)$$

Equation (6) expresses the rate of direct imported intermediate input used in the production process of exporting goods. The total vertical specialization (direct + indirect) ratio of any sector in any *i* country can be calculated. It could be obtained as follows (Hummels, Rapoport and Yi, 1998: 96; Hummels, Ishii and Yi, 2001: 78-82; Dağıstan, 2019: 8-10):

$$\frac{VS_i}{X_i} = \frac{u.A^m[I-A^d]^{-1}.X}{X_i} \quad (7)$$

$(I\text{-}A^d)^{-1}$ denotes Leontief inverse matrix. Equation (7) represents the basic equation to calculate the vertical specialization rate.

[2] $(I\text{-}A)^{-1}$ denotes Leontief inversion matrix. (See Miller and Blair, 2009; Aydoğuş, 2015). The final demand vector (F) denotes the sum of domestic final demand and foreign final demand

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