Working Paper 2023.2.2.9
- Vol 2, No 2

VAI TRÒ CỦA XUẤT KHẨU CÔNG NGHỆ CAO ĐỐI VỚI TĂNG TRƯỞNG KINH TẾ Ở CÁC NƯỚC G-20

Lê Huỳnh Tường Minh[1], Đỗ Mai Linh, Lê Mai Na, Nguyễn Quỳnh Như,

Trần Lệnh Thiếu Long, Trần Phạm Quốc Minh, Ngô Quang Phú

Sinh viên K59, chuyên ngành Kinh tế đối ngoại

Cơ sở II Trường Đại học Ngoại thương tại TP. HCM

Lê Hằng Mỹ Hạnh

Giảng viên bộ môn Kinh tế

Cơ sở II Trường Đại học Ngoại thương tại TP. HCM

Tóm tắt

Với tốc độ tăng trưởng nhanh chóng và sự đổi mới trong cơ cấu trong công nghệ cao, tác động của công nghệ cao đến sản lượng kinh tế đã thu hút được sự chú ý đáng kể trong các tài liệu (ví dụ: Fagerberg (1994), Chen và Williams (1999). Bởi vì sản xuất công nghệ cao đòi hỏi phải sản xuất các sản phẩm có giá trị gia tăng cao nên hiện nay các nước phát triển đang chiếm vị trí dẫn đầu toàn cầu về xuất khẩu hàng hóa công nghệ cao. Do đó, việc xuất khẩu công nghệ cao được cho là một trong những yếu tố quan trọng trong chiến lược tăng trưởng và phát triển của đất nước (Yıldız, 2017). Mặc dù đã có một số nghiên cứu xem xét mối quan hệ nhân quả giữa xuất khẩu công nghệ cao và tăng trưởng kinh tế nhưng kết quả hầu như vẫn chưa thuyết phục (Kemal và Semra, 2019). Vì vậy, nghiên cứu này nhằm nghiên cứu và nắm bắt chiều hướng của mối quan hệ nhân quả này trước khi đưa ra các quyết định cho việc ưu tiên phát triển các ngành công nghiệp tăng trưởng kinh tế có ảnh hưởng trực tiếp đến xuất khẩu. Nghiên cứu tập trung vào mối tương quan giữa xuất khẩu công nghệ cao và tăng trưởng kinh tế của các nước G20, một nhóm quan trọng gồm các quốc gia có nền kinh tế phát triển và mới nổi, chiếm 2/3 dân số toàn cầu, chiếm 90% sản xuất của thế giới và 80% thương mại toàn cầu. Sử dụng Kiểm tra nhân quả của bảng Dumitrescu Hurlin Granger và Kiểm định đồng liên kết dữ liệu bảng của Pedroni, nghiên cứu cho thấy xuất khẩu công nghệ cao

[1] Tác giả liên hệ, Email: lehuynhtuongminh2011156149@ftu.edu.vn

và GDP có mối quan hệ tích cực trong ngắn hạn và dài hạn, điều này chứng tỏ tầm quan trọng của xuất khẩu công nghệ cao trong việc thúc đẩy tăng trưởng kinh tế mạnh mẽ và bền vững.

Từ khóa: Xuất khẩu công nghệ cao, G-20, phát triển kinh tế

THE ROLE OF HIGH-TECHNOLOGY EXPORT ON ECONOMIC GROWTH IN G-20 COUNTRIES

Abstract

With expeditious growth and structural reform in high-technology (HT), the impact of high-technology (HT) on economic output has gained considerable attention in the literature (e.g. Fagerberg, 1994; Chen and Williams, 1999). Because high-technology manufacturing simultaneously entails the production of high-value-added products, developed countries take the leading position globally in exports of high-tech goods. Therefore, exporting high-technology products is believed to be one of the crucial factors in financing a country's growth and development strategy (Yıldız, 2017: 27). Although there have been several studies examining the causal relationship between high-tech exports and economic growth, the results are inconclusive (Kemal and Semra, 2019). Therefore, this research is to investigate and grasp the direction of this causality before deciding whether to prioritize economic growth-based industries that contribute to exports. The research focuses on the correlation between the high-technology export and economic growth of G20 countries, which is an important group of countries comprising both developed and emerging economies that consist of two-thirds of the global population, making up 90 percent of the global world production and 80 percent of the global trade. Using the Dumitrescu & Hurlin's Granger Panel Causality Test and Pedroni's panel cointegration analysis, the research reveals that HT and GDP have a positive short-run and long-run relationship, which proves the importance of high technology exports in terms of promoting high and sustainable economic growth.

Keywords: High-technology export, G-20 countries, Economic growth

Introduction

Since the 1980s, international trade and advanced technology has greatly boosted all economies by facilitating more effective resource allocation, increased capacity utilization, product diversification, creation of economies of scale, and advanced technology spillovers (Kruger, 1975; Bhagawati, 1982; Feder, 1983; Awokuse, 2003). The relationship between exports and economic growth has been one of the most attractive researched topics in the economics literature. Theoretical and empirical studies illustrate that there is a positive relationship between international trade and economic growth (Frankel & Romer, 1999).

The ability to convert knowledge into innovation and to apply it to reality determines the international competitive power of nations. Within such scope, economic growth is not only associated with their ability to innovate but also with their ability to export these inventions (Avc et al., 2016: 50-51). In 1997, the OECD established a standard definition by categorizing high-tech sectors and products in mainly four different categories: high-tech, medium-high-tech, medium-low-tech, and low-tech. According to this classification, high-tech products are defined as aerospace, computer, pharmaceutical, scientific instruments, electrical machines, medical precision, and optical instruments (OECD, 2011: 5).

The HT sectors have made the greatest contribution in terms of employment growth. Furthermore, HT exports are significantly impacted by the strength of national innovative capacity and stimulate economic development (Stern et al., 2000). Over our period of study from 2007 to 2020, G-20 has undergone unprecedentedly remarkable changes in high-tech export and economic growth (World Bank, 2020). Global growth predictions, however, anticipate slower economic growth rates for developed countries, including those in the G-20 for the next 20 years (Tytell et al., 2018: 3). Additionally, to date, no research has examined the causal link between high-tech exports and economic growth in G-20. Therefore, this research has examined the G-20 countries to test whether high-technology export has a significantly positive impact on their economic growth. Relying on the results of the study, we aimed to fill this gap in the literature and determine the foreign trade policies that need to be implemented in order to achieve long-term sustainable economic growth in G-20 countries as well as provide policy-makers with appropriate suggestions related to the issue.

The rest of the study is organized as follows. In chapter 1, the authors summarize the literature on the relationship between high-tech export and economic growth. The second chapter includes a complete overview of the data, variables, and methodology. Chapter 3 summarizes the results of the empirical research on the matter. Finally, in the Conclusion, we come to conclusions and discuss some policy implications of the research.

1. Literature review

1.1 Literature review

1.1.1 Export and economic growth

The relationship between exports and economic growth has been, for a long time, a compelling and important topic that has been thoroughly studied in massive empirical studies (e.g, Awokuse 2008; Balassa 1978; Bastos, Silva, and Verhoogen 2014; Feder 1983). The positive relationship between exports and economic growth is grounded in the Export-Led Growth Hypothesis (ELGH) in the economics literature.

A first argument for the ELG is that “openness” enlarges the market dimension, and an increase in production and sales arises as a result of higher demand pressure (Andraz and Rodrigues 2010; Hesse 2006; Soukiazis and Antunes 2011). It also reduces unitary fixed costs in the presence of high fixed investment costs, which motivates enterprises to make such investments (Bastos, Silva, and Verhoogen 2014). Furthermore, an increase in exports may encourage specialization, particularly in the production of tradable goods, resulting in a better reallocation of resources from (relatively) inefficient non-tradable sectors to higher-productivity export-oriented sectors, allowing for comparative advantages; thus, as exports rise, domestic production goes up through productivity growth (Andraz and Rodrigues 2010; Awokuse 2008; Soukiazis and Antunes 2011). Furthermore, exporting requires a higher level of competitiveness, which supports the utilization of economies of scale and leads to a faster rate of technological advancement and better integration of production processes (Andraz and Rodrigues 2010; Awokuse 2008). Furthermore, international commerce has been proven to favor "spillover effects" from technology and information transfers by allowing for quicker international dispersion (e.g, Coe and Helpman 1995; Kali, Mendez, and Reyes 2007; Keller 2004; Soukiazis and Antunes 2011). Finally, export growth relieves the nation's external financial constraint: it enhances the economy's potential demand and, as a consequence, increases the ability to save and accumulate capital; at the same time, it provides the country with greater capability to acquire intermediate capital products. Both effects contribute to promoting growth (Ramos, 2001; Awokuse, 2008). As a result, increased exports can boost productivity not just in the exporting industry, but also in industries that would provide services or raw materials to these industries.

1.1.2 Export diversification toward manufacturing industries

Export diversification is nothing but change in country's export composition and structure which can be achieved either by making changes in the existing export commodities pattern or by expanding innovation and technology on them (Dennis and Shepherd, 2009). Through export diversification, an economy can progress towards the production and exportation of sophisticated products which may greatly contribute towards economic development. Besides, export diversification allows a government to achieve some of its macroeconomic objectives, namely sustainable economic growth, a satisfactory balance of payments situation, employment and redistribution of income (Raja et al., 2014)

A number of studies have found a link between export diversification and economic development (De Ferranti et al. 2002; Al-Marhubi 2000; Hausmann and Rodrik 2006; Matthee and Naude 2007; Funke and Ruhwedel 2005). Export diversification is a key factor in economic growth since it leads to greater exports and technological spillovers, both of which would benefit other industries (Dunusinghe, 2009). Diversification of a country's export basket is frequently regarded as beneficial for export earnings stability and boosting export-led growth by allowing a country to benefit from growth in many sectors of the global economy (Hausmann et al. 2005; Alexander and Warwick 2007).

According to Feenstra and Kee (2004), a 10% increase in export diversity in a country's sectors boosts productivity by 1.3 percent. Rich nations not only have a significant amount of exports, but also a diverse range of exports, resulting in a rise in the economy's overall export volume (Hummels & Klenow, 2005). In the example of Sri Lanka, Dunusignhe (2009) discovered that diversification in exports has resulted in economic growth, particularly in the manufacturing sector. Diversifying into manufacturing industries entails technical improvement as well as the manufacturing of higher-tech commodities. A quality spectrum designed by Hausman et al. (2007) to test the export baskets of different countries shows that countries producing goods higher up on this spectrum perform higher and vice versa. Santos et al. (2013) examined the impact of export structure on growth in 23 EU nations from 1995 to 2010 and concluded that export diversification toward high technology also enhanced growth substantially.

1.1.3 High-tech export and economic growth

The impact of high technology (HT) on economic production has gained considerable attention in the literature due to its rapid growth and structural change. HT exports are significantly affected by the amount of national inventive capacity and economic development stimulation (Stern et al., 2000). High-tech exports, in particular, have a greater impact on economic growth than medium- and low-tech exports.

Lee (2011) conducted an empirical study to determine the extent to which technological characteristics are required to influence a country's economic growth. The study discovered that, in comparison to low-tech exports, an increase in high-tech exports has a more rapid influence on economic growth. These findings are in line with the findings of Lucas (1988) and Young (1991), which found that specialized technology exports improve a country's growth at a faster rate than low technology exports.

In the case of Malaysia, Ghatak et al. (1997) discovered that manufactured goods, rather than primary ones, drive economic growth. For developing countries, shifting to manufactured goods appears to be a strategy to boost economic growth because they may not be able to go into higher technological products immediately. Yoo (2008) also explored the influence of high-technology export on economic growth with panel data from 91 nations over the period 1988-2000 and the obtained results confirmed that high-technology export has a strong positive impact on economic growth. New evidence on the impact of the change in high-tech export on economic output is given by Kemal and Semra (2019). The results from the observed sample covering EU-15 countries between 1998-201722 indicated a bidirectional causal relationship between high-tech export and GDP. The long-term causal analyses also showed that 1% raise in HT causes a 0.34 % increase in GDP, which is relatively significant.

When it comes to China, Jarreau and Poncet (2012) found that regions producing sophisticated products lead to higher economic growth. In fact, the Chinese economy offers a fascinating case study for scholars in terms of high-tech export and economic growth. The Chinese economy has experienced significant growth since the implementation of the trade openness policy. Sun and Heshmati (2010) conducted empirical research to determine the impact of foreign trade on economic growth in 31 Chinese regions from 2002 to 2007. According to the study, net exports and high-tech exports had a beneficial impact on the efficiency of the region. They further elaborated that China's remarkable economic success is a result of globalization and a dynamic trade policy.

However, in Sub-Saharan African countries, Bbaale and Mutenyo (2011) fond that agricultural exports, rather than manufactured exports, have led to per-capita growth. They discover that 35 countries in their sample have a comparative advantage in agricultural exports and that they should continue to invest in these for long-term development. They propose that policies in these Sub-Saharan African countries be geared toward agriculture in the medium term and manufacturing in the long run.

In the example of Pakistan, Usman (2017) found that agriculture productivity per worker had a greater impact on the country's economic growth than high-tech exports. There are two key explanations for this outcome: First, Pakistan is a highly agriculture-dependent country, and second, it still has poor performance in high tech exports when compared to other countries. These findings confirm Grancay et al. (2015)'s conclusion that under-developed or developing countries will not necessarily improve if they begin focusing on high-tech products, but they will also need the appropriate infrastructure to support those industries.

According to the publications cited above, high-technology export is a substantial predictor of economic output with a positive impact in general. However, it may be beneficial for countries to develop export and production strategies that are tailored to the country's advancement and export specialization. The focus should stay on manufacturing and high-tech industries, but it should follow a path that benefits from both the country’s infrastructure and its overall advancement. It is critical to distinguish between the types of exports and how they affect economic growth in developed, developing, and underdeveloped countries. The export composition will also help in understanding the various types of exports in relation to the development of the economies.

1.2 Hypothesis development

The above literature review has indicated that there are 3 crucial variables affecting the GDP in both short and long term. To test the impact of high- tech export on one country’s economic growth, we have set up 4 hypotheses as below:

H1: High-technology export (HT) positively affects GDP in the short term.

H2: High-technology export (HT) positively affects GDP in the long term.

H3: Labor force (LF) positively affects GDP.

H4: Gross fixed capital formation (FC) positively affects GDP.

2. Methodology and Data

2.1 Data description

From the "G-20" country group, we omitted India, Indonesia, and Mexico due to a lack of data on high-tech exports, and the European Union for a more in-depth analysis. As a result, sixteen countries were included in the sample: Argentina, Australia, Brazil, Canada, China, France, Germany, Italy, Japan, Republic of Korea, Russian Federation, Saudi Arabia, South Africa, Turkey, United Kingdom, and the United States. The dataset used in this report includes 224 observations of national gross domestic product (GDP), high-technology exports (HT), labor force (LF), and gross fixed capital formation (FC) for sixteen mentioned countries from 2007 to 2020. The descriptive statistics as well as the interpretation and source of all of the variables used can be seen in Table 2.1 and Table 2.2.

Table 2.1 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP	224	3.27e+12	4.45e+12	3.16e+11	2.00e+13
lnGDP	224	28.24808	.9954864	26.47943	30.62548
HT	224	9.18e+10	1.46e+11	1.31e+08	7.58e+11
lnHT	224	23.76663	2.127933	18.69	27.35353
LF	224	9.10e+07	1.84e+08	8648499	8.00e+08
lnLF	224	17.51971	1.04273	15.9729	20.50015
FC	224	8.42e+11	1.23e+12	4.60e+10	6.31e+12
lnFC	224	26.78883	1.108121	24.55217	29.47371

Note: ln: natural logarithm, d: first difference, l: one lag

Table 2.2. Variable description

Variable		Interpretation	Source
Dependent variable	GDP	GDP as a measure of economic growth (constant 2015 US$)	World Bank (2021)
Independent variable	HT	High-tech exportation (current US$)	
	LF	Labor force	
	FC	Gross fixed capital formation (current US$)	

2.2 Research methodology

The test for causal relationship between high-tech export (HT) and economic growth (GDP) will be performed following three steps.

Firstly, the functional, statistical, and VAR models were established. A number of pre- tests are required to select appropriate test methods before proceeding with the long-term and short-term analysis. These pre-tests are cross-section dependence, series stationary, and parameters homogeneity. Because panel causality analysis with non-stationary time-series data yields biased results, the stationary of the series (evaluated by the Unit root test) as well as the integration levels need to be determined before panel causality tests can be utilized. A cross-section dependence test is used to determine the correlation between the units before deciding which unit root test is appropriate for producing accurate results. If cross-section dependence exists, one of the second-generation unit root tests should be used instead of first-generation ones. Breusch-Pagan (1980) LM, Pesaran (2004) scaled LM, Baltagi, Feng, and Kao (2012) bias-corrected scaled LM, and Pesaran (2004) CD test are among the cross-section dependency tests supplied by Eviews 12.0 in this study. Then Pesaran (2007) CADF was used to define the stationary of the series. Another important pre-test for determining the best estimate method is parameter homogeneity. The Delta test (Pesaran and Yamagata, 2008; Blomquist and Westerlund, 2013) was conducted to determine if the parameters were homogeneous.

Secondly, based on the mentioned pre-test, the Dumitrescu & Hurlin's Granger Panel Causality Test was utilized to investigate the short-term causal connection.

Thirdly, we examine the long-run relationship among the variables using Pedroni's panel cointegration analysis. Pedroni proposed two types of tests. The first includes four statistics and is based on the within-dimension of the panel while the second includes three statistics based on between-dimension. The between-dimension statistics allow for heterogeneous coefficients across cross units. Then, as the variables are cointegrated, the Pooled Mean Group Estimator was chosen as the proper method to explore the bilateral short-run and long-run relationship between these variables (two-step Engle and Granger (1987) method).

2.3 Research model

To investigate the influence of high technology exports on economic growth, the equation based on the Cobb-Douglas function developed by Solow (1957), which is presented in Equation (1), was implemented.

$$Y_t = A(t)K_t^{\alpha}L_t^{(1-\alpha)} \quad (1)$$

Solow's equation can be expressed in logarithmic function form as in Equation (2)

$$LogYt = LogA(t) + \alpha LogK + (1-\alpha)LogL \qquad (2)$$

Accordingly, the functional model that will be employed in this research is Equation (3). The model's predicted variable is GDP, whereas the model's predictor variables are high-technology exports (HT), labor force (LF), and gross fixed capital formation (FC). This model is also used in Kemal and Semra's study (2019).

$$GDP = f\ (HT, LF, FC) \quad (3)$$

Equation (2) can be expressed statistically asin Eq. (4)

$$GDPit = \alpha + \beta 1HTit + \beta 2LFit + \beta 3FCit + uit \qquad (4)$$

In Equation (4) where α represents fixed term and β_1, β_2 and β3 are the coefficients of the regression indicating the sensitiveness of GDP corresponding with per unit change in HT, LF and FC respectively. t symbolizes the time trend and u is the error term, while i represents countries (i = 1 ... N).

By considering lagged values of the series, the static model stated in Equation (4) may be expressed in dynamic equations in the VAR System as in Equations (5), (6), (7), and (8) below:

$$dGDP_t = \alpha_{11} + \sum_{l=1}^{n} \beta_{1l} dGDP_{it-l} + \sum_{l=1}^{n} \beta_{2l} dHT_{it-l} + \sum_{l=1}^{n} \beta_{3l} dLF_{it-l} + \sum_{l=1}^{n} \beta_{4l} dFC_{it-l} + u_{1t} \quad (5)$$

$$dHT_t = \alpha_{21} + \sum_{l=1}^{n} \beta_{5l} dHT_{it-l} + \sum_{l=1}^{n} \beta_{6l} dGDP_{it-l} + \sum_{l=1}^{n} \beta_{7l} dLF_{it-l} + \sum_{l=1}^{n} \beta_{8l} dFC_{it-l} + u_{2t} \quad (6)$$

$$dLF_t = \alpha_{31} + \sum_{l=1}^{n} \beta_{9l} dLF_{it-l} + \sum_{l=1}^{n} \beta_{10l} dGDP_{it-l} + \sum_{l=1}^{n} \beta_{11l} dHT_{it-l} + \sum_{l=1}^{n} \beta_{12l} dFC_{it-l} + u_{3t} \quad (7)$$

$$dFC_t = \alpha_{41} + \sum_{l=1}^{n} \beta_{13l} dFC_{it-l} + \sum_{l=1}^{n} \beta_{14l} dGDP_{it-l} + \sum_{l=1}^{n} \beta_{15l} dHT_{it-l} + \sum_{l=1}^{n} \beta_{16l} dLF_{it-l} + u_{4t} \quad (8)$$

In the VAR Model, d shows "the first differences",u1t, u2t, u3t, and u4t are the "error terms", n is "the number of lag-lengths" and β11 to β161 are the coefficients of the model.

3. Research results

3.1 Pre-tests

3.1.1 Cross-section dependence analysis

The correlation between the units should be addressed while defining the correct unit root test technique and the right panel cointegration method (Hurlin and Mignon, 2007). The second-generation panel unit root test will be used if there is cross-section dependency between the units; otherwise, the first-generation panel unit root test will be employed. Similarly, if the units have a cross-sectional dependence, the second-generation cointegration tests should be employed; otherwise, the first-generation cointegration tests should be utilized. Table 3.1. shows the results of four cross-section dependence tests provided by Eviews used to examine the correlation between the units.

Table 3.1. Cross-Section Dependence Test

	GDP	**HT**	**LF**	**FC**
Breusch-Pagan LM	950.8909*	396.4529*	1264.160*	402.7290*
Pesaran scaled LM	53.63378*	17.84496*	73.85522*	18.25008*
Bias-corrected scaled LM	53.01839*	17.22957*	73.23984*	17.63469*
Pesaran CD	24.76644*	9.726792*	27.15955*	8.621896*

Note: * indicate cross-section dependence at 1% significance level

The null hypothesis “There is no cross-section dependence in residuals” was tested. It can be seen that all of the p-values for GDP, HT, LF, and FC at each test are less than 1% significance level, indicating that the null hypothesis is rejected. The four approaches all came up with the same conclusion, showing that there is a correlation between the units.

3.1.2 Stationarity analysis

We decided to employ the Pesaran (2007) CIPS test, which is a second-generation unit root test that takes into account unit correlation. "Unit root" is the null hypothesis, which implies that the data series are non-stationary. As GDP, HT, FC, and LF are not stationary, we decided to take the first difference of those variables and re-employ the test.

The results of the test are shown in Table 3.2. Because the p-values of Z [t-bar] statistics belonging to the series are less than 5%, it indicates that the first difference of GDP, HT, FC, and LF are stationary.

Table 3.2. Unit Root Test

Variable	t-stat	cv10	cv5	cv1	p-value
		Original series			
GDP	-0.7796	-1.54	-1.68	-1.94	>=0.10
HT	-0.4162	-1.54	-1.68	-1.94	>=0.10
LF	-0.3941	-1.54	-1.68	-1.94	>=0.10
FC	-1.7075	-1.54	-1.68	-1.94	>=0.10
		First-difference series			
d.GDP	-1.6204***	-1.54	-1.69	-1.96	<0.10
d.HT	-2.1397*	-1.54	-1.69	-1.96	<0.01
d.LF	-1.7524**	-1.54	-1.69	-1.96	<0.05
d.FC	-2.0907*	-1.54	-1.69	-1.96	<0.01

Note: ***, **, and * indicate cointegration at 10%, 5% and 1% significance level respectively.

3.1.3 Homogeneity analysis

The heterogeneity or homogeneity of the parameters must be determined before the appropriate panel causality method can be defined. In order to assess slope homogeneity, the Delta Test (Pesaran and Yamagata, 2008) was used, which is based on a standardized version of Swamy's test (Swamy, 1970). The results are shown in Table 3.3.

Table 3.3. Homogeneity Analysis

Dependent variable	GDP	
Independent variables	HT, LF, FC	
Testing for slope heterogeneity		
	Delta	**p-value**
	9.717	0.000
adj.	12.119	0.000

The null hypothesis H0: "Slope coefficients are homogenous" was tested against H1: "The parameters are heterogeneous". The null hypothesis was rejected at the 1% significance level since the p-values were less than 0.01. As a result, we came to the conclusion that parameters are heterogeneous and then implemented heterogeneous panel causality and heterogeneous cointegration methods.

3.2 Short-term causality analysis

In the short-term causality analysis between the series, Dumitrescu & Hurlin's (2012) Granger Panel Causality Test, which takes into account the heterogeneity, is employed.

Table 3.4. VAR Panel Causality Test Results

H0:	**W-Stat.**	**Z-bar Stat. (p-value)**	**Relationships**
HT $\nRightarrow$ GDP	3.88639	14.1388 (0.000)	HT $\leftrightarrow$ GDP
GDP $\nRightarrow$ HT	4.49254	9.13163 (0.000)	

Note: ($\nRightarrow$) *refers to "does not homogeneously cause"*

Table 3.4 shows the outcomes of Dumitrescu & Hurlin's (2012) Granger Panel Causality Test, which indicated a two-way causality between HT and GDP. Therefore, H1 is confirmed.

3.3 Long-term analysis

The Pedroni ECM Panel Co-integration Test, one of the cointegration test techniques that incorporate cross-section dependency between the units and parameter heterogeneity, was used to examine the existence of long-term relationships. The null hypothesis of "no cointegration" was tested. Table 3.5 summarizes the results of the exam.

Table 3.5. Pedroni ECM Panel Co-integration Outcomes

	Statistic	**p-value**
Modified Phillips-Perron t	3.3487	0.004

Phillips-Perron t	-4.1891	0.0000
Augmented Dickey-Fuller t	-3.1581	0.0008

Table 3.5 displays the values of test statistics and p-values and robust p-values of Modified Phillips-Perron t, Phillips-Perron t, and Augmented Dickey-Fuller t. "H0: no cointegration hypothesis" was tested. Since the p-values which are considered in heterogeneous panel cointegration are less than the 5% significance level, the null hypothesis is rejected and therefore we concluded that the co-integration between the units exists.

Because the outcomes of Table 3.5 confirmed a long-term relationship, Pooled Mean Group Estimator, which is an intermediate estimator that allows the short-term parameters to differ between groups while imposing equality of the long-term coefficients between groups, is employed to get more detail. Table 3.6 summarizes the results of the PMG Estimator. We use the logarithm form of all the variables to interpret the change in the variables in the percentage form.

Table 3.6. PMG Estimator Outcomes

d.lnGDP	**Coef.**	**Std. Err.**	**z**	**P>z**	**[95% Conf. Interval]**	
_Ec						
l.lnHT	0.251313	0.019448	12.92	0.000	0.213195	0.289431
l.lnLF	1.331746	0.132818	10.03	0.000	1.071428	1.592063
l.lnFC	0.978087	0.06149	15.91	0.000	0.857569	1.098605
SR						
ec	-0.0322134	0.0186203	-1.73	0.084	-0.0687084	0.0042816
d.lnHT	0.118425	0.038207	3.1	0.002	0.043541	0.193309
d.lnLF	0.183842	1.12131	0.16	0.870	-2.01389	2.381568
d.lnFC	0.129416	0.070972	1.82	0.068	-0.00969	0.26852
d.l.lnGDP	0.075238	0.285005	0.26	0.792	-0.48336	0.633836

d.l.lnHT	-5.1E-05	0.040878	-0.000	0.999	-0.08017	0.080069
d.l.lnLF	-1.12777	1.336625	-0.84	0.399	-3.74751	1.49197
d.l.lnFC	-0.02865	0.032888	-0.87	0.384	-0.09312	0.035805
_cons	-2.38735	2.234471	-1.07	0.285	-6.76684	1.992131

Note: ln: natural logarithm, d: first difference, l: one lag

Table 3.6 includes short- and long-term coefficients, standard errors, z-values, p-values, and 95% confidence intervals. The long-term associations are shown in the upper part. Since the p-values are lower than 0.01, the long-term coefficients of the variables are considered to be significant at any significance level. Taking into account the long-term coefficients, it is interpreted that:

(a) a 1% increase in HT causes a 0.25 % increase in GDP,

(b) a 1% increase in LF causes a 1.33 % increase in GDP,

(c) a 1% increase in FC causes a 0.98% increase in GDP.

As a result, high-tech exports have a substantially positive long-term influence on economic growth. Labor force and gross fixed capital formation also share the same pattern.

The short-term association is seen in the second part of the MG Estimator's results. The error correction coefficient (EC) is negative, with a p-value of 0.084. Therefore, the short-term relationships are in general significant at the 10% significance level. Considering the short- term coefficients belong to HT, LF and FC it is concluded that:

(a) a 1% increase in HT causes 0.12 % increase in GDP,

(b) a 1% increase in LF causes 0.18 % increase in GDP,

(c) a 1% increase in FC causes 0.13 % increase in GDP.

(d) Although HT, LF, and FC themselves do not appear significant in the short term (due to the interaction between the HT, LF, and FC), the effect of the variables on economic growth in the short term is positive.

(e) Approximately 3% of the imbalances in a period that occur as a result of a shock can be recovered in the following period.

Based on these results, three hypotheses H2, H3, and H4 are confirmed.

3.4 Research results discussion

The empirical results show that in the short run, there is a bidirectional relationship between high-tech exports and economic growth. The explanation for this outcome is that most countries in the G-20 which have advanced technology levels (France, Germany, Japan, Republic of Korea, the United States, etc.), can use their competitive materials to export a huge amount of high-tech products. In those countries, R&D and human capital display significant statistical effects on technology specialization (Gokce et al, 2009). Moreover, recent studies have shown that the location of export production is changing from the industrialized to developing countries, and exports by the latter have grown rapidly and diversified away from traditional resource and labor-intensive products to high technology manufacture (Lall, 1998). High-technology products like semiconductors or consumer electronics have a mixture of rapid innovation, demand growth, and relocation of assembly processes (high value-to-weight ratios make the splitting of processes economical).

This study also points out that high-tech exportation has a significant positive impact on economic growth both in the long-run and short-run. More specifically, the impact of the long- run is relatively bigger compared to the short-run. In addition, labor force and gross fixed capital formation also positively influence economic growth. Based on the Solow growth model, the results can be explained by the fact that the increase in technology level will result in a rise in economic growth (Solow, 1956). The higher the growth rate in the manufacturing industry that export determines, the faster the transfer of the labor will be from sectors in which economic productivity is low to the industrial sector, which leads to a faster productivity increase (Kılavuz & Topcu, 2012). At the same time, there is a long-run equilibrium relationship between total factor productivity growth and economic growth (Lee & Ye, 2019). High-tech export, labor resources as well as capital investment adds significantly to the country's technological level and development, which directly contributes to the country's total economic output (Sultanuzzaman et al, 2019).

Conclusion and Recommendations

Research conclusion

Regarding theoretical implications, the research demonstrated that there is a bidirectional causal relationship between high-tech export and economic growth in the short-term causality test while in the long term, high-tech export considerably influences economic growth. HT and GDP have been proved to have a positive short-run and long-run relationship, which reveals the importance of high technology exports in terms of promoting high and sustainable economic growth. Therefore, G-20 countries should make an effort to increase high technology shares in their exports and incentivize high technology production.

Regarding practical implications, this study presented a practical understanding of the relationship between high-tech export and economic growth and then give evidence-based recommendations for governments who are responsible for determining foreign trade policy. Governments can implement these measures to encourage high-tech export and as a result, enhance economic growth.

Recommendations

In both the short term and long term, there is a positive relationship between HT and economic growth, especially a two-way causality relationship between the two variables. Policymakers in the G-20 countries should co-develop policies on high tech export and increasing GDP when they are to steer their economies towards long-term future economic growth (Arvin, M. B., Pradhan, R. P., & Nair, M.,2021). Based on this background as well as the results of the study, this paper proposes the following policy recommendations:

Firstly, to improve the quality of export products from the endogenous to promote sustained, rapid, and healthy economic development. The development of a country's economy means the government can offer much more investment in R&D, infrastructure construction, and government policy support can support the improvement of the quality of G-20 countries' exports.

Secondly, to promote R&D investment and encourage enterprises to innovate. Domestic enterprises should actively increase investment in research so as to improve their own R&D and innovation capability and enhance the absorptive capacity of advanced production technology and management experience of foreign-funded enterprises. In addition, companies should provide a more humane employment system, as well as a good working environment to attract the best talent. Government should continue to encourage independent research, and increase investment in R&D to enhance their own innovation capability.

Finally, a scientific and rational utilization of foreign capital should be applied in order to increase spillovers of foreign investment. Active use of the positive spillover effects of foreign investment and full use of domestic resources and markets to attract FDI to transfer high value-added processing sectors to G-20 countries. Policymakers should also strive to learn advanced foreign technology and management experience, but avoid the blind pursuit of foreign investment. They also need to improve the international competitiveness of domestic enterprises fundamentally to establish a positive feedback mechanism between domestic and foreign-funded enterprises. Hence, a high-tech export plan will go a long way in enhancing economic growth in the G-20 countries.

Limitations and suggested future research

This research has some limitations that are worth noting. First, our results were based on data provided by World Bank; hence, the lack of data might be a problem because some countries in the "G20" group have been excluded. Additionally, the research only examined the relationship between high-tech export and economic growth of the overall G-20 countries instead of considering the specific economic and political structure of each country. Future studies should investigate using time-series analysis to take a deeper analysis of each country's case to provide the most efficient and effective policy for sustainable growth according to its economic development structure and technical level.

References

Al-Marhubi, F. (2000), “Export diversification and growth: an empirical investigation”, *Appl Econ Lett*, Vol. 7, pp. 559–562.

Alexander, C., & Warwick, K. (2007), “Governments, exports and growth: responding to the challenges and opportunities of globalisation”, *The World Economy*, Vol. 30 No. 1, pp. 177–194

Ali, G. (2015), “Gross fixed capital formation & economic growth of Pakistan”, *Journal of Research in Humanities, Arts and Literature Applied*, Vol. 1 No2, pp. 21-30.

Andraz, J., & P. Rodrigues. (2010), “What Causes Economic Growth in Portugal: Exports or Inward FDI?”, *Journal of Economic Studies*, Vol. 37 No 3, pp. 67–87.

Anorou, E., & Ahmad, Y. (2000), “Openness and economic growth: Evidence from selected ASEAN countries”, *Indian Economic Journal*, Vol. 47 No. 3, pp. 110.

Arip, M. A., Yee, L. S., & Abdul Karim, B. (2010), *“Export diversification and economic growth in Malaysia”*, Munich Personal RePEc Archive MPRA, Reitaku University.

Arvin, M. B., Pradhan, R. P., & Nair, M. (2021), “Uncovering interlinks among ICT connectivity and penetration, trade openness, foreign direct investment, and economic growth: The case of the G-20 countries”, *Telematics and Informatics*, Vol. 60, pp. 101-567.

Awokuse, T. (2008), “Trade Openness and Economic Growth: Is Growth Export-led or Import-led?”, *Applied Economics*, Vol. 40 No. 2, pp. 161-173.

Awokuse, T. O. (2003), “Is the export-led growth hypothesis valid for Canada?”, *Canadian Journal of Economics*, Vol. 36 No. 1, pp. 126–136.

Balassa, B. (1978), “Exports and Economic Growth: Further Evidence”, *Journal of Development Economics*, pp. 27- 40 & 181-189.

Baltagi, B. H., Feng, Q. & Kao, C. (2012), “A Lagrange Multiplier test for cross-sectional dependence in a fixed effects panel data model”, *Journal of Econometrics, Elsevier*, Vol. 170 No. 1, pp. 164-177.

Bastos, P., J. S., & Verhoogen, E. (2014), *“Export Destinations and Input Prices”,* CEPR Discussion Paper 9985, London, UK.

Bbaale, E. & Mutenyo, J. (2011), “Export Composition and Economic Growth in SubSaharan Africa: A Panel Analysis”, *Consilience: The Journal of Sustainable Development*, Vol. 6, pp. 1–19.

Begum, E. S. (2019), “Impact of High Technology Export on Economic Growth: An analysis on Turkey”, *Journal of Business and Finance*, Vol. 8 No. 3.

Bhagwati, J. N. (1978), “Anatomy and Consequences of Exchange Control Regimes”, *International Economic Relations, pp. 7-52.*

Blomquist, J. & Westerlund, J. (2013), "Testing slope homogeneity in large panels with serial correlation", *Economics Letters, Elsevier,* Vol. 121 No. 3, pp. 374-378.

Bolaky, B., Freund, C. (2004), "Trade, Regulations, and Growth", *World Bank Policy Research Working Paper,* Vol. 3255, pp. 1-40.

Chandra, P., & Sahoo, P. (2007), "Export-led growth in South Asia: a panel cointegration analysis", *International Economic Journal,* Vol. 21 No. 2, pp. 155-175.

Chen, J.-H. & Williams, M. (1999), "The determinants of business failures in the US low-technology and high-technology industries", *Applied Economics,* Vol. 31, pp. 51–63.

Christophe, H., Valérie, M. (2007), "Second Generation Panel Unit Root Tests", *HAL open science,* Available at: https://shs.hal.science/halshs-00159842.

Coe, D., & H. Helpman. (1995), "International R&D Spillovers", *European Economic Review,* Vol. 39 No. 5, pp. 59–87.

Connolly, R. (2019), "Climbing the Ladder? High-Technology Export Performance in Emerging Europe", *Eurasian Geography and Economics,* Vol. 53 No. 3, pp. 356–379.

Cuaresma, J. C., & Wörz, J. (2005), "On export composition and growth", *Review of World Economics,* Vol. 141 No. 1, pp. 33-49.

David, H., & Peter, J. Klenow. (2005), "The Variety and Quality of a Nation's Exports", *American Economic Review,* Vol. 95 No. 3, pp. 704-723

De Ferranti, D., G. E. Perry, D. Lederman, & W. F. Maloney. (2002), "From Natural Resources to the Knowledge Economy: Trade and Job Quality", *World Bank Publication,* Vol. 14040.

Dumitrescu, E. I., & Hurlin, C. (2012), "Testing for Granger non-causality in heterogeneous panels", *Economic modelling,* Vol. 29 No. 4, pp. 1450-1460.

Dennis, A., & Shepherd, B. (2009), "Trade facilitation and export diversification", *The World Economy,* Vol. 34 No. 1, pp. 101–122.

Dunusinghe, P. (2009), "On Export Composition and Growth: Evidence from Sri Lanka", *South Asia Economic Journal,* Vol. 10 No. 2, pp. 275-304.

Edwards, S. (2001), "Trade orientation, distortions and growth in developing countries", *Journal of Development Economics,* Vol. 2001 No. 39, pp. 31– 57.

Erkisi, K. & Boğa, S. (2019), "High-technology products export and economic growth: a panel data analysis for EU-15 countries", *Bingöl Üniversitesi Sosyal Bilimler Enstitüsü Dergisi,* Vol. 9 No. 18, pp. 669-684.

Esra K. et al. (2017), "The Determinants of High-technology Exports: A panel data approach for selected OECD countries", *Dubrovnik International Economic Meeting,* Vol. 3 No. 1, pp. 888-900.

Fagerberg, J. (1994), “Technology and international differences in growth rates”, *Journal of economic Literature*, Vol. 32 No. 3, pp. 1147-1175.

Fagerberg, J. (2000), “Technological progress, structural change and productivity growth: a comparative study”, *Structural change and economic dynamics*, Vol. 11 No. 4, pp. 393-411.

Falk, M. (2009), “High-tech exports and economic growth in industrialized countries”, *Applied Economics Letters*, Vol. 16 No. 10, pp. 1025-1028.

Feder, G. (1983), “On exports and economic growth”, *Journal of Development Economics”,* Vol. 12 No. 2, pp. 59–73.

Frankel, J. A., & Romer, D. H. (1999), “Does trade cause growth?”, *American economic review*, Vol. 89 No. 3, pp. 379-399.

Frantzen, D. (2000), “R&D, Human Capital and International Technology Spillovers: A Cross-Country Analysis”, *Scandinavian Journal of Economics*, Vol. 102, pp. 57-75.

Funke, M., Ruhwedel, R. (2005), “Export variety and economic growth in East European transition economies”, *Econ Transit*, Vol. 13 No. 1, pp. 25–50

Ghatak, S., & Stephen, W. (1997), “Export Composition and Economic Growth: Cointegration and Causality Evidence for India”, *Review of World Economics*, Vol. 133 No. 3, pp. 38–53.

Grancay, M., Grancay, N. & Dudas T. (2015), “What You Export Matters: Does it Really?”, *Contemporary Economics*, Vol. 9 No. 2, pp. 233-244.

Hausmann, R. & Klinger, B. (2006), “South Africa’s export predicament”, *CID working*, pp. 129.

Hausmann, R., Rodrik, D. (2006), “Doomed to choose: industrial policy as predicament”, *Center for International Development*, Harvard University.

Hausmann R., Hwang J. & Rodrik D. (2005), “What you export matters”, *Faculty research working paper*, pp. 05-63.

Hesse, H. (2008), “Export Diversification and Economic Growth”, *Commission on Growth and Development Working Paper 21*, World Bank, Washington, DC.

Hobday, M. (2001), “The electronics industries of the AsiaPacific: exploiting international production networks for economic development”, *Asian-Pacific Economic Literature*, Vol. 15, pp. 13-29.

Hummels, D. & Klenow, P.J., (2005), “The Variety and Quality of Nation’s Exports”, *American Economic Review*, Vol. 95, pp. 704–723.

IMF (2021), “Regional Economic Outlook: Asia and Pacific*”*, *International Monetary Fund*, Available at: https://www.imf.org/en/publications/reo?sortby=Region&series=Asia+and+Pacific

Jarreau, J. & Poncet, S. (2012), “Export Sophistication and Economic Growth: Evidence from China”, *Journal of Development Economics,* Vol. 97 No. 2, pp. 281-292.

Jung Wan, L. & Xuan, Y. (2019), “Effects of Technology and Innovation Management and Total Factor Productivity on the Economic Growth of China”, *The Journal of Asian Finance, Economics and Business,* Vol. 6 No. 2, pp. 63-73

Kali, R., F. Mendez, & J. Reyes. (2007), “Trade Structure and Economic Growth”, *Journal of International Trade and Economic Developmen*t, Vol. 16 No. 2, pp. 45–69.

Keller, W. (2004), “International Technology Diffusion”, *Journal of Economic Literature,* Vol. 42 No. 3, pp. 52–82.

Kılavuz, E., & Topcu, B. A. (2012), “Export and economic growth in the case of the manufacturing industry: panel data analysis of developing countries”, *International Journal of Economics and Financial Issues,* Vol. 2 No. 2, pp. 201-215.

Lall, S. (1998), “Exports of manufactures by developing countries: emerging patterns of trade and location”, *Oxford Review of Economic Policy,* Vol. 14 No. 2, pp. 54-73

Lall, S. (2000), “Export performance, technological upgrading and foreign direct investment strategies in the Asian newly industrializing economies”, *CEPAL*, Available at: https://repositorio.cepal.org/server/api/core/bitstreams/c53fd58d-4556-422e-812e-b9bc4908b2db/content.

Lee, J. (2011), “Export specialization and economic growth around the world”, *Economic Systems,* Vol. 35 No. 1, pp. 45-63.

Lucas, R. E. (1988), “On the mechanics of economic development”, *Journal of monetary economics,* Vol. 22 No. 1, pp. 3-42

Matthee M. & Naude, W. A. (2007), “Export diversity and regional growth: empirical evidence from South Africa”, *WIDER research paper,* United Nations University, Helsinki, Finland.

Sultanuzzaman, M. R., Fan, H., Mohamued, E. A., Hossain, M. I., & Islam, M. A. (2019), “Effects of export and technology on economic growth: Selected emerging Asian economies”, *Economic research-Ekonomska istraživanja,* Vol. 32 No. 1, pp. 2515-2531.

Mohsen M., Samaneh S. & Abbas R. K. (2017), “Determinants of high-tech export in developing countries based on Bayesian model averaging”, *Proceedings of Rijeka Faculty of Economics: Journal of Economics and Business,* Vol. 35 No. 1, pp. 199-215

Naudé, W., & Rossouw, R. (2011), “Export diversification and economic performance: evidence from Brazil, China, India and South Africa”, *Economic Change and Restructuring,* Vol. 44 No. 1, pp. 99-134.

OECD (2011), “Technology Intensity Definition. Classification of manufacturing industries into categories based on R&D intensities”, *OECD Directorate for Science,* *Technology and Industry*.

OECD (2015), “International Labour Organization”, *The Labour Share in G20 Economies.*

OECD (2017), “Rebalancing Turkey’s Growth by Improving Resource Allocation and Productivity in Manufacturing”, *OECD Economic Surveys.*

Pesaran, M.H. & Yamagata, T. (2008), “Testing Slope Homogeneity in Large Panels”, *Journal of Econometrics*, Vol. 142, pp. 50-93.

Pesaran, M.H.. (2004), “General Diagnostic Tests for Cross Section Dependence in Panels”, *Cambridge Working Papers in Economics,* Faculty of Economics, University of Cambridge.

Raja V.S., Boopendra S. & Matthew J.L. (2014), “Export diversification and economic growth: The case of Mauritius”, *Connecting to Global Markets*, pp. 11-23.

Ribeiro, A. P., Carvalho, V., & Santos, P. (2016), “Export-led growth in the EU: where and what to export?”, *The International Trade Journal*, Vol. 30 No. 4, pp. 319-344.

Sahin, B. E. (2019), “Impact of high technology export on economic growth: An analysis on Turkey”, *Journal of Business Economics and Finance*, Vol. 8 No. 3, pp. 165-172.

Santos, P. G., Ribeiro, A. P., & Carvalho, V. M. (2013), “Export-led growth in Europe: Where and what to export”, *FEP Working papers* 479.

Satrovic, E.(2018), “Economic Output and High-Technology Export: Panel Causality Analysis”, *International Journal of Economic Studies*, Vol. 4 No. 3, pp. 55-63.

Sinem Gokce S., Karatepe S. & Karagoz M. (2009), “The impact of R&D intensity on high-tech export: Case of Turkey and EU-27 countries”, *International Journal of Business and Economics Research*, Vol. 7 No. 6, pp. 191-202.

Solow, R. M. (1956), “A contribution to the theory of economic growth”, *The quarterly journal of economics*, Vol. 70 No. 1, pp. 65-94.

Soukiazis, E. & Antunes, M. (2011), “Is Foreign Trade Important for Regional Growth? Empirical Evidence from Portugal”, *Economic Modelling,* Vol. 28 No. 3, pp. 63–73.

Stern, S., Porter, M. & Furman, J. L. (2000), “The determinants of national innovative capacity”, *National Bureau of Economic Research*, Inc, NBER Working Papers 7876.

Sun, P. & Heshmati, A. (2010), “International trade and its effects on economic growth in China”, *iza*, Available at: https://docs.iza.org/dp5151.pdf

Tytell, I. & Emsbo-Mattingly, L. & Hofschire, D. (2016), “Secular Outlook for Global Growth: 2015–34”, *Business Economics. Palgrave Macmillan;National Association for Business Economics*, Vol. 51 No. 1, pp. 18-26.

Usman, M. (2017), “Impact of high-tech exports on economic growth: empirical evidence from Pakistan", *Journal on Innovation and Sustainability*, Vol. 8 No. 1, pp. 91-105.

Wabiga, P., & Nakijoba, S. (2018), "High Technology Exports, Gross Capital Formation and Economic Growth in Uganda: A Vector Auto Regressive Approach", *International Journal of Economics and Business Research*, Vol. 7 No. 5, pp. 5-13

Xiong, J., & Qureshi, S. (2013), "The quality measurement of China high-technology exports", *Procedia Computer Science*, Vol. 17, pp. 290-297.

Yanikkaya, H. (2003), "Trade openness and economic growth: a cross-country empirical investigation", *Journal of Development economics*, Vol. 72 No. 1, pp. 57-89.

Yıldız, Ü. (2017), "BRICS Ülkeleri ve Türkiye'de Yüksek Teknoloji İhracatı ve Ekonomik Büyüme İlişkisinin Panel Veri Analizi", *Dumlupınar Üniversitesi Sosyal Bilimler Üniversitesi Dergisi*, Vol. 53, pp. 26-34.

Yoo, S. H. (2008), "High-technology exports and economic output: an empirical investigation", *Applied Economics Letters*, Vol. 15 No. 7, pp. 523-525.

Young, A. (1991), "Learning by doing and the dynamic effects of international trade", *The Quarterly Journal of Economics*, Vol. 106 No. 2, pp. 369-405

Appendices

Appendix 1. Summary statistics

```
. encode Country, gen(ID)

. tsset ID Year
       panel variable:  ID (strongly balanced)
. sum *
```

Variable	Obs	Mean	Std. Dev.	Min	Max
Country	0				
Year	224	2013.5	4.040157	2007	2020
GDP	224	3.27e+12	4.45e+12	3.16e+11	2.00e+13
lnGDP	224	28.24808	.9954864	26.47943	30.62548
HT	224	9.18e+10	1.46e+11	1.31e+08	7.58e+11
lnHT	224	23.76663	2.127933	18.69	27.35353
LF	224	9.10e+07	1.84e+08	8648499	8.00e+08
lnLF	224	17.51971	1.04273	15.9729	20.50015
FC	224	8.42e+11	1.23e+12	4.60e+10	6.31e+12
lnFC	224	26.78883	1.108121	24.55217	29.47371
ID	224	8.5	4.620096	1	16

Appendix 2. Cross-section Dependence Test

Cross-Section Dependence Test
Series: GDP
Null hypothesis: No cross-section dependence (correlation)
Sample: 2007 2020
Periods included: 14
Cross-sections included: 16
Total panel observations: 224
Note: non-zero cross-section means detected in data
Cross-section means were removed during computation of correlations

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	950.8932	120	0.0000
Pesaran scaled LM	53.63392		0.0000
Bias-corrected scaled LM	53.01854		0.0000
Pesaran CD	24.76654		0.0000

Cross-Section Dependence Test
Series: HT
Null hypothesis: No cross-section dependence (correlation)
Sample: 2007 2020
Periods included: 14
Cross-sections included: 16
Total panel observations: 224
Note: non-zero cross-section means detected in data
Cross-section means were removed during computation of correlations

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	396.4528	120	0.0000
Pesaran scaled LM	17.84495		0.0000
Bias-corrected scaled LM	17.22957		0.0000
Pesaran CD	9.726795		0.0000

Cross-Section Dependence Test
Series: FC
Null hypothesis: No cross-section dependence (correlation)
Sample: 2007 2020
Periods included: 14
Cross-sections included: 16
Total panel observations: 224
Note: non-zero cross-section means detected in data
Cross-section means were removed during computation of correlations

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	402.7294	120	0.0000
Pesaran scaled LM	18.25011		0.0000
Bias-corrected scaled LM	17.63472		0.0000
Pesaran CD	8.621901		0.0000