DETERMINANTS OF MANUFACTURING INDUSTRY EXPORTS IN BRICS COUNTRIES

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ABSTRACT

This study aims to analyze the determinants of manufacturing industry exports in BRICS countries (Brazil, Russia, India, China, and South Africa), with a particular emphasis on the role of Foreign Direct Investments (FDI). To this end, a panel data model based on a Vector Error Correction method (VECM) was employed for the period from 2001 to 2022. This approach enabled the identification of FDI's influence and other determining factors on manufacturing exports in BRICS countries, considering each country's characteristics within specified time frames. Results demonstrated that FDI, Gross Capital Formation (GCF), and average years of schooling have a positive impact on manufacturing exports. A 1% increase in FDI is associated with a 0.40% increase in exports, while increases in GCF and average years of schooling contribute to an increase in exports by 1.12% and 0.53%, respectively. Exchange rates, although not statistically significant, had a negative relationship, suggesting that depreciation favors competitiveness. These findings highlight the importance of FDI and structural factors and reinforce the need for policies that encourage investment and workforce qualification.

KEYWORDS

BRICS; Foreign Direct Investment; Manufacturing industry.

JEL CLASSIFICATION

F14; F15

CONTENTS

Introduction, 2. Theoretical framework, 3. Methodological procedures, 4. Analysis and discussion, 5. Conclusions.

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DETERMINANTES DE LAS EXPORTACIONES DE LA INDUSTRIA MANUFACTURERA EN LOS PAÍSES BRICS

RESUMEN

Este estudio tiene como objetivo analizar los determinantes de las exportaciones de la industria manufacturera en los países BRICS (Brasil, Rusia, India, China y Sudáfrica), con un énfasis particular en el papel de las Inversiones Extranjeras Directas (IED). Para ello, se empleó un modelo de datos de panel basado en un método de Corrección de Errores Vectoriales (VECM) para el periodo de 2001 a 2022. Este enfoque permitió identificar la influencia de la IED y otros factores determinantes en las exportaciones manufactureras de los países BRICS, considerando las características de cada país dentro de plazos específicos. Los resultados demostraron que la IED, la formación bruta de capital (FVC) y el promedio de años de escolaridad tienen un impacto positivo en las exportaciones manufactureras. Un aumento del 1 por ciento en la IED se asocia con un aumento del 0,40 por ciento en las exportaciones, mientras que los aumentos en el FVC y el promedio de años de escolaridad contribuyen a un aumento de las exportaciones en un 1,12 por ciento y un 0,53 por ciento, respectivamente. Los tipos de cambio, aunque no fueron estadísticamente significativos, tuvieron una relación negativa, lo que sugiere que la depreciación favorece la competitividad. Estos resultados ponen de relieve la importancia de la IED y de los factores estructurales, y refuerzan la necesidad de políticas que fomenten la inversión y la cualificación de la mano de obra.

PALABRAS CLAVE

BRICS; Inversión Extranjera Directa; Industria manufacturera.

CLASIFICACIÓN JEL:

F14; F15

CONTENIDO

1.Introducción, 2. Marco teórico, 3. Procedimientos metodológicos, 4. Análisis y discusión, 5. Conclusiones.

DETERMINANTES DAS EXPORTAÇÕES DA INDÚSTRIA MANUFATUREIRA NOS PAÍSES BRICS

RESUMO

Este estudo tem como objetivo analisar os determinantes das exportações da indústria manufatureira nos países BRICS (Brasil, Rússia, Índia, China e África do Sul), com ênfase especial no papel dos investimentos diretos estrangeiros (IDE). Para isso, utilizou-se um modelo de dados em painel baseado em um método de correção de erros vetorial (VECM) para o período de 2001 a 2022. Essa abordagem permitiu identificar a influência dos IDE e de outros fatores determinantes nas exportações manufatureiras dos países BRICS, considerando as características específicas de cada país ao longo do tempo. Os resultados demonstraram que os IDE, a formação bruta de capital (FBC) e a média de anos de escolaridade têm um impacto positivo sobre as exportações manufatureiras. Um aumento de 1 por cento nos IDE está associado a um aumento de 0,40 por cento nas exportações, enquanto os aumentos na FBC e na média de anos de escolaridade contribuem para elevações nas exportações de 1,12 por cento e 0,53 por cento, respectivamente. As taxas de câmbio, embora não tenham sido estatisticamente significativas, apresentaram relação negativa, o que sugere que a depreciação favorece a competitividade. Esses resultados destacam a importância dos IDE e dos fatores estruturais, reforçando a necessidade de políticas que incentivem o investimento e a qualificação da força de trabalho.

PALAVRAS-CHAVE

BRICS; Investimento Direto Estrangeiro; Indústria manufatureira.

CLASSIFICAÇÃO JEL

F14; F15

CONTEÚDO

Introdução, 2. Referencial teórico, 3. Procedimentos metodológicos, 4. Análise e discussão, 5. Conclusões.

1 INTRODUCTION

Jim O'Neill first introduced the term "BRIC" in 2001. At that time, he led global economic research at Goldman Sachs (Stuenkel, 2017). Additionally, Stuenkel (2017) explains that O'Neill sought to identify a group of large countries with rapid economic growth based on indicators such as Gross Domestic Product (GDP) growth rate, GDP per capita, and population size, as an alternative to a political assessment. Based on these criteria, O'Neill projected that the countries with those characteristics would experience significant growth in the following ten years, and China especially stood out because of its global economic impact. The group, originally composed of Brazil, Russia, India, and China, was formally established on June 16, 2009 (Stuenkel, 2017). South Africa joined the group in 2011, and from then on, it was formally known as BRICS, and it emerged as one of the most important developments in international politics at the beginning of the 21st century.

According to Cavalcanti (2018), BRICS' primary objective is to establish a connection that generates influence for emerging countries in the global economy, boosting sustainable development and economic growth. In this regard, in addition to pursuing greater economic stability, BRICS also aim to reduce poverty, a challenge for countries like India and Brazil.

Moreover, globally, member countries have a significant impact on international trade. In 2022, BRICS countries' global export share was 20.7%, and all of them, apart from India, had positive trade balances, as Freire *et al*. have shown (2024). Although exports play a fundamental role in BRICS economic growth, their strategies appear to diverge, as Marconi *et al*. explain (2014). According to the authors, while some countries, like China and India, have reduced the importance of the primary sector in their export agendas, others, including Brazil and Russia, have reduced the participation of their manufacturing sector.

Industrial growth, however, is a significant concern for all member countries, which recently convened at the 7th BRICS Industry Ministers Meeting and at the 13th BRICS Trade Ministers Meeting to discuss cooperation strategies aimed at promoting the strengthening of their industries (Brazil, 2023). Foreign investment is one of the key factors, as it "plays a strategic role in the economic development of countries, complementing domestic savings and contributing to the modernization of productive capacity" (Siqueira, 2022, p. 1).

Although such positive effects of foreign direct investment (FDI) are recognized in the literature, other theoretical strands argue that FDI can displace firms in host countries due to transnational firms' competitive advantages (Günes et al., 2020).

From this perspective, this study aims to empirically verify these contrasting views, considering that, from an empirical standpoint, this topic is still little explored, especially regarding developing countries.

The objective, therefore, is to analyze the determinants of BRICS countries' manufacturing industry exports, with a particular emphasis on the role of foreign direct investments (FDI). The analysis covers the period from the beginning (informal) of the group at the turn of the century in 2001 until the year before the expansion of the number of constituent members, 2022, given that new countries joined in 2023, and changes were implemented in 2024. To this end, a Vector Error Correction Model (VECM) was employed for a panel data set comprising Brazil, Russia, India, China, and South Africa.

From this approach, this study intends to provide a systematic, in-depth approach to analyze the economic dynamics that influence BRICS countries' exports. To achieve its objective, the article is structured in four additional sections. Section two addresses the theoretical framework and explores the main elements that influence foreign trade, with a particular emphasis on the role of foreign direct investment (FDI), which is recognized as an essential driver for economic growth, especially in emerging markets. The third section outlines the methodological procedures employed. The fourth section presents and discusses the results obtained, and the final section contemplates the conclusions, summarizing the main findings, highlighting the relevance of FDI and other factors in export performance, in addition to suggesting potential paths for future research.

2 THEORETICAL FRAMEWORK

To develop a theoretical framework on the determinants of BRICS' manufacturing exports, it is important to consider the economic, social, political, and technological factors that influence international trade. One of these factors is Foreign Direct Investment, but other variables can influence the performance of the countries' trade relations, as detailed in the following sections.

2.1 Foreign Direct Investment

The comparative advantage theory is one of the main frameworks in international trade discussions. David Ricardo, who introduced this concept, argues that countries benefit from specializing in producing goods in which they have comparative advantages. FDI facilitates this specialization by allowing multinational companies to transfer capital, technology, and knowledge to regions where

these resources are most effectively utilized. Alfaro's (2003) study, for instance, corroborates FDI's role, indicating that it contributes to economic growth by improving production and promoting technology transfer, especially in countries with well-developed financial systems.

Regarding production efficiency, the Product Life Cycle Theory, as set forth by Raymond Vernon[1], suggests that at first, companies manufacture new products in their home countries but, as production becomes routine and costs become an important factor, they transfer their production to countries where costs are lower, frequently emerging economies. This not only reduces costs but also facilitates the development of industrial and technological capabilities in host countries. As for the role of FDI in this context, Markusen & Venables (1997) demonstrated that it can help create and expand industrial clusters, resulting in significant positive spillovers.

The Internalization Theory, as developed by Buckley & Casson (1976), offers another perspective on FDI. According to this framework, firms engage in direct investments abroad to internalize transactions that would otherwise be inefficient if conducted through the market, due to high transaction costs. Instead of licensing its technology or brand, a firm may choose to establish subsidiaries abroad to ensure more rigorous control over quality and management. Dunning (1988) further developed this perspective with the Eclectic Paradigm (ownership, location, internalization – OLI), which combines ownership, location, and internalization advantages to explain FDI. These concepts are fundamental to comprehend multinational company decision-making processes regarding their investments and the structuring of their activities.

Emerging economies often benefit considerably from FDI, which is an important source of much-needed capital that is usually scarce domestically. This capital inflow helps to finance investments in infrastructure, industry, and other critical sectors. Empirical studies, like the studies Borensztein, De Gregorio, and Lee (1998) conducted, have indicated that FDI has a significant positive effect on economic growth, particularly when the host country has a minimum level of human capital to absorb new technologies.

In addition to providing capital, FDI often brings new technologies and management practices that can enhance local productivity and stimulate innovation. In this regard, Haddad & Harrison (1993) demonstrated that the presence of multinational corporations in Morocco had a positive impact on the productivity of local firms, primarily through technology spillovers. This transfer of technology and managerial

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[1] This theory illustrates that decision-making regarding investments in product innovations is contingent upon identifying comparative cost advantages (Vernon, 1966).

knowledge is extremely important for the long-term economic development of emerging economies.

Hymer's Foreign Direct Investment Theory (1960) argues that investments entail more than the exchange of resources (capital and technology). According to this framework, an increase in foreign capital could also lead to greater human capital investment (Wang, 1990). In this sense, De Mello (1999) demonstrated that there would be positive effects of FDI on economic growth, due to the spillover effects of technology and knowledge. Investments of this nature promote the labor market by creating productive capacity and more jobs, and by transferring intangible resources such as technology, management techniques, and production processes (Ho & Rashid, 2011).

Additionally, FDI can also help create jobs indirectly, in supplier sectors and throughout the value chain. According to Alfaro *et al.* (2004), FDI has a multiplier effect on employment, increasing the demand for labor in related sectors. Furthermore, FDI promotes the integration of emerging economies into the global market, positioning them as vital components of global value chains. Such integration improves the competitiveness of host countries and mitigates their vulnerability to domestic economic shocks by diversifying sources of economic growth.

To better understand FDI, Dunning (1988) proposes a classification system based on objectives: (i) resource seeking, when there is limited connection with the host country and the objective is to acquire resources, which contributes to exports positively; (ii) market seeking, exemplified by multinational companies that transfer technology to a subsidiary; (iii) asset seeking, which is characterized by purchasing companies - joint ventures is a good example of this case; and (iv) efficiency seeking, which aims to create economies of scale in the domestic market.

2.2 Determinants of Manufacturing Industry Exports

Manufacturing industry advances in BRICS countries have been fundamental factors for economic growth and productive diversification of these emerging economies. This industry, which encompasses the production of goods from raw materials and components, plays a vital role in job creation (Luquini *et al.*, 2018).

Existing literature indicates that certain macroeconomic variables can influence the export performance of countries' manufacturing industry. Fluctuations in exchange rates, for example, have the potential to have an impact on the competitiveness of exports due to their effects on trade prices. Tebaldi (2011) investigated this relationship and did not find a significant result, indicating that high-tech exports

per worker are not impacted by changes in this rate. On the other hand, Hassan *et al.* (2022) observed that the exchange rate has both a positive and negative relationship, and that in the long run, exports are cointegrated with the real exchange rate. The authors analyzed the case of Canada and concluded that the effective exchange rate causes significant reductions in the country's export level.

From a political and institutional standpoint, it is also necessary to consider the relevance of trade policies adopted by India, Brazil, Russia, and China, including tariffs, subsidies, and other trade barriers, that can also affect their exports directly. Participation in regional and multilateral trade agreements can facilitate access to new markets and reduce tariff barriers. Conversely, government institutions' political instability and quality can affect investors´ confidence and economic policy continuity, which in turn can influence export performance.

Social and demographic factors also play an important role in trade. Labor availability, qualification, and costs are significant determinants of manufacturing industries' competitiveness. The workforce's education and technical training levels have a direct impact on industries' productivity and innovation capacity. Therefore, investments in education and training are essential to improve export competitiveness.

Furthermore, economic growth is also an important determinant of trade, as it impacts a country´s productive capacity and demand for exports. Herzer *et al.* (2006) investigated the Export-Led Growth (ELG) hypothesis from 1960 to 2001 for the five BRICS countries. The authors concluded that there is a long-term relationship between capital, labor, manufactured exports, primary goods exports, and GDP. Additionally, Oo, Kueh, and Hla (2019) also evidenced the positive impact of GDP on exports in the long run.

Other studies have identified the positive effects of FDI on exports. For instance, Paulino (2000) analyzed the correlation between FDI and the volume of exports in 48 developing countries, focusing on how trade liberalization impacted this relationship. Güneş *et al.* (2020) discussed the impacts of FDI on exports of high-tech products and identified a negative relationship. The study also revealed that a significant proportion of the investments were allocated to medium-technology sectors.

In contrast, Sumiyyati (2020) found no significance in the effects of FDI on Indonesia's manufactured exports. Other variables with a relevant effect were Indonesia's GDP, with a positive relationship, and inflation, with a negative effect. The exchange rate also showed no statistical significance.

Gökmen & Turen (2013) tested the impacts of greater economic freedom, according to the Economic Freedom Level (EFL), human capital levels, and the influx of foreign investment on exports of goods and services with higher technological content for fifteen countries in the European Union. The results obtained evidenced that these three factors were relevant to explain export increases. Similarly, Zapata *et al*. (2023) analyzed high-technology exports to OECD member countries and demonstrated the importance of domestic and foreign investments in research and development (R&D) and high-technology imports. In this regard, Mehrara et al. (2017) sought to verify which variables are decisive for developing countries' exports. The authors conclude that institutions, human capital, economic growth, trade openness, and foreign investment can influence high-technology-intensity export behaviors.

Regarding FDI, it has also served as a significant factor for BRICS´s industries since the group emerged. These countries, which represent some of the largest emerging economies in the world, have attracted FDI inflows due to their economic liberalization policies, expanding markets, and abundant natural resources. Considering FDI importance, Batista Jr. (2016) explains that BRICS countries have also acted to enhance FDI appeal through collaborative initiatives with the New Development Bank (NDB). It was established in 2014 in response to these countries' discontentment with multilateral institutions that limit developing nations' decision-making authority. According to the author, NDB serves as a complement to the World Bank, providing financing for infrastructure and sustainable development projects (Batista Jr., 2016).

In China, FDI has played a crucial role in its rapid economic growth. Since its economic opening in the 1980s, China has been one of the largest recipients of FDI in the world (Buckley *et al*., 2009). As Zeng & Zhou (2021) have observed, FDI has been fundamental for technology transfer, industrial modernization, and Chinese companies' enhanced global competitiveness. As a result of these developments, China has undergone a significant economic transition, evolving from an agrarian economy to a diversified economy with a robust manufacturing sector, which has contributed to global trade.

India has also experienced a period of robust economic growth, particularly over the past two decades. Kumar & Misra (2019) highlight that the economic reforms of the 1990s, which liberalized the country's economy and encouraged FDI, were fundamental to this growth. Das (2019) estimates that FDI, exchange rate, world income, Indian GDP, and trade liberalization indices have a causal relationship with exports. In the long run, only FDI has had an effect different than the effect observed in short-term models.

Brazil, with its considerable endowment of natural resources, occupies a prominent position in the global trade of commodities. As reported by the Brazilian Trade and Investment Promotion Agency (Apex Brazil, 2019), in 2019, the country was among the largest exporters of soybeans, coffee, beef, and iron ore. However, according to Rodrigues' study (2014), the Brazilian manufacturing industry has faced challenges due to factors such as high tax burden, inadequate infrastructure, and regulatory complexity. Despite economic and political challenges, Fernandes (2024) highlights that Brazil has succeeded in attracting foreign investment to strategic sectors such as manufacturing, infrastructure, and natural resources, which has contributed to its economic growth.

Russia, which also possesses substantial natural resources, particularly oil and gas, has been a major force in the global economy. Kalotay (2007) suggests that the energy sector is the foundation of Russian economy, with companies such as Gazprom and Rosneft playing a crucial role. Russian manufacturing industry advances have been FDI-driven, especially in sectors like oil and gas (Kalotay, 2010). Nevertheless, the Russian economy faces challenges due to the volatility of commodity prices and international sanctions, which affect its capacity to attract investment and fully engage in global trade.

South Africa, the most recent member to join the BRICS, has a diversified economy that encompasses mining, manufacturing, and financial services. Maduku & Zerihun (2021) explain that the country has applied its natural resource endowments to attract FDI, despite internal challenges such as elevated crime rates and political instability. Nxazonke & Wyk (2019) conducted a study and analyzed the impact of foreign investment on the development of domestic firms in South Africa, and they concluded that FDI had a positive short- and long-term relationship with domestic entrepreneurship in the country from 2000 to 2018. Furthermore, the authors emphasized the need for governmental policies to reduce regulatory constraints on new firms and to establish localization policies for large corporations.

This brief contextualization of BRICS member countries demonstrates that their participation in international trade is characterized by distinctive features. For instance, China´s participation in the global economy has been more prominent compared to the other four members of the group. Despite the global economic crisis that affected most economies from 2008 to 2009, China experienced an increase in its export share in this period, which went from 8.54% in 2008 to 9.54% in 2009 (Figure 1).

Figure 1. BRICS countries' export share in global economy (2000-2024)
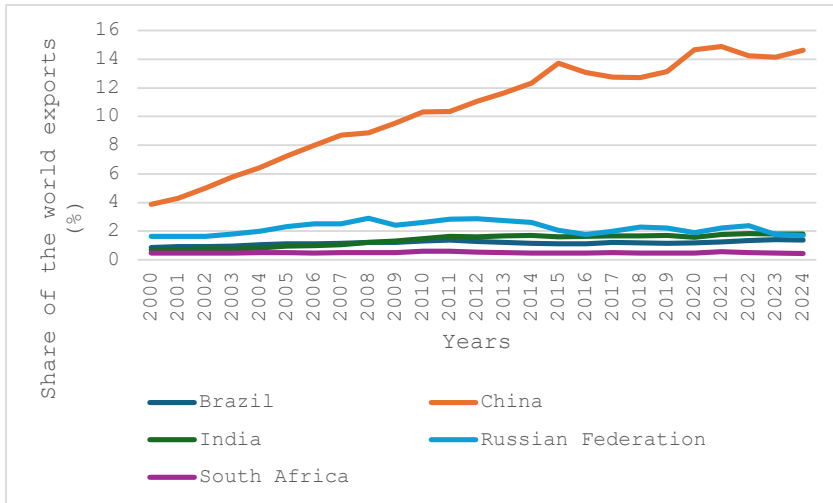
Source: Prepared by the authors based on United Nations Trade & Development (UNCTAD, 2025) data.

Chinese export preponderance in comparison to other members of the group indicates a need to discuss the extent of China´s influence on the global context. Given that China's economy is oriented towards exports and investments, it is more susceptible to global crises now. Niu (2013) argues that China should prioritize its domestic market and the establishment of a sustainable economy, and the country´s participation as a member of the BRICS could facilitate the development of a more solid economy.

Russia ranks second in exports. India is third, with export values very close to Brazil, which is fourth, with percentages that have the highest results in mid-2011, representing 1.38% of total global exports. South Africa ranks last. It is noteworthy that the country´s exports have a linear trend, with minimal fluctuations, indicating that South Africa's economy in terms of exports is one of the most stable in the group.

The literature presented so far provides a solid basis to construct a methodology, detailed in the following section, as it indicates the key variables considered by the theories and that are used in empirical studies on the determinants of manufactured or high-tech exports.

3   METHODOLOGICAL PROCEDURES

To achieve the proposed objectives, the study employed the Panel Vector Error Correction method. The following subsections provide a detailed description of the data and the model.

3.1 Data

The data under consideration encompasses the period from 2001 to 2022. Even though the group was formalized in 2009, with South Africa joining in 2011, the countries have been informally recognized as a group since 2001, as previously discussed. Another factor defining the starting period of analysis is the data on FDI for Brazil, which is available on the UNCTAD database from 2001 onwards. Although data are available before 2001 in other databases, such as those of the Central Bank of Brazil (BCB), they exhibit minor discrepancies when compared to the time series on UNCTAD, which led us to opt for a shorter time frame, aiming at greater temporal uniformity. The final period, 2022, was also delimited according to data availability, and it also considered the fact that, in 2023, the group underwent significant changes, as previously mentioned. Table 1 provides a detailed overview of the variables employed in the model.

Table 1. Data set description

Variables of interest	Description/proxy	Unit	Source
Manufacturing industry exports	Manufacturing industry exports	% of GDP	UNCTAD
Foreign Direct Investment	FDI Influx	% of GDP	World Bank
Exchange rate	Nominal Exchange Rate	US$ (Log)	UNCTAD
Production capacity	Gross Capital Formation	% of GDP	World Bank
Intellectual capital	Average years of schooling	Years (Log)	UNESCO

Source: Prepared by the authors.

The nominal exchange rate was used, as in Uysal and Mohamoud (2018) and Oo *et al.* (2019), due to the unavailability of a real exchange rate for India. As a measure of the country's intellectual capital or level of training, the average years of schooling was used as a proxy, because data on research and development (R&D) – the most used time series for these purposes – were found to have flaws for some countries in several years. Similarly, Güneş *et al.* (2020) employed this indicator as a measure of human capital, which corroborates its suitability for our study. Regarding the variables expressed in monetary terms, they were employed as a GDP proportion to enhance standardization (Alves & Pereda, 2018).

3.2 Empirical Model

The Vector Autoregressive (VAR) model is a valuable tool for economic analysis as it takes into account the endogeneity of variables and their simultaneous interactions (Bueno, 2018). Its variation, the Vector Error Correction Model (VECM), is derived from variable cointegration. Consequently, if the variables present a long-term balance, that is, if their levels are not stationary, the VECM should be estimated at the expense of the VAR model (Bueno, 2018).

In the case of panel data, the equation is represented following the model Bueno (2018) presented, as Equation 1 illustrates.

$$\Delta X_{ct} = \Phi_c X_{ct-1} + \sum_{i=1}^{p-1} \Lambda_{ci}\Delta X_{ct-i} + \varepsilon_{ct}, \tag{1}$$

Where: ε is an uncorrelated terms vector; $\Phi_c X_{ct-1}$ is the long-term relationship factor per country c in period t; the short-term relationship is given by $\sum_{i=1}^{p-1}\Lambda_{ci}\Delta X_{ct-i}$, with Λ_j in which $\Lambda_j = -\sum_{n=1+j}^{p}\Phi_i$. X is a vector of analyzed variables (FDI, Gross Capital Formation, manufacturing industry exports, exchange rate, and average years of schooling).

To ascertain the existence of cointegrating vectors, a cointegration test must be applied. A common test for this purpose when estimating panel VECM is the Kao test, which is based on an augmented Dickey-Fuller test, modified to calculate the cointegration in fixed effect residuals (Baltagi, 2005). The test starts with a generic panel regression model (2).

$$y_{it} = x'_{it}\beta + y'_{it} + e_{it}, \tag{2}$$

The null hypothesis is that there is no cointegration, that is, $\rho = 1$. Equation 3 represents the error term.

$$\hat{e}_{it} = \rho\hat{e}_{it-1} + v\_it \tag{3}$$

The next step involves defining an optimal number of lags, which is necessary to avoid information loss. For this purpose, there is a set of lag length criteria tests, such as Schwartz (SC), Akaike (AIC), Final Prediction Error (FPE), and Hannan-Quinn (HQ).

Once the Vector Error Correction model has been estimated, following the aforementioned procedures, it is essential to assess its stability and the absence of serial correlation in error terms. The stability of the model can be observed through the inverse roots of the characteristic polynomial. In the E*views* 14 software, which

was used to conduct this empirical study, the test generates a graph that indicates the model's stability when the roots are in the unit circle.

To guarantee the absence of serial correlation between the model's residuals, it is recommended to run a Breusch-Godfrey test. The procedure is based on a Lagrange Multiplier (LM) statistic, as Equation 4 illustrates.

$$LM = nR^2 \qquad [4]$$

Where: n is the number of observations, and R^2 is derived from an auxiliary regression concerning the primary model's errors. This test follows a χ^2 distribution, with a null hypothesis that there is autocorrelation between residuals.

Regarding anticipated outcomes, the literature review suggests that an FDI inflow can bring host countries several benefits (Tebaldi, 2011; Gökmen & Turen, 2013; Oo *et al.*, 2019; Zapata *et al.*, 2023). However, it can also harm national enterprises (Güneş *et al.*, 2020), which may subsequently affect the industry's exports. To evaluate these potential effects, studies frequently employ innovation and human resources indicators, based on the premise that increased availability of human resources will result in positive impacts on FDI flow use (Borensztein *et al.*, 1998). Considering these discussions and based on the literature review conducted in the above section, we anticipate the following relationships, as detailed in Table 2.

Table 2. Anticipated outcomes

Variable	Anticipated relationship	Source
Foreign Direct Investment (FDI)	Negative	Güneş *et al.* (2020)
	Positive	Tebaldi (2011); Gökmen & Turen (2013); Oo *et al.* (2019); Zapata *et al.* (2023)
Exchange rate (ER)	Negative	Tebaldi (2011); Hassan *et a*l. (2022); Uysal & Mohamoud (2018)
Gross Capital Formation (GCF)	Positive	Zapata *et al.* (2023)
Average years of schooling (EDUC)	Positive	Tebaldi (2011); Güneş *et al.* (2020)

Source: Prepared by the authors.

Domestic investment increases also have implications for productivity. In this regard, capital formation is expected to play an important role in increasing manufacturing industry exports (Zapata *et al.*, 2023). Additionally, exchange rates are acknowledged for their negative influence on industrial production and exports (Tebaldi, 2011; Hassan *et al.*, 2022).

After presenting the model, verification tests, and variables, the following section presents and discusses the results, contrasting them with existing literature.

4 ANALYSIS AND DISCUSSION

A stationarity test was initially employed to identify the presence of unit roots in the time series employed in the model. Among available panel data tests, the Levin *et al.* (2002) test was selected. Table 3 presents the results.

Table 3. Results of the Levin, Lin e Chu test

Variables	Stationarity	Statistic	p-value
Manufacturing industry exports	In first difference	-3,88007	0,0001
FDI	In first difference	-5,62919	0,0000
Gross Capital Formation	In level	-2,21117	0,0135
Average years of schooling	In level	-3,49810	0,0002
Exchange rate	In first difference	-1,60819	0,0539

Source: Prepared by the authors.

The results indicate that the majority of variables are stationary only in first difference, which suggests a need to employ multivariate cointegration models. Considering these findings, we proceeded to verify the existence of long-term relationships between variables of interest. Before conducting a Kao cointegration test, it was necessary to estimate an initial VAR to determine optimal lag numbers. Table 4 presents the results of the lag length criteria test.

Table 4. Results of the lag length criteria test

Lag	LogL	LR	FPE	AIC	SC	HQIC
0	339.9186	NA	1,59e-10	-8,372964	-8,224087	-8,313275
1	938,8434	1108,011	9,35e-17	-22,72109	-21,82783*	-22,36295*
2	973,4913	59,76760	7,40e-17*	-22,96228*	-21,32464	-22,30570
3	986,9921	21,60127	1,00e-16	-22,67480	-20,29278	-21,71978
4	1012,926	38,25297*	1,02e-16	-22,69816	-19,57175	-21,44469

Source: Prepared by the authors.

Note: LR refers to the likelihood ratio; FPE refers to a Final Prediction Error test; AIC refers to Akaike criteria; SC refers to Schwartz criteria; HQ refers to Hannan-Quinn criteria; * indicates the lag length each criterion recommends.

Results indicated different lag lengths: Akaike and the FPE criteria indicated the presence of two lags, while Schwartz and Hannan-Quinn criteria indicated the presence of one lag. Given this divergence, we proceeded to estimate using one lag, following Stock's (1994) recommendation; he argues that the Schwartz criterion is a more robust and parsimonious option.

The next step consisted of conducting a Kao cointegration test to confirm the existence of long-term variable relationships. Table 5 details the results.

Table 5. Kao Cointegration Test Results

	Statistic	Probability
ADF	-1,727419	0,0420
Residual Variance	0,000147	
HAC Variance	0,000224	

Source: Prepared by the authors.

The probability value obtained led to the rejection of the null hypothesis, which confirmed the existence of cointegration between the variables of interest. This result justifies a Vector Error Correction model estimate (Table 6).

Table 6. Long-Term Model Results

Variables	FDI	GCF	Exchange rate	Average years of schooling
Results	0,406706	1,125800	-0,025912	0,527371
	(0,24356)	(0,20157)	(0,02480)	(0,13237)
	[-1,66987]	[-5,58526]	[1,04480]	[-3,98418]

Source: Prepared by the authors.

Note: Standard deviation in ( ); t-statistic in [ ]. For the result to be considered significant, at a minimum level of 10%, the t-statistic must have a value greater than 1.65.

Results were statistically significant for all variables except exchange rate. The use of the nominal exchange rate may explain this unsuccessful result. Although not statistically significant, the relationship was negative, in line with anticipated outcomes, following those Tebaldi (2011), Uysal and Mohamoud (2018), and Hassan et al. (2022) reported.

For variables with significant results, the values obtained indicated that an increase in FDI, GFCG, and average years of schooling, about 1%, leads to an increase in BRICS member countries' manufacturing industry exports of 0.40%, 1.12%,

and 0.52%, respectively. These results are also in line with expected behaviors and with the studies detailed in the section above.

In addition to a VECM coefficient analysis, impulse-response functions were calculated to verify the response of manufacturing industry exports in the face of shocks in the independent variables of the model. Figure 2 outlines the results.

Figure 2. Response of the manufacturing industry's exports to analyzed variable shocks
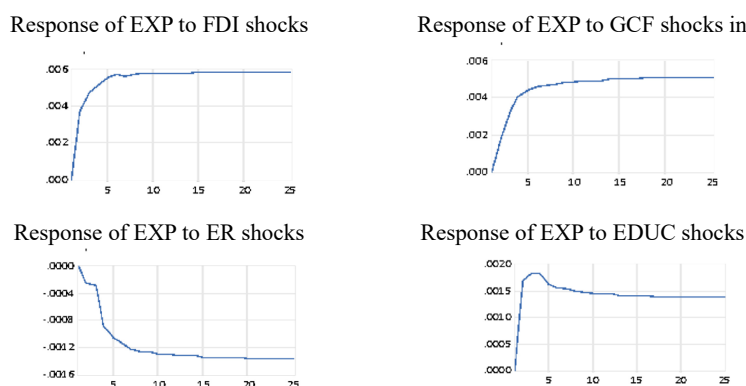
Source: Prepared by the authors.

Estimated impulse-response functions indicate that BRICS countries' manufacturing industry exports react positively to FDI, GCF, and EDUC variable shocks. This positive reaction is more pronounced in the starting periods and tends to stabilize at elevated levels after approximately five periods. These results are in line with those obtained through a Vector Error Correction Model, and are consistent with anticipated outcomes, corroborating foreign direct investment's important role in analyzed countries' performance of manufacturing industry exports. As mentioned above, FDI for BRICS countries' relevance is contingent upon their capacity to address internal resource constraints. In instances where domestic resources are limited, FDI can ensure investment availability for national industries to expand their operations. In addition to FDI's role, it is also noteworthy that other variables, such as gross capital formation and intellectual capital, in this case, measured by the average years of schooling, also influence this industry's success in international trade, with results similar to FDI's (Figure 2). Such positive relationships can be attributed to the effects that these variables have on productivity and on enhancing national production competitiveness.

Regarding the manufacturing industry's export response to an exchange rate shock, a negative reaction is observed, which tends to stabilize after approximately fifteen periods. A similar negative relationship was observed in the long-term model, although the coefficient was not statistically significant. This relationship is supported by existing literature, as previously detailed. It is coherent that local currency depreciation contributes to fostering manufacturing industry exports, by making national product prices more competitive in the international market, even though this may increase the costs for companies that depend on importing technology and raw materials. Coronel and Copetti (2021) obtained similar results. They analyzed manufacturing industry exports in the state of Rio de Janeiro using a VECM. The authors also observed that exchange rate devaluation had a positive impact on the target industry's performance.

In addition to the proposed model's analyses, we present the results of the tests that confirm that the methodological procedures adopted meet minimum stability conditions. To this end, the inverse roots of the characteristic polynomial were obtained (Figure 3).

Figure 3. Inverse roots of a characteristic polynomial
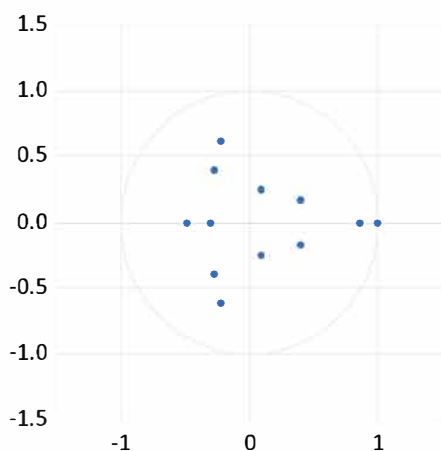
Source: Prepared by the authors.

The fact that all inverse roots are contained within the limits of the unit circle indicates that the estimated model satisfies stability conditions. In addition to this test, the presence of autocorrelation was evaluated using a Lagrange Multiplier (LM) test (Table 7).

Table 7. Autocorrelation test results

L*ag*	Statistic	p-value
1	1,435196	0,0862
2	0,889038	0,6210

Source: Prepared by the authors.

Results demonstrate that no autocorrelation was identified in residuals, thereby confirming the adequacy of the Vector Error Correction Model estimate, with two lags. The following section presents an excerpt of the results, including main findings and economic implications.

5 CONCLUSIONS

This study aimed to analyze the determinants of BRICS countries' manufacturing industry exports, with a particular emphasis on foreign direct investments (FDI). The results of the long-term VECM revealed that BRICS member countries' context, in terms of FDI inflow, their industries' production capacity (gross capital formation), and human capital (average years of schooling) availability, exerts a significant influence on their manufacturing industry exports. It is noteworthy that, apart from a (nominal) exchange rate, all other variables analyzed were found to be statistically significant.

Regarding impulse-response functions, the same relationships were identified as in the long-term model. Upon the introduction of a shock to FDI, GCF, and average years of schooling, the manufacturing industry exports exhibited a positive reaction, stabilizing at elevated levels in subsequent periods. Response to exchange rate shock was negative, under anticipated outcomes, which reinforces that the depreciation of local currencies in BRICS countries favors the commercialization of their industrial products in the international market. This is probably because their prices have become more attractive to foreign buyers, even at the expense of an increase in import costs.

The relationships addressed in this study are supported by the existing literature and were based on the premise that FDI plays a very significant role for BRICS countries, favoring not only the production of their manufacturing industries but also their trade relations and economic development. Furthermore, the production capacity and the availability of intellectual capital are also decisive for their manufacturing industries' exports, as they contribute to enhancing national product competitiveness.

Furthermore, the results of this research fill a certain gap created by a lack of empirical studies on manufactured BRICS exports, especially regarding the relationship between this variable and FDI, which has complex, divergent effects in the literature. As a contribution to theory, this study highlights FDI's positive effect on manufactured export growth and, consequently, on countries' growth.

These findings can also enable countries to develop public policies aimed at increasing their manufacturing exports. Thus, policies focused on attracting greater foreign investment, increasing investment in human capital (by increasing the population's years of schooling), and domestic investment itself are significant because, as shown, they are relevant to exports.

While the results obtained with this estimated model have proven to be consistent, meet stability conditions, and are aligned with existing literature, the fact that the variable employed to analyze exchange rate effects did not generate a significant result is considered a limitation. It is well established that a country´s currency fluctuations can have a significant impact on international trade. Consequently, failure to obtain a more accurate result may be attributed to the use of a nominal exchange rate.

Furthermore, it is known that panel data models tend to be more effective when applied to analyze a larger number of observations. In the case being examined, this was not feasible, given that the BRICS group is relatively recent, and the analysis was thus concentrated on a twenty-two-year time frame. Furthermore, the use of alternative methodologies widely used for the same purpose, such as dynamic panel models, could also have been adopted if more data were available.

These limitations, however, provide future research opportunities on the subject, as new countries have recently been invited to join BRICS, allowing an extension of the analysis to this new context. Discussions such as this contribute to a deeper comprehension of this important economic group and to the role played by foreign direct investment in emerging industries.

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