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Analysis of Trade Openness and Economic Growth in Emerging Markets

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Abstract

The purpose of this research is to analyze the relationship between trade openness and economic growth for 21 emerging markets using the wavelet method. The results demonstrate that trade openness and economic growth are correlated. Furthermore, trade openness stimulates economic growth in 57% of emerging markets. İn addition to, causality is supported in 76% of the emerging markets. The results emphasize the positive impact of trade openness on economic growth in emerging markets. Therefore, the rate and number of customs duties in emerging markets should be reduced. Data availability is scarce, and recommendations depend on the discretion of policymakers. The findings demonstrate that trade has a significant impact on economic growth. The study applies a method frequently used in engineering to economics and produces unique results for emerging markets. Sustainability of both trade and economic growth is possible with policies that will increase low inflation and financial development.

JEL Classification: C02, F14, F43.
Keywords: Trade Openness, Economic Growth, Wavelet

Análısıs de la apertura comercıal y el crecımıento económıco en los mercados emergentes

Resumen

El propósito de esta investigación es analizar la relación entre la apertura comercial y el crecimiento económico en 21 mercados emergentes utilizando el método wavelet. Los resultados demuestran que la apertura comercial y el crecimiento económico están correlacionados. Además, la apertura comercial aumenta el crecimiento económico en el 57% de los mercados emergentes. Además, la causalidad se sustenta en el 76% de los mercados emergentes. Los resultados enfatizan el impacto positivo de la apertura comercial en el crecimiento económico en los mercados emergentes. Por lo tanto, la tasa y el monto de los aranceles aduaneros en los mercados emergentes deberían reducirse. La disponibilidad de datos es limitada y las recomendaciones dependen del criterio de los formuladores de políticas. Los hallazgos demuestran que el comercio tiene un impacto significativo en el crecimiento económico. El estudio aplica un método usado frecuentemente en ingeniería a la economía y produce resultados únicos para los mercados emergentes. La sostenibilidad tanto del comercio como del crecimiento económico es posible con políticas que incrementen la baja inflación y el desarrollo financiero.

Clasificación JEL: C02, F14, F43.
Palabras clave: Apertura comercial, crecimiento económico, Wavelet

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1. Introduction

Economic growth progresses in cycles. Economic cycles are explained by periodic oscillations. Naturally, they include expansion, growth, recession, and depression phases (Cantú et al., 2023). Nevertheless, there are factors that support economic growth. One of them is trade. Trade openness (TRD) is considered both the most important determinant and the biggest challenge of globalization in both developed and emerging markets (EMs). Therefore, it is a topic that attracts attention. The role of TRD on economic growth (GDP) is a focus of academic studies (Ben Abdallah, 2024). The idea that TRD is positively correlated with GDP is very old. In this study, we investigate the question of whether TRD stimulates to GDP in EMs that are striving to integrate into the global economy.

A. Smith was the first to systematically systematize the positive relationship between TRD and GDP. People seek to increase their own benefits through trade. Because the market is larger in international trade, profitability also increases. Smith explains this with the theory of absolute advantage (Schumacher, 2012). Ricardo agreed with Smith about the contribution of TRD to GDP, but had a new view about the source of trade. According to Ricardo, the condition for countries to gain from trade depends on their specialization in their comparative advantages. The Ricardian theory of comparative advantage points to differences in labor productivity as the basis for economies' relative advantages over one another (Konstantakopoulou & Tsionas, 2019).

One theory that looks elsewhere for the sources of growth is the Harrod-Domar model. Also known as the knife-edge growth model, this model argues that the driving force of growth is full employment. According to another theory, known as endogenous growth theory, Solow (1957) argues that economic growth is made possible by technology. Therefore, empirical studies can resolve this issue (Harrison, 1996; Hochstein, 2017). Although there are different theories, we focus on the empirical aspect of the relationship between TRD and GDP. In summary, trade links can affect economic activity between countries. For example, countries with significant trade relations can significantly impact each other's GDP as a result of exports and imports. If demand decreases in the US, a major export partner for Mexico, US imports will decrease, negatively impacting Mexico. Furthermore, global supply chains also have an impact on countries' GDP, as disruptions in the supply chain can negatively affect production processes spread across countries (Perales, 2024).

In empirical studies examining the relationship between TRD and GDP, inflation (INF), financial development (FD), and foreign direct investment (FDI) are generally considered as control variables (Mercan, Gocer, Bulut, & Dam, 2013; Asghar & Hussain, 2014; Uslu, Aydogan, & Ketenci, 2015; Malefane & Odhiambo, 2018; Epor, Yua, & Terhemba, 2024). Researchers have intensively investigated the relationship between TRD and GDP over the past 15 years (see Table 1). However, there is no consensus on the TRD-GDP relationship. One group of researchers argues that TRD improves GDP (Majeed, 2010; Marelli & Signorelli, 2011; Sakyi, Villaverde & Maza 2015; Tahir & Azid, 2015; Kong, Peng, Jiang & Wang 2021; Ben Abdallah, 2024). How TRD affects GDP is a question discussed in the literature. The answer can be complex. At its core is the specialization of economies. Indeed, with specialization in the division of labor, production becomes more efficient. Thus, the possibility of exchanging goods and services between national economies arises. This exchange means consuming lower-cost and higher-quality products. Therefore, with more efficient production, a wide variety of goods and services emerge, contributing to GDP (Atiq-ur-Rehman, Shaheen & Munir,

2021). According to another group of researchers TRD reduces GDP (Ugurlu, 2010; Ramzan, Sheng, Shahbaz, Song & Jiao, 2019; Fatima, Chen, Ramzan & Abbas, 2020; Udeagha & Ngepah, 2021; Rakshit, 2022). International trade is expected to have a positive impact on GDP. However, when increased TRD stimulates foreign capital investment, competition between domestic and foreign capital may be detrimental to the domestic investor (Ugurlu, 2010). In addition, it may reduce learning by importing (Ramzan et al., 2019). Therefore, TRD may slow down GDP.

In addition to time series methods, there are also studies in the literature that use a limited number of wavelet methods for TRD. Mutascu (2018) and Kalmaz & Kirikkaleli (2019) analyze the environmental relationship of TRD for France and Turkiye, respectively. Other studies generally analyze the relationship between TRD and the environment using the wavelet method (Mutascu & Sokic, 2020; Jun, Mahmood & Zakaria, 2020; Adebayo, 2021; Soylu, Adebayo & Kirikkaleli, 2021). To summarize the current literature, studies examining all EMs are limited. Furthermore, studies using the wavelet method, which is rarely preferred, analyze the TRD-CO2 relationship rather than the TRD-GDP relationship. This gap in the literature indicates that there is no TRD-GDP relationship that includes all EMs and uses the wavelet method.

In this study, the validity of the hypothesis that there is a positive relationship between TRD and GDP is analyzed for 21 EMs defined by Morgan Stanley Capital International (MSCI) using empirical methods. We use wavelet coherence analysis, which is one of the methods of engineering science. Wavelet approach analyses primarily focus on two questions. The first is whether wavelet fit coefficients can characterize time series data without bias, and the second is whether the original time series can be reconstructed from the wavelet fit coefficients. According to the current literature, the answers to both questions are affirmative. Furthermore, the Wavelet approach's ability to provide time-frequency output without requiring the analyzed data to meet the stationarity requirement offers a new perspective on alternative tests frequently used in the literature (Liu, 1994). Another advantage of the Wavelet method over traditional methods is that in addition to producing correlation and coefficient (positive or negative) outputs, it also reports causality results. Another advantage is that it presents the results by dividing them into low and high investment horizons. To our best knowledge, the relationship between TRD and GDP has not been analyzed using the wavelet method for all EMs. Another contribution of this study to the literature is the analysis of the longest available dataset for all EMs. Finally, the recommendations based on the analysis results will contribute to the literature. The other parts of the paper are structured as follows: The second section examines the literature on the relationship between TRD and the GDP. The third section explains data and the methodology of empirical method. The fourth section reports the findings with the help of figures. The last section offers policy recommendations for EMs in the light of the empirical results

2. Literature Review

There has been a great deal of research on the TRD-GDP relationship over the last 30 years. The literature sought to explain how TRD affected GDP rather than looking at the gains from trade in a particular period (Dao, 2014). Early studies were conducted for different countries and shaped the TRD-GDP literature (Dollar, 1992; Sach & Warner, 1995; Savvides, 1995; Edwards, 1998; Bahmani-Oskooee & Niroomand, 1999).

The empirical question asks whether TRD deficits positively affect GDP. There are many studies in the literature that test the question, with both countries and methods differing, so it is almost impossible to examine all studies. Uslu (2015) conducted an extensive literature search on EMs up to the early 2010s. A summary of the literature on EMs is provided in Table 1.

Table 1: Literature Summary on the Relationship Between TRD and GDP

Author(s) / Country / Period	Method and Variables	Findings
Panel A:	**Studies with time series and panel methods**	
Majeed (2010) / China, Malaysia, India, Indonesia, Philippines and Korea Rep./ 1970-2008	Fixed Effects and Random Effects / GDP, Gini Index, Human Capital, Gross Capital Formation, Inflation and TRD	TRD →+ GDP
Ugurlu (2010) / Greece / 1996-2004	Fixed Effect, Random Effect / GDP, Government Expenditure, Inflation, Investment, TRD	TRD →- GDP
Marelli & Signorelli (2011) / China and India / 1980-2007	Fixed Effect / GDP, Gross Capital Formation, TRD, FDI	TRD →+ GDP
Mercan et al. (2013) / Brazil, India, China and Turkiye / 1989-2010	Two-way Fixed Effects Model / GDP and TRD	TRD →+ GDP
Dao (2014) / Poland, Egypt, Korea, Malaysia, Mexico, Greece, Brazil, Hungary, Chile, Turkey, China, India, Colombia Indonesia, Philippines / 1980-2010	Fixed effect, random effect / GDP, TRD, Population, Life expectancy, Gross capital formation, government final consumption	TRD →+ GDP
Asghar & Hussain (2014) / Chile, China, Egypt, India, Indonesia, Korea, Malaysia, Philippines and Thailand / 1978-2012	Pedroni (2001), Hurlin and Venet (2001), Pedroni (2001) and FMOLS / GDP, Financial Development, TRD, FDI, Human Capital Index, Gross capital formation, Real interest rate	TRD →+ GDP, TRD ↔ GDP
Menyah, Nazlioglu & Wolde-Rufael (2014) / Egypt, S. Africa / 1965-2008	Panel Granger Causality-Konya (2006)/ GDP, TRD, Financial Development	GDP ← TRD
Chatterji, Mohan & Dastidar (2014) / India / 1970-2010	VAR, Granger Causality / TRD, Import Penetration Ratio, Trade Share, Total Taxes	TRD →+ GDP GDP←TRD
Tahir & Azid (2015) / Brazil, Chile, China, Colombia, Egypt, Indonesia, India, Malaysia, Mexico, Philippines, S. Africa, Thailand, Turkiye / 1990-2009	Fixed Effect / GDP, Capital, Investment, Labor force, Population, İndustrial Output, TRD	TRD →+ GDP
Pradhan, Arvin & Norman (2015) / India / 1994-2011	ARDL, VECM, Granger Causality / Export, Import, Total Trade, Banking Sector Depth, Stock Market Depth	TRD →+ GDP TRD ↔ GDP
Sakyi et al. (2015) / Greece, Hungary, Korea, Poland and Taiwan / 1970-2009	FMOLS, DOLS, CCEMG, Granger Causality / Income Per Capita, TRD	TRD →+ GDP TRD ↔ GDP
Uslu et al (2015) / Brazil, Chile, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, S. Africa, Thailand, Turkiye / 1995-2013	Pedroni (1999) and Westerlund (2006) / GDP, Financial Development, Money Supply, TRD	Cointegrated
Khalid (2016) / Turkiye / 1960-2014	ARDL / GDP, Trade Index, Export, Import, Gross Capital Formation	TRD →+ GDP

Iyke (2017) / Czechia , Hungary, Poland / 1994-2014	Fixed Effect / GDP, Labor force participation, Gross fixed capital formation, government consumption expenditure, exports, ımports TRD	TRD →+ GDP
Adeel-Farooq, Abu Bakar & Raji (2017) / Pakistan and India / 1985-2014	ARDL / GDP, TRD, financial liberalization index, human and physical capital	TRD →+ GDP
Malefane & Odhiambo (2018) / S. Africa / 1975-2014	ARDL / GDP, TRD, Investment, Government Consumption Expenditure, Inflation Rate and Financial Development	TRD →+ GDP
Asamoah, Mensah & Bondzie (2019) / S. Africa / 1996-2016	Structural equation model (SEM) / GDP, FDI, TRD, Human Capital Development, Financial Development, Natural Resource Rent,	TRD →+ GDP
Ramzan et al. (2019) / Brazil, Greece, Peru, Hungary, Philippines, Poland, India, Korea, S. Arabia, Chile, China, Colombia, Malaysia, Turkiye, United Arab Emirates, Egypt, Mexico / 1980-2014	Static Panel LSDV estimates, Two-step system GMM estimates / GDP, Inflation, Financial development, Capital Stock, Total Factor Productivity and TRD	TRD →- GDP
Fatima et al. (2020) / Brazil, Peru, Hungary, Philippines, Poland, India, Korea, S. Arabia, Chile, China, Colombia, Malaysia, South Korea, Turkiye, Mexico, United Arab Emirates, Egypt / 1980-2014	Panel Threshold Regression, Fixed Effect, GMM / GDP, TRD, Exports, Imports, Education, Public Expenditure, Capital, Labor, Private Credits, Inflation Rate, Government Expenditure	TRD →- GDP
Kong et al. (2021) / China / 1994-2018	ARDL / GDP quality, FDI, TRD, Real exchange rate fluctuation	TRD →+ GDP
Udeagha & Ngepah (2021) / S. Africa / 1960-2016	ARDL, NARDL, Gregory-Hansen, Markov / GDP, Capital-Labour, TRD, Human Capital, Health Expenditure, Infrastructure, Financial Development, Government Consumption	Short Run → TRD →+ GDP Lon Run → TRD →- GDP
Atiq-ur-Rehman et al. (2021) / Brazil, Chile, China, Czechia, Greece, Hungary, India, Indonesia, Malaysia, Mexico, Philippines, Peru, Poland, S. Africa, Thailand, Turkiye / 1995-2018	fixed effect and generalized method of moments / TRD, physical capital, The years of schooling, government expenditure, arable land, population	TRD →+ GDP
Arif et al. (2022) / India / 1980-2018	Westerlund (2007), pooled mean group, Mean group, common correlated effect mean group, Granger Causality / Financial development, TRD and GDP	TRD →+ GDP TRD x GDP
Rakshit (2022) / India / 1979-2017	ARDL, Toda-Yamamoto Causality Test / FDI, TRD, labour force, capital formation and GDP	TRD →- GDP TRD x GDP
Sghaeir (2023) / Egypt / 1991-2015	Pedroni (2001) / GDP, Fixed Capital Formation, FDI, Inflation, Government Spending, TRD	TRD →+ GDP
Kumari et al. (2023c) / India / 1985-2018	Johansen Cointegraiton, VAR, Granger Causality / FDI inflows, TRD, GDP	No cointegration TRD x GDP
Epor et al. (2024) / Brazil / 1990-2021	ARDL / GDP, FDI, TRD, Human Capital Development, Capital Stock, Financial Development	TRD →+ GDP, statistically insignificant result
Ben Abdallah (2024) / Egypt, Turkiye, Qatar, S. Arabia, Kuwait	ARDL, Granger / GDP, FDI, TRD, labor, and capital stock	TRD →+ GDP TRD ↔ GDP

and United Arab Emirates / 1990-2012		
Monyela & Saba (2024) / S. Africa / 1991-2021	Johansen Cointegration, VECM, Granger Causality / GDP, Human Development Index, TRD, Exchange Rates, FDI, Government Expenditure	TRD →+ GDP GDP←TRD
Panel B: Studies with WTC		
Mutascu (2018) / France / 1960-2013	WTC, Granger Causality / TRD and CO2	TRD→+CO2 TRD x CO2
Kalmaz & Kirikkaleli (2019) / Turkiye / 1960-2015	ARDL and WTC / CO2, GDP, TRD, Energy Consumption	CO2→+ TRD and CO2→+ GDP
Adebayo (2020) / Nigeria / 1981-2018	WTC, ARDL and Toda-Yamamoto Causality / GDP, Export, Gross Capital Formation, Gross Domestic Savings and FDI	GDP →+Export GDP ↔ Export
Mutascu & Sokic (2020) / European Union / 1960-2014	WTC / TRD and CO2	CO2 →+ TRD
Adebayo & Kalmaz (2020) / Nigeria / 1980-2018	ARDL, Toda-Yamamoto and WTC / GDP, Foreign Aid, TRD, Gross Fixed Capital Formation and Inflation	No cointegraiton GDP x TRD
Jun et al. (2020) / China / 1982-2016	WTC, Wavelet Based Causality / TRD and CO2	CO2 →+ TRD TRD → CO2
Husnain, Nasrullah & Khan (2021) / Canada, China, Germany, India, Iran, Japan, Russia, South Korea, USA / 1970-2018	WTC / GDP, TRD, Energy Consumption	EC →+ GDP EC →+ TRD
Adebayo (2021) / Indonesia / 1980-2016	WTC and ARDL / EC, TRD and CO2	GDP, EC, TRD →+ CO2
Soylu et al. (2021) / China / 1965-2019	Bayer and Hanck Cointegration Test, WTC, Gradual Shift Causality Test / GDP, TRD, Renewable Energy Consumption, CO2, Energy Use	GDP→+ CO2 TRD x CO2
Adebayo, Sevinc, Sevinc, Ojekemi & Kirikkaleli (2024) / Mexico, Indonesia, Nigeria, and Turkiye / 1961-2018	WTC / Ecological Footprint and TRD	EFP → + TRD

Notes: GDP: GDP, TRD: Trade Openness, EC: Energy Consumption, EF: Ecological Footprint, +: positive effect; −: negative effect; →: unidirectional causality (from GDP to TRD); ←: unidirectional causality (from TRD to GDP); ↔: bidirectional causality

There is no consistent result between TRD and GDP. This is due to differences in both countries and periods. Different studies report different results in the same countries. For example, in India, Majeed (2010) presents that TRD has positive impact on GDP, Rakshit (2022) reports negative impact. A similar result is available for Greece. Ugurlu (2010) suggest that TRD increases GDP, whereas Atiq-ur-Rehman et al. (2021) suggest that negative effect. Similar results have been found in studies conduct for Brazil, China, India and Turkiye. While Mercan et al (2013) provides evidence that TRD and GDP are positive relationship, and Ramzan et al. (2019) reports that TRD and GDP have negative relationship.

Inconsistent results are obtained not only for the same country and different studies, but also for the same tests and different countries. For example, Kumari et al. (2023) report that TRD and GDP

haven't long-term relationship for India in Johansen Cointegration test, while Monyela & Saba (2024) suggest that TRD and GDP are cointegrated for South Africa in Johansen Cointegration test. Similarly, Malefane & Odhiambo (2018) find that significant cointegrated variables in ARDL, but Epor et al. (2024) reports that insignificant relationship among variables in same test.

The differing results for TRD and GDP in EMs may be due to time series and panel methods tests commonly used in studies. Therefore, this article differs from the research in the literature because it analyzes with the method known as wavelet transformed coherence in engineering. Studies investigating TRD or GDP using the wavelet are limited in the literature. These papers are as follows: Mutascu (2018) for France, Kalmaz & Kirikkaleli (2019) for Turkiye, Adebayo (2020) for Nigeria, Mutascu & Sokic (2020) for European Union, Adebayo & Kalmaz (2020) for Nigeria, Jun et al. (2020) for China, Husnain et al. (2021) for Canada, China, Germany, India, Iran, Japan, Russia, Korea and USA, Adebayo (2021) for Indonesia, Soylu et al. (2021) for China, Adebayo et al. (2024) for Mexico, Indonesia, Nigeria, and Turkiye. We implemented the wavelet coherence approach since it allows us to picture any correlation between two-time series x and y in combined time-frequency-based causalities (Kalmaz & Kirikkaleli, 2019).

Although researchers have shown considerable interest in TRD and GDP in literature, they conduct analyses using conventional methods. To our best knowledge, there is no study in literature that analyzes the relationship between TRD and GDP using the wavelet method for all EMs. Furthermore, the analysis of the longest available dataset is another contribution to the literature.

3. Data and Econometric Methodology

3.1. Data Description

The variables used in the analysis, the abbreviations used in the study, the calculation methods and the source from which they were obtained are shown in Table 2. In the analysis of the relationship between TRD and GDP, we use control variables in the study. These are INF, FD and FDI, respectively. According to the Barro-Gordon model, INF is negatively related to TRD. The model argues that an unexpected increase in the money supply will increase INF. Government savings are also related to INF. Increasing INF through public policies can negatively affect TRD and indirectly GDP (Ugurlu, 2010). There are various possible effects of FD. These can be listed as the formation of a priori information about investments, monitoring of investments, direction of TRD, and aggregation of savings. These effects can affect TRD. Thus, FD can indirectly affect GDP (Asghar & Hussain, 2014). FDI is related to capital formation in an economy. Especially if sufficient capital stock can be provided to EMs, it is possible to achieve higher growth rates. Also, the increased investment level through FDI offers an advantage for EMs to converge with developed economies in the long term (Rakshit, 2022).

Table 2. Definition of Variables

Variables	Representation	Measurement	Source
Economic Growth	GDP	GDP per capita growth (annual %)	WDI (2025)
Inflation	INF	Consumer prices (annual %)	WDI (2025)

Financial Development	FD	Domestic credit to private sector by banks (% of GDP)	WDI (2025)
Foreign Direct Investment	FDI	Foreign direct investment, net inflows (% of GDP)	WDI (2025)
Trade Openness	TRD	Trade (% of GDP)	WDI (2025)

Source: Author's own elaboration

In this study, we test the effects of TRD on GDP for EMs. For this, we follow MSCI's EMs classification. Since data is not available for all countries, the sample consists of 21 countries. Annual data covers the period from 1970 to 2023. We choose the data period with the longest time interval according to data availability. Data size varies for each country depending on data availability. Therefore, the number of observations and start/end dates are listed in Table 3.

Table 3. Data and Periods

Countries	Years	Countries	Years	Countries	Years
Brazil	1981-2023	India	1970-2021	Philippines	1981-2023
Chile	1971-2023	Indonesia	1980-2023	Poland	1995-2023
China	1987-2023	Korea	1970-2023	Qatar	1994-2022
Colombia	1990-2023	Kuwait	1991-2022	S. Arabia	1970-2017
Czechia	1993-2023	Malaysia	1970-2023	S. Africa	1992-2023
Egypt	1970-2023	Mexico	1970-2023	Thailand	1970-2023
Hungary	1991-2023	Peru	1970-2022	Turkiye	1970-2023

Source: Author's own elaboration

3.2. Econometric Methodology

Since the wavelet transform method does not require stationarity analysis of the data set, it offers a new perspective on Fourier spectrum analysis (Liu, 1994). Traditionally, Fourier coherence reveals the correlation between two different time series data. Torrent & Webster (1999) define wavelet coherence using time and scale smoothing, where the amount of smoothing depends on both the choice of wavelet and the scale. Given two different datasets X and Y with wavelet transforms $W_n^X(s)$ and $W_n^Y(s)$, where n represents time and s represents scale, defined as follows: (Torrence & Webster 1999):

$$W_n^{XY}(s) = W_n^X(s)W_n^{Y*}(s), \tag{1}$$

where (*) indicates complex conjugate. $W_n^X(s)$ and $W_n^Y(s)$ are continuous wavelet transforms of X and Y, respectively.

$$R_n^2(s) = \frac{|\langle s^{-1}W_n^{XY}(s)\rangle|^2}{\langle s^{-1}|W_n^X(s)|^2\rangle\langle s^{-1}|W_n^Y(s)|^2\rangle}, \tag{2}$$

where $\langle\ \rangle$ and s represent the smoothing in time scale and the smoothing along the investigated cycle with frequency, respectively. Thus, $0 < R_n^2(s) < 1$. The closer the value is to 1, the more relevant the data is.

The wavelet-coherence phase difference is calculated as in equation (3),

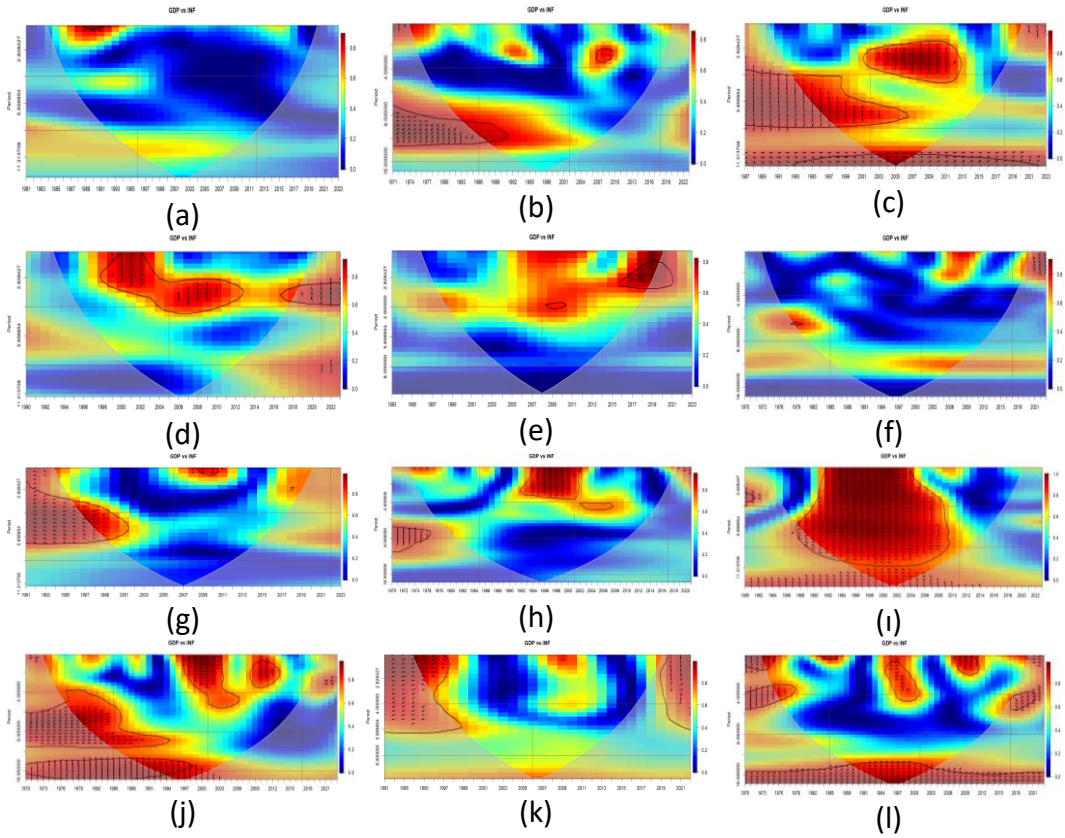
$$\phi_n(s) = \tan^{-1}\left(\frac{\Im\{\langle s^{-1}W_n^{XY}(s)\rangle\}}{\Re\{\langle s^{-1}W_n^{XY}(s)\rangle\}}\right), \tag{3}$$

where ($\Re$) is smoothed real, ($\Im$) is imaginary parts. These values need to be estimated already in (2). Also, $R_n^2(s)$ and $\phi_n(s)$ are functions of n and s.

4. Results and discussion

When interpreting wavelet coherence, the white cone represents the influence cone. Significance levels are shown with a thick black line. Significance levels are calculated with Monte Carlo simulation. In the figures, time is on the horizontal axis and frequency is on the vertical axis. In addition, the scale increases as frequency decreases. In the time-frequency domain, two-time changes are positioned according to the wavelet coherence. The intensity of the relationship increases as the coloring increases towards red, while the color increases towards blue, indicating that the change between the series decreases. (Adebayo, 2020).

As used in the field of economics, this article investigates both correlation and causality results using wavelet analysis (Kalmaz & Kirikkaleli, 2019; Adebayo et al., 2024). Arrows indicate causality and correlation. If the arrows point to the → (←) at 90, it indicates + (-) correlation. If the arrows point ↓ (↑) at 90, it focuses on causality from GDP to TRD (from TRD to GDP) (Yavuz, Ergen, Avci, Akcay & Kilic, 2024). The wavelet coherence results of EMs (GDP vs INF) are shown in Figure 1.



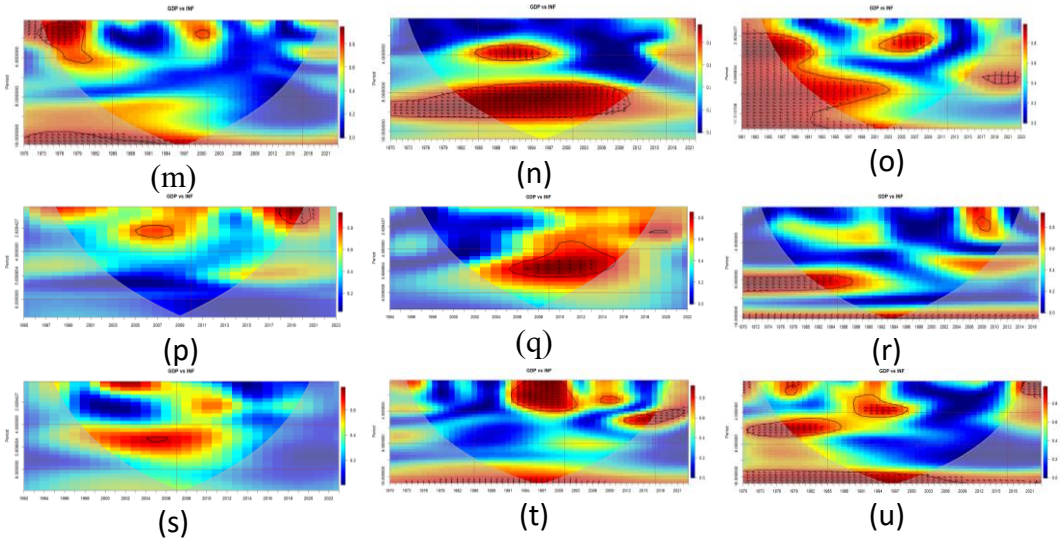
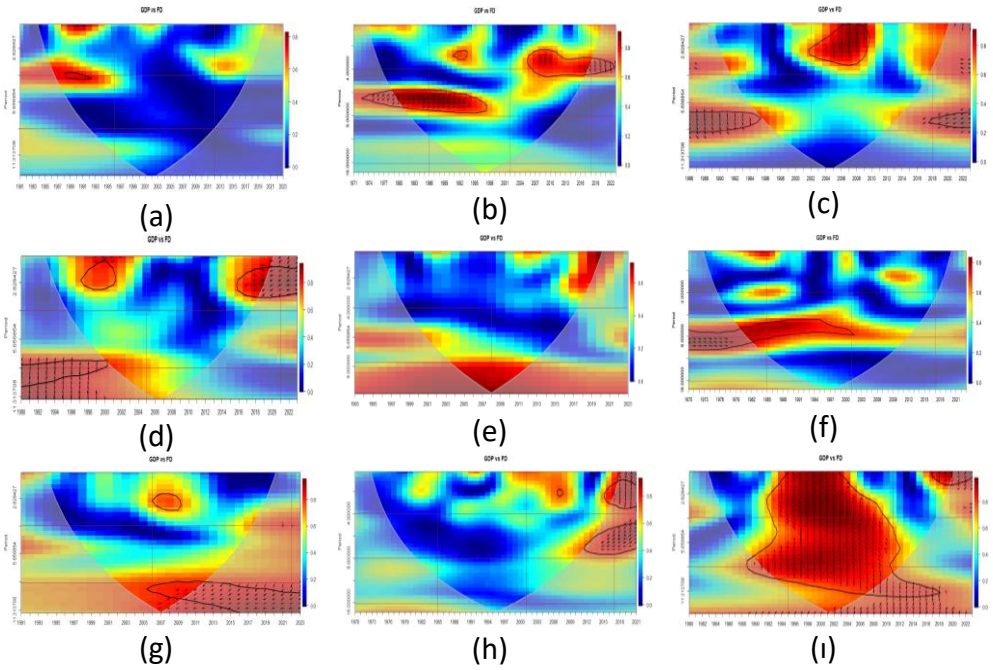


Figure 1. Wavelet Coherence Results (GDP vs INF)

Notes: (a) Brazil, (b) Chile, (c) China, (d) Colombia, (e) Czechia, (f) Egypt, (g) Hungary, (h) India, (ı) Indonesia, (j) Korea, (k) Kuwait, (l) Malaysia, (m) Mexico, (n) Peru, (o) Philippines, (p) Poland, (q) Qatar, (r) S. Arabia, (s) S. Africa, (t) Thailand, (u) Turkiye.

According to Figure 1, INF increases GDP in China (2002-2007), S. Arabia (2007) and Thailand (2013-2017). However, it is negatively related to GDP in Brazil (1988-1991), Hungary (1997-1999), Indonesia (1988-2008), Korea (1978-1990 and 1997-2003), Malaysia (1996-1997), Mexico (1974-1979), Peru (1983-2008), Philippines (1985-1996), S. Arabia (1981-1985), Thailand (1993-2001) and Turkiye (1978-1984 and 1991-2002). The wavelet coherence results of EMs (GDP vs FD) are shown in Figure 2.



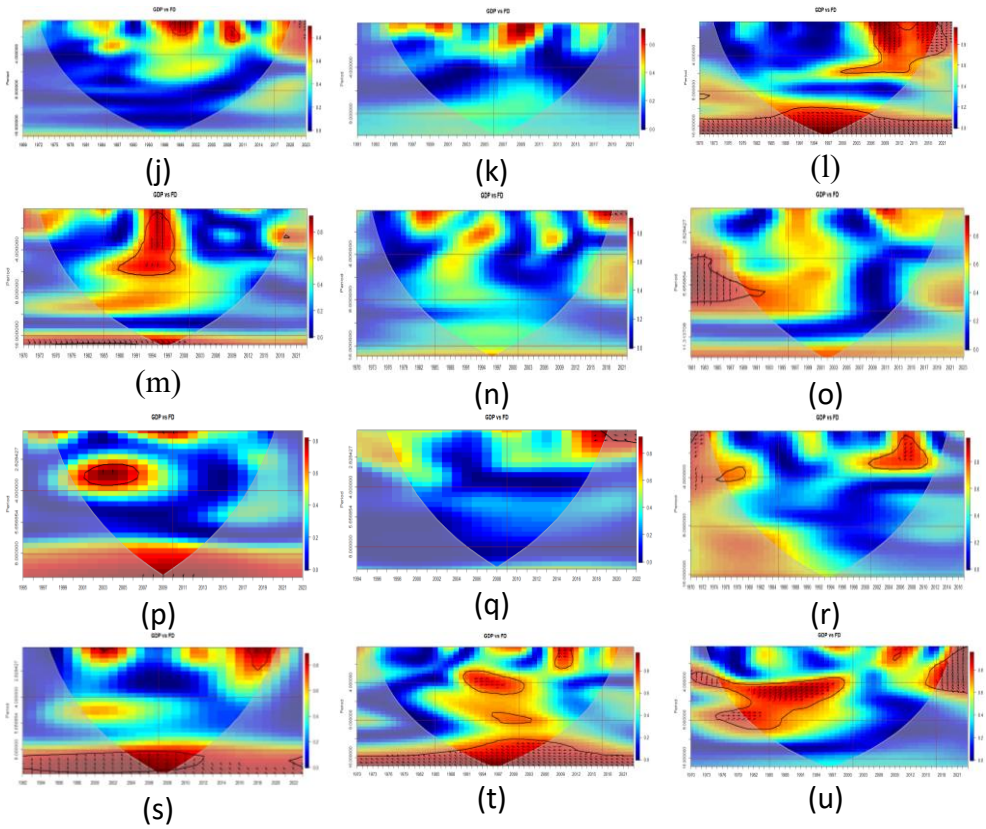
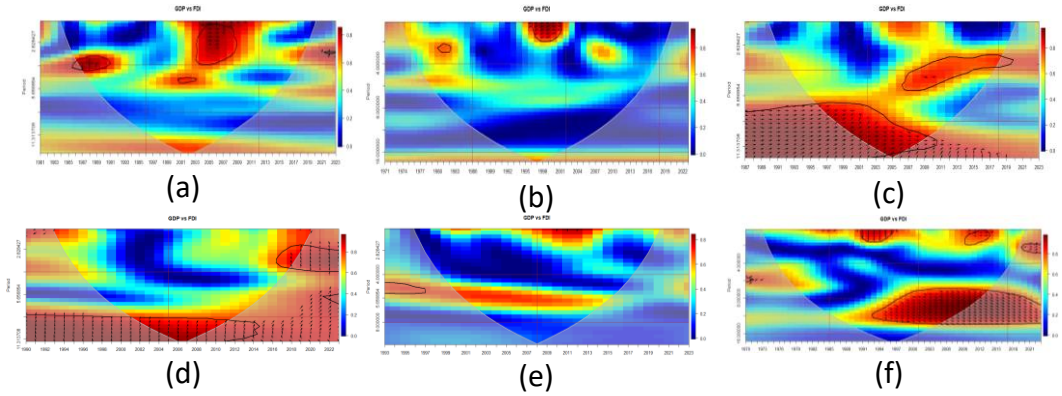


Figure 2. Wavelet Coherence Results (GDP vs FD)
Notes: (a) Brazil, (b) Chile, (c) China, (d) Colombia, (e) Czechia, (f) Egypt, (g) Hungary, (h) India, (ı) Indonesia, (j) Korea, (k) Kuwait, (l) Malaysia, (m) Mexico, (n) Peru, (o) Philippines, (p) Poland, (q) Qatar, (r) S. Arabia, (s) S. Africa, (t) Thailand, (u) Turkiye.

In Figure 2, FD increases GDP in the limited sample. FD is positively associated with GDP at low investment horizons in Indonesia (2004) and Turkiye (1980-1997). In contrast, FD is negatively correlated with GDP in Chile (1990-1993), Colombia (1999-2001 and 2016-2018), Hungary (2007-2009), Indonesia (2004 and 2009-2010), Malaysia (1991-2004 and 2015-2018), Peru (2017-2018), Qatar (2018), S. Arabia (2007-2008) and Thailand (1993-2010). The wavelet coherence results of EMs (GDP vs FDI) are shown in Figure 3.



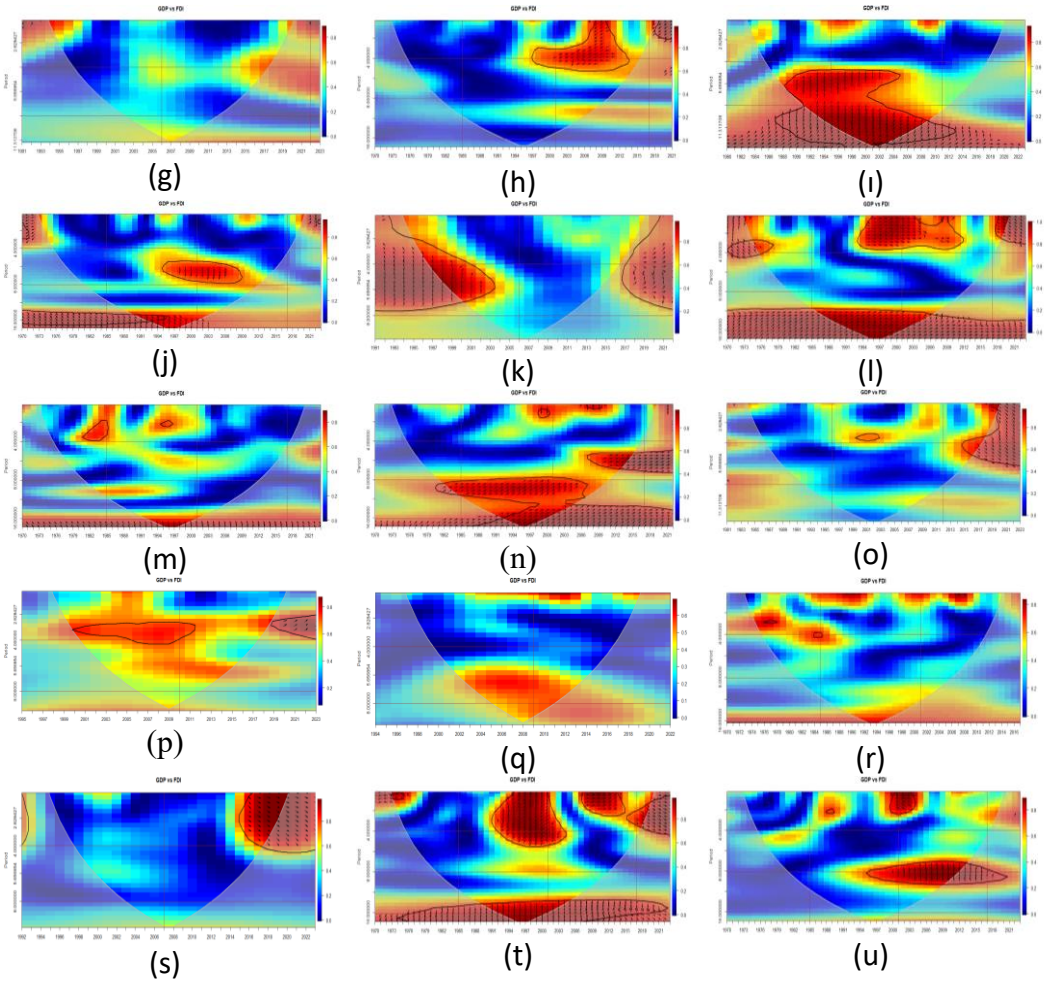
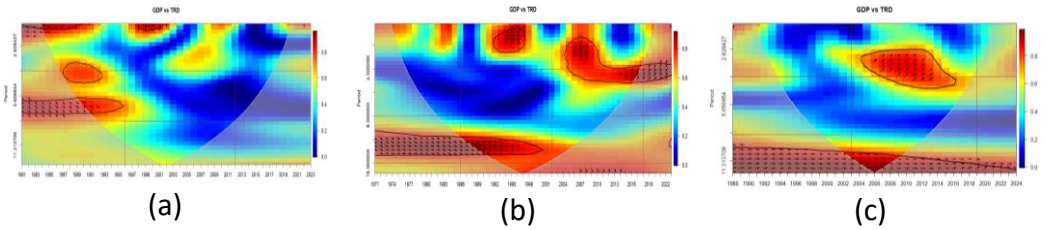


Figure 3. Wavelet Coherence Results (GDP vs FDI)
Notes: (a) Brazil, (b) Chile, (c) China, (d) Colombia, (e) Czechia, (f) Egypt, (g) Hungary, (h) India, (ı) Indonesia, (j) Korea, (k) Kuwait, (l) Malaysia, (m) Mexico, (n) Peru, (o) Philippines, (p) Poland, (q) Qatar, (r) S. Arabia, (s) S. Africa, (t) Thailand, (u) Turkiye.

The relationship between FDI, which was added to the model as a control variable, and GDP is presented in Figure 3 for 21 EMs. According to Figure 3, FDI increases GDP in Brazil (2003-2006), China (1996-2010), Egypt (1995-2013), Malaysia (1986-2009), Peru (1992-1995 and 2009-2014) and Thailand (2006-2012). The sample where FDI is negatively related to GDP is limited. These are Chile (1995-2020), India (2001-2011) and Turkiye (2000-2003). In summary, while FDI supports GDP in about 29% of countries, it negatively impacts it in about 14%. The wavelet coherence results of EMs (GDP vs TRD) are shown in Figure 4.



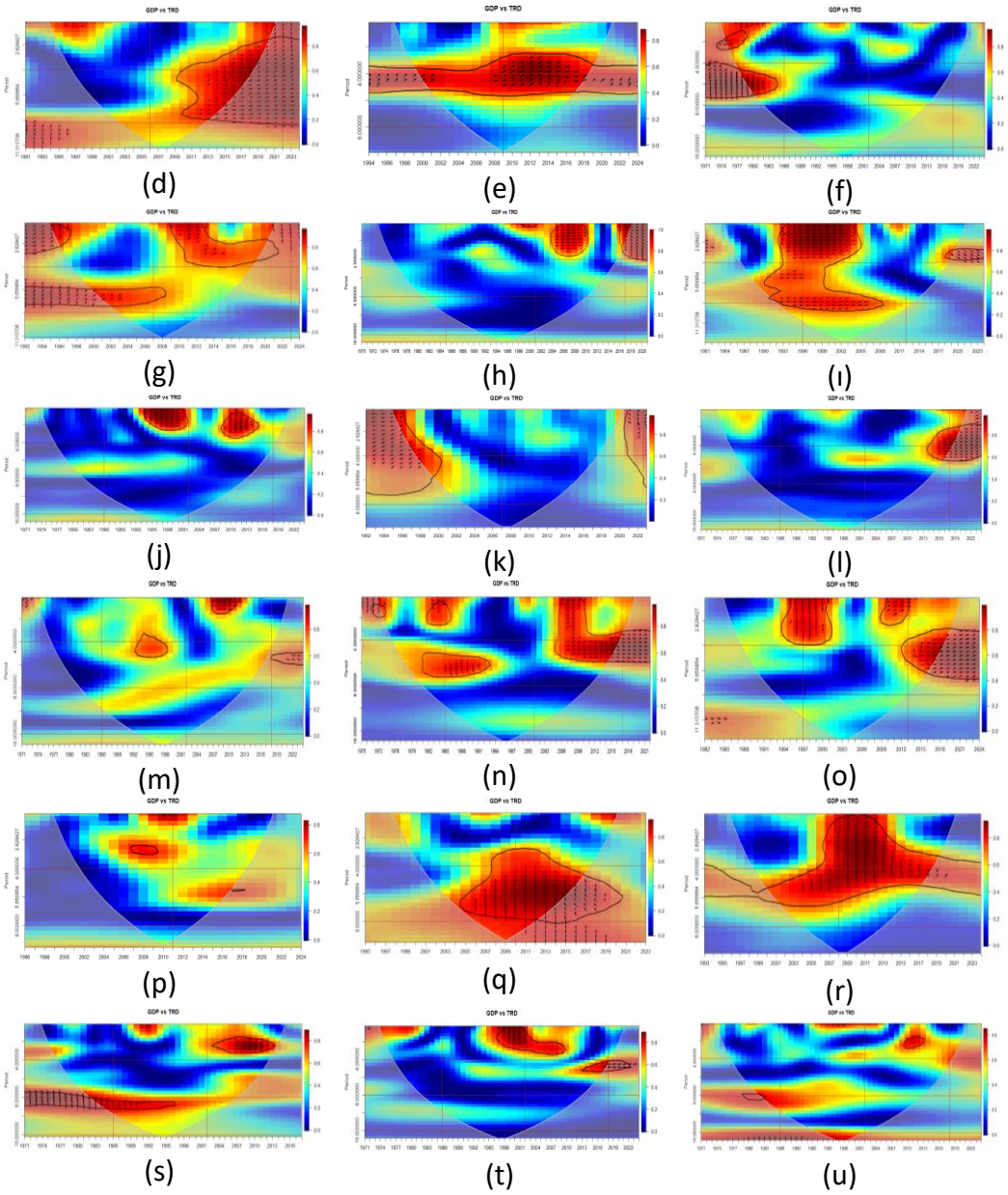


Figure 4. Wavelet Coherence Results (GDP vs TRD)
Notes: (a) Brazil, (b) Chile, (c) China, (d) Colombia, (e) Czechia, (f) Egypt, (g) Hungary, (h) India, (ı) Indonesia, (j) Korea, (k) Kuwait, (l) Malaysia, (m) Mexico, (n) Peru, (o) Philippines, (p) Poland, (q) Qatar, (r) S. Arabia, (s) S. Africa, (t) Thailand, (u) Turkiye.

According to Figure 4, TRD improves GDP in Chile (1992-1999), in China (2002-2009), in Colombia (2011-2019), in Czechia (2008-2018), in Hungary (2009-2016), in Malaysia (2015-2016), in Mexico (2007-2012), in Peru (2006-2018), in Philippines (2009-2020), S. Arabia (2006-2012), S. Africa (2008-2012) and in Thailand (2016-2018). Some studies in the literature have reached similar conclusions. Such as: Iyke, 2017; Malefane & Odhiambo, 2018; Asamoah et al., 2019; Kong et al., 2021; Monyela & Saba, 2024. According to Figure 4, TRD and GDP have negative relationship in Brazil (1985-1989), in Chile (1973-1978), in Colombia (2011-2019), in India (1999-2002 and 2005-2011), in Indonesia (1994-2007), in Korea (1994-2001), in Kuwait (1996-1998), in Peru (1982-1987), S.

Arabia (1990-1993) and Thailand (1997-1998). Scarced studies in the literature have reached similar conclusions (see Ramzan et al., 2019; Fatima et al., 2020).

According to Figure 4, there is unidirectional causality (GDP→TRD) in Brazil (1998-2002), in China (2006-2015), in Hungary (1996-2003), in Korea (2009-2014), in Philippines (1994-2001), in Qatar (2006-2016), in S. Arabia (1983-1990), in S. Africa (2004-2018) and in Thailand (1999-2002). In some countries, unidirectional causality (GDP←TRD) is seen in Figure 4. These countries are: Egypt (1978-1983), Peru (1986-1993), Poland (2009-2011) and Turkiye (1996-1998). In limited countries, there is bidirectional causality (GDP↔TRD). According to Figure 4, these countries are: Colombia (2013-2015), Czechia (2014-2016) and Indonesia (1993). The summary results of the findings described are in Table 4.

Table 4: Summary of Results (GDP vs TRD)

Countries	Corre-lation	Relation	Causality	Countries	Corre-lation	Relation	Causality
Brazil	✓	- (1985-1989)	→ (1998-2002)	Malaysia	✓	+ (2015-2016)	x
Chile	✓	- (1973-1978) and + (1992-1999)	x	Mexico	✓	+ (2007-2012)	x
China	✓	+ (2002-2009)	→ (2006-2015)	Peru	✓	- (1982-1987) and + (2006-2018)	← (1986-1993)
Colombia	✓	- (1996-1998) and + (2011-2019)	↔ (2013-2015)	Philippines	✓	+ (2009-2020)	→ (1994-2001)
Czechia	✓	+ (2008-2018)	↔ (2014-2016)	Poland	✓	x	← (2009-2011)
Egypt	✓	x	← (1978-1983)	Qatar	✓	x	→ (2006-2016)
Hungary	✓	+ (2009-2016)	→ (1996-2003)	S. Arabia	✓	- (1990-1993) and + (2006-2012)	→ (1983-1990)
India	✓	- (1999-2002) and + (2005-2011)	x	S. Africa	✓	+ (2008-2012)	→ (2004-2018)
Indonesia	✓	- (1994-2007)	↔ (1993)	Thailand	✓	- (1997-1998) and + (2016-2018)	→ (1999-2002)
Korea	✓	- (1994-2001)	→ (2009-2014)	Turkiye	✓	x	← (1996-1998)
Kuwait	✓	- (1996-1998)	x				

Notes: +: positive effect; −: negative effect; →: unidirectional causality (from GDP to TRD); ←: unidirectional causality (from TRD to GDP); ↔: bidirectional causality

The findings are clearly seen in Table 4. There is a relationship between GDP and TRD in all 21 EMs. Also, TRD affects GDP positively or negatively except Egypt, Poland, Qatar and Turkey. In addition, there is causality between GDP and TRD except Chile, India, Kuwait, Malaysia and Mexico. TRD positively affects GDP in 12 EMs (Chile, China, Colombia, Czechia, Hungary, Malaysia, Mexico, Peru, Philippines, S. Arabia, S. Africa and Thailand), while it negatively affects it in 9 EMs (Brazil, Chile, Colombia, India, Indonesia, Korea, Kuwait, Peru, S. Arabia and Thailand).

The findings are consistent with the literature because TRD is expected to improve GDP. Wavelet results of the GDP and TRD relationship are shown in Figure 4. Table 5 and Table 6 in the appendix show robustness tests. Accordingly, the correlation results of the variables are 67% consistent. The causality results are 34% consistent. Because the wavelet method offers several advantages. First, it allows the choice of the basis of the expansion of the signal. Second, the frequency range can be determined. Third, the wavelet method makes it possible to show characteristic oscillatory rhythms (Pavlov et al. 2012). Finally, it allows to monitor two data sets both in time and frequency (Yavuz et al., 2024). In 52% of the sample, INF is negatively correlated with GDP. INF can negatively affect EMs' TRD by increasing the relative price of goods, thus decreasing GDP. Thus, INF indirectly reduces GDP. While FD positively affects GDP in 2 countries, it negatively affects it in 9 countries. This situation is expressed by Lucas (1988) as finance has no effect on GDP. In more clear terms, it states that the effect of finance on GDP is overemphasized. In fact, the findings of the study can be explained by the fact that EMs are economies with high volatility that are subject to structural changes (Uslu et al 2015). In almost one-third of the sample, FDI is positively correlated with GDP. FDI increases production capacity and hence marketable output. Thus, it indirectly stimulates GDP.

Volatility has been a problem for EMs in the last decade. Economic crises, in addition to regime changes and stabilization policies, have increased the importance of studying GDP in EMs. EMs are exposed to both internal and external shocks more frequently and significantly than developed countries (Ibragimov, Ibragimov & Walden, 2015). There are different results in the literature. The preferred methods can be shown as the reason for this situation. Because EMs have volatile data. Therefore, they should be examined in both the long and short term. Since it is a time-varying test, the fact that the years other than economic crisis periods can be examined in both the long and short term constitutes the difference of this study from other studies. Since the wavelet method is advantageous in this regard, it was preferred in the study.

According to the correlation results in Figure 4, the correlation relationship between TRD and GDP is seen in all 21 EMs. The findings in Figure 4 show that TRD increases GDP in 57% of the sample. This result is in line with the general results in the empirical literature. The findings suggest that TRD can significantly increase GDP in EMs, which is to be expected because trade can help countries acquire advanced technology and expand into regions where the market is large, thus stimulating GDP. In addition, when the causality results in Figure 4 are examined, there is a causality relationship in 76% of the sample. While this relationship is bidirectional in 3 countries, it is unidirectional in 13 countries. In other words, TRD and GDP support each other in EMs. This can be interpreted as a complementary result to the findings that TRD promotes GDP. The global economy is increasingly influenced by EMs. Over the last two decades, these economies have become much more integrated with global markets, creating greater economic "spillovers" to the rest of the world. This effect also spreads to other countries and companies through trade (IMF, 2024). Indeed, the improving effect of TRD on GDP has been evident since the 2000s, as can be seen in Table 4. International trade in EMs has increased rapidly since the 1990s. An interesting question is why this is happening. Because most EMs became members of the World Trade Organization (WTO) in 1995 (WTO, 2025). In addition, in the last decade, not only lower labor costs but also high value-added services have been the focus of trade in EMs. The changing demographic structure in EMs is also notable for the change in demand for consumer goods. For example, a decrease in the national median age is expected in India.

Similarly, it is known that 50% of the population in Indonesia is under the age of 29 (ITC, 2011). Therefore, increasing demand in EMs improves GDP.

5. Conclusion and Policy Implications

This article investigates the relationship between TRD and GDP in 21 EMs for the period 1970-2023. While studies investigating the relationship between GDP and TRD focus on classical tests, this study uses the wavelet method to examine the existing effect, unlike other studies. Thus, it aims to contribute to the literature. Wavelet presents a detailed analysis in terms of frequency and time. Since it is a parametric method, it investigates nonlinear relationships without any loss of information. In addition, it explains both the direction and strength of the relationship between two data sets. Thus, it enables the findings to be interpreted in detail.

TRD has an effect on GDP in all the examples considered in the analysis. The last two decades are especially noteworthy in the examples where TRD improves the GDP. While there is a unidirectional causality from GDP to TRD in 9 EMs, there is a unidirectional causality from TRD to GDP in 4 examples. In addition, there is bidirectional causality in 3 EMs. This means that increasing TRD will improve GDP.

Brazil, Indonesia, Korea, and Kuwait have a negative correlation with GDP. It's unlikely that TRD would negatively impact GDP for this group of countries. This could be due to the negative impact on domestic production due to imports. Furthermore, learning by doing could be negatively impacted by foreign trade in these countries. In summary, these countries demonstrate that the hypothesis tested in this study is not valid. The following recommendations can be made for these countries:

- Import substitution policies should be implemented,
- Human capital investments should be increased,
- Tax policies should be implemented to support domestic production.

China, Czechia, Hungary, Malaysia, Mexico, and S. Africa demonstrate a positive relationship between TRD and GDP. Therefore, the hypothesis tested in the study (TRD positively impacts GDP) cannot be rejected. TRD increases GDP in these countries. Therefore, the following recommendations can be made for these countries:

- Reduce customs duties both in terms of rate and amount,
- Ensure the rule of law,
- Increase infrastructure investments,
- Ensure a trustworthy environment.

In addition, it is recommended to reduce transaction costs, as low costs are important in trading. Cryptocurrencies, which share characteristics with traditional currencies, have the advantage of low transaction costs and the ability to be converted into various currencies globally. Due to these advantages, trading can be carried out with cryptocurrencies (Cerecedo Hernández et al., 2019).

Although the article contributes to the effect of TRD on GDP, it has some limitations. First, the study analyzes a limited number of countries. Future research may prefer to examine a wider range of countries. Second, this article analyzes the effect of trade. Future researchers can include the effects of technological development and artificial intelligence in their forecasting models. Finally, this

article prefers the Wavelet method, which can produce periodic findings. In the future, researchers can repeat similar analyses with long memory and fractional integration-based methods and obtain comparative findings.

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Appendix

Table 5. Robustness check for Wavelet, ARDL Results for 21 EM's

Dependent Variable: GDP								
	Brazil	**Chile**	**China**	**Colombia**	**Egypt**	**Hungary**		
INF	0.01	-0.17**	-0.02	-0.08***	-0.24*	-0.56***		
FD	-0.08**	-0.19*	-0.03*	-0.09*	-0.12*	-0.28		
FDI	-1.05***	-0.28	0.25	-0.62	0.55*	-0.01		
TRD	0.29**	0.23**	0.10*	0.62*	0.04***	-0.07		
c	0.78	4.19	7.79	-15.46**	5.83*	27.81***		
F-stat Bounds Test	5.97	3.492	7.07	3.60	7.71	1.89		
ECM	-1.28*	-0.98*	-2.03*	-6.57*	-1.03*	-1.18*		
R^2	0.77	0.78	0.93	0.94	0.65	0.91		
F-Stat	2.82**	5.81*	10.04*	3.13***	3.89*	3.11***		
Cusum	✓	✓	✓	✓	✓	✓		
Cusum²	✓	✓	✓	✓	✓	✓		
	India	**Korea**	**Peru**	**Philippines**	**Poland**			
INF	0.13	-0.23*	-0.01*	-0.51*	0.08			
FD	0.03	-0.06	-0.05	-0.08	0.02			
FDI	-5.29*	-0.65	1.35*	-0.34	0.21			
TRD	0.35*	-0.03	0.07	0.04	-0.03			
c	-4.05***	13.95*	-2.64	5.82***	4.63**			
F-stat Bounds Test	8.26	11.80	7.66	10.77	3.53			
ECM	-1.69*	-1.02*	-1.21*	-1.31*	-1.79*			
R^2	0.71	0.49	0.68	0.82	0.84			
F-Stat	3.66*	9.17*	6.42*	6.44*	4.14**			
Cusum	x	✓	✓	✓	✓			
Cusum²	✓	✓	✓	x	✓			
	Qatar	**S. Arabia**	**S. Africa**	**Thailand**	**Turkiye**			
INF	0.60***	0.47**	0.13	4.77	-0.14*			
FD	0.04	0.17*	0.936**	0.42	-0.12***			
FDI	0.08	-1.76*	0.09	8.72	-5.46*			
TRD	-0.63**	-0.05	-0.24***	-0.11	0.29*			
c	57.99**	-2.38	-42.80**	-57.03	4.11***			
F-stat Bounds Test	8.53	9.74	2.24	3.65	8.31			
ECM	-1.47*	-1.61*	0.86*	0.10*	-1.17			
R^2	0.77	0.87	0.79	0.69	0.65			
F-Stat	-3.64**	7.09*	2.74**	4.11*	2.38**			
Cusum	✓	✓	✓	✓	✓			
Cusum²	✓	✓	x	✓	✓			
F-Bounds Test	I(0)	(%1) 3.29	(%5) 2.56	(%10) 2.2	I(1)	(%1) 4.37	(%5) 3.49	(%10) 3.09

Notes: Since the dependent variable is I(0), there is no ARDL result for Czechia, Indonesia, Kuwait, Malaysia and Mexico. *, **, and *** show significance at the 1%, 5%, and 10% levels, respectively. ARDL test represent cointegration test of Pesaran et al. (2001). The null hypothesis is no relationship in levels between variables.

Table 6: Robustness check for Wavelet, Granger Causality Results for 21 EM's

GDP → TRD					
Countries	**p-value**	**Countries**	**p-value**	**Countries**	**p-value**
Brazil	0.0435	India	0.6047	Philippines	0.2942
Chile	0.0785	Indonesia	0.6419	Poland	0.0025
China	0.0983	Korea	0.1084	Qatar	0.0435
Colombia	0.0118	Kuwait	0.9967	S. Arabia	0.0980
Czechia	0.0136	Malaysia	0.5901	S. Africa	0.2661
Egypt	0.6470	Mexico	0.0648	Thailand	0.0460
Hungary	0.7461	Peru	0.2891	Turkiye	0.0083
GDP ← TRD					
Countries	**p-value**	**Countries**	**p-value**	**Countries**	**p-value**
Brazil	0.0027	India	0.0079	Philippines	0.2041
Chile	0.3443	Indonesia	0.8867	Poland	0.6579
China	0.6129	Korea	0.0205	Qatar	0.0027
Colombia	0.8619	Kuwait	0.0940	S. Arabia	0.0073
Czechia	0.5592	Malaysia	0.5901	S. Africa	0.0313
Egypt	0.0185	Mexico	0.4361	Thailand	0.3018
Hungary	0.3073	Peru	0.4919	Turkiye	0.3143

Notes: Granger causality test represent the time series causality test of Engle and Granger (1987). The null hypothesis is regressor variable does not cause dependent variable.