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Foreign direct investment on high and medium technology intensity exports: Evidence for countries in Latin America and the Caribbean (2002–2021)

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FOREIGN DIRECT INVESTMENT ON HIGH AND MEDIUM TECHNOLOGY INTENSITY EXPORTS: EVIDENCE FOR COUNTRIES IN LATIN AMERICA AND THE CARIBBEAN (2002-2021)

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Abstract: This article analyzed the impact of Foreign Direct Investment (FDI) on the competitiveness of high- and medium-technology exports in Latin America and the Caribbean (2002–2021). The econometric results indicated a negative impact of FDI on the competitiveness of exports in countries with lower per capita income, using the Autoregressive Distributed Lag (ARDL) model, estimated by Pooled Mean Group (PMG). However, this impact can become positive after a specific threshold of per capita income; that is, the empirical results revealed a non-linear relationship between the effects of FDI on export competitiveness and the per capita income level of the countries in the sample. The empirical evidence presented in the article showed that FDI harms the competitiveness of exports in countries with low per capita income but becomes beneficial after a critical value of US\$ 5,172.44. This dynamic is due to the greater absorptive capacity of technologies entering through this channel (FDI) in countries with higher per capita income levels, as they have more consolidated, mature, and competitive companies. In contrast, low-income countries may have their companies displaced from the market, decreasing their competitiveness. The robustness of the econometric evidence is confirmed by the Error Correction Term (ECT) of -0.74, indicating a rapid adjustment (74% per year) to long-term equilibrium. The article concludes that institutional development and domestic income are preconditions for foreign capital to be able to drive regional technological sophistication.

Keywords: International trade; Technological competitiveness; Multinational companies.

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1 INTRODUCTION

According to the United Nations Conference on Trade and Development (UNCTAD, 2025), throughout the 1990s and into the first decade of the 2000s, Latin American and Caribbean countries experienced a significant increase in foreign direct investment (FDI), rising from an average of US\$37.6 billion to US\$81.57 billion for the group of countries. This type of investment was sought by developing economies, such as most Latin American and Caribbean nations, due to its potential benefits, such as supplementing domestic savings, capacity to transfer more advanced technologies, and increased competition in domestic markets. However, some researchers criticized FDI regarding its ability to supplement national savings (Bresser-Pereira; Gala, 2007) and the effectiveness of technology transfer to industries with low absorption capacity (Radošević, 1999; Saggi, 2002; Chiarini, 2016; Loukil, 2016). Reviews of empirical literature, such as those by Horvatin (2019) and Otieno and Aduda (2022), also pointed to a wide variety of FDI effects found in the studies. The 2025 FDI report by the Economic Commission for Latin America and the Caribbean (ECLAC, 2025a) also points to different effects of this investment. Mainly based on the entry-level sector, where it has greater benefit capabilities when it enters more innovative sectors. According to the report, from 2020 to 2024 there was a greater targeting of global FDI projects to the renewable energy sectors, to the detriment of coal, oil and gas, which had the highest average of annual projects between 2010 and 2019. In addition to these sectors, Semiconductors and Electronic components also had a large increase change. In Latin America and the Caribbean, however, the mineral resource sectors – coal, oil and gas – remained the main recipients.

From 1995 to 2001, exports of high-technology goods – according to Lall's⁴ classification – increased sharply from 8.37% to 16.17% of the region's total exports. However, from that point onward, these products experienced a decline in share, falling to 9.42% in 2011, maintaining an average of 10.27% of total exports from 2012 to 2024. Exports of primary products, in turn, followed the opposite path. In 2001, exports of primary products reached their lowest level in the period from 1995 to 2024, accounting for approximately 25.98% of exported products; since then, their downward trend has reversed, heading towards 36.2% of the export portfolio (UNCTAD, 2025).

This context leads to the question of what the effect of FDI is on these countries. Is it possible that FDI has been unable to promote the technological development of this region, or are there other factors that have led to technological "stagnation"? This research addresses this inquiry based on the determinants of

⁴ This classification was proposed by Lall (2000) as an attempt to develop the technological intensity classification of the Organization for Economic Co-operation and Development (OECD), also using Pavitt's taxonomy (1984), which classifies sectors based on their absorption, diffusion, and conduction of innovations. Thus, this classification has divisions such as "Primary Products," "Resource-Based Manufacturing," "Low-Technology Manufacturing," "Medium-Technology Manufacturing," "High-Technology Manufacturing," and "Unclassified Products." Comparative Advantage Index (RCAI) as the dependent variable, estimating the effects of FDI and other variables on the effective gain in technological competitiveness, in addition to using a dynamic and cointegrated model, which allows for the analysis of short- and long-term impacts.

the competitiveness of high and medium technology intensity exports, through an approach that incorporates the quantity exported, which may be influenced by participation in economic groups, for example, and the quality of exports, which is crucial for conquering large international markets.

Innovation, as an engine of economic development (Schumpeter, 1982), is primarily a product of industry, which invests in research and development (R&D), seeking to guarantee the market leadership of its products. Thus, the competitiveness of exports of technologically intensive goods is an indicator of a country's ability to integrate into the international market, characterized by greater competition and the presence of nations with high per capita income. Like Schumpeter, Nicholas Kaldor also viewed industry as a promoter of development due to its productivity spillovers to other sectors. According to Ferreira-Filho and Oreiro (2026), for Kaldor, in addition to the domestic market – insufficient when isolated – development requires reaching new markets through import substitution combined with export promotion. The escalation in the sophistication of exports would reveal positive impacts on domestic income and stimulate productivity spillovers, a process mentioned earlier, also known as the Kaldor-Verdoorn Law.

Thirlwall (2019) deepens this discussion by formulating the “dynamic analogue” of Harrod’s (1933) trade multiplier, establishing that the long-term growth of an open economy is fundamentally limited by the ratio between the growth of its exports (x) and the income elasticity of demand for imports, (π) a relationship expressed by the formula $y = (x/\pi)z$, also known as Thirlwall’s Law⁵. This perspective is essential for the context of Latin America and the Caribbean, as it demonstrated that competitiveness in high-technology-intensive sectors is not only a metric of trade performance, but a necessary condition for raising the growth ceiling compatible with balance of payments equilibrium. Without a structural change that reduces the technological gap, the region remains vulnerable to a rate of expansion restricted by low-income elasticity of primary products in the export basket.

A document from the second session of the Conference on South-South Cooperation in Latin America and the Caribbean (ECLAC, 2025b) cites three development pitfalls that most countries in the region face: low economic growth – due to stagnant productivity – high income inequality, and low institutional capacities. Technological competitiveness would be of great relevance, at least in the first trap, promoting the acceleration of growth with contributions to productivity. Regarding the convergence of Latin American countries with developed countries, Cimoli, Porcile and Rovira (2010) indicated the persistence of the former in low-technology sectors as the main limiting factor. In contrast, those that did demonstrate an economic restructuring toward Schumpeterian and Keynesian efficiency sectors as the main sources. Cimoli, Pereima, and Porcile (2019), based on the development of a technological gap model of trade and growth, point to the liberal policies of the mid-1970s in Argentina and 1980s in Brazil as obstacles

⁵ Where z is the income growth rate of the rest of the world.

to convergence. According to them, these liberal policies discontinued industrial ones, and, as a result, repressed their productive and technological capacities. The case of South Korea, analysed in contrast, showed that industrial policies were dynamic over time, meeting the different emerging technological challenges.

In this sense, this article verified the impacts of Foreign Direct Investment (FDI) inflows into Latin American and Caribbean countries on the competitiveness of their technological exports between 2002 and 2021. More specifically, it will analyze the influence of FDI and other factors that may have affected the competitiveness of the region's high-technology products. To achieve the proposed objectives, an Autoregressive Distributed Lag (ARDL) will be used. One innovative aspect of this research is the use of the Revealed Comparative Advantage Index (RCA) as a dependent variable, seeking to estimate the effects of FDI and other variables on the effective gain in technological competitiveness, in addition to using a dynamic and cointegrated model, which allows for the analysis of short- and long-term impacts.

Muratoğlu and Muratoğlu (2016), Gamariel and Hove (2019), Ganai et al. (2023), and Şaşmaz (2025) also implemented competitiveness indicators in their respective studies but still allow for further development. Thus, the contribution of this article, in addition to using a cointegrated model, advances the consideration of non-linear effects of FDI on countries of different income levels (including estimating the approximate income level at which the effect changes) and the use of control variables for the specialization in primary products of countries – with possible effects resulting from the commodities boom during the analysis period – and the “distortions” of the RCA due to the effect of *maquiladoras*⁶ in some countries.

This article is structured in four sections, in addition to this introduction. The following section presents the main studies on the determinants of high-technology exports and the effects of FDI on countries' exports. Next, the third section presents the methodological basis of the econometric model and describes the variables used, their sources, and the expected signs. The fourth section discusses the results of the literature, while the final section presents the conclusions.

2 LITERATURE REVIEW

The study by Borensztein, De Gregorio, and Lee (1998) is a classic that started from an endogenous growth model, seeking to understand the effects of FDI on economic growth. According to the authors, the inflow of FDI from developed countries is positive for the state of technological knowledge of recipient countries that reach a certain level of human capital. Their results showed that, in comparison, FDI has a greater effect on growth than domestic investment itself and demonstrated a complementary, not substitutive (*crowding-in*), effect.

⁶ Companies, mostly foreign, linked to the country through tax benefits and low-cost labor, and which carry out import and assembly processes or low value-added transformations, aiming at export

Iwamoto and Nabeshima (2012) evaluated the determinants of export sophistication and diversification in various countries using the Generalized Method of Moments (GMM). The authors reported relevant factors for sophistication, such as the stock of FDI, the degree of openness, the lagged GDP per capita of the country, and the population, while inflation was the only variable with a negative impact. From the perspective of diversification, only the lagged diversification itself and the population were significant, with positive effects.

Muratoğlu and Muratoğlu (2016) measured the variables that influence the competitiveness of manufactured exports from the Organization for Economic Co-operation and Development (OECD). The estimation, made using a random effects model, indicated the inflow of FDI to the manufacturing industry and wages as negative factors for competitiveness, while exports of high-technology-intensive goods, investments in research and development (R&D), and the number of mobile phones (as a measure of infrastructure) were positive factors.

Camargo and Gala (2017) discussed the case of Dutch disease using a GMM regression, focusing on the concentration of exports in natural products; the authors concluded that greater concentration in these primary sectors reduces national complexity. As an example, they described the cases of Nigeria and Indonesia as opposites. Until the early 1980s, Nigeria had a higher per capita income than Indonesia. From that point on, a reversal occurred, with Indonesia taking the lead and achieving a per capita income more than twice that of Nigeria. These divergences were also observed in the increased economic complexities of the countries. As the main strategy adopted by Indonesia to protect itself from Dutch disease, the authors cited institutional changes and currency devaluations.

Gamariel and Hove (2019) investigated the determinants of export competitiveness – measured through export sophistication – in African countries. Their results, estimated using the GMM model, indicated a positive and significant relationship between foreign direct investment (FDI), export demand, macroeconomic environment, available human capital, and institutional quality. A factor of negative relevance to competitiveness is the unit labor cost. Expanding the study, the authors verified how FDI non-linearly impacts variables in the model, such as domestic investment, firm productivity, human capital, and the share of capital goods imports in total imports. These interactions proved to be statistically significant and positive for the last two variables. The interaction with human capital revealed the need for human capital to provide the country with the absorptive capacity for new technologies. In the interaction with imports, the authors argued that competitiveness is increased through the encouragement of vertical linkages, with the attraction of export-oriented foreign companies.

For the Brazilian case, Vieira and Reis (2019) explored the determinants of Brazilian exports by technological intensity, from 2000 to 2015, using a gravity model estimated by the Poisson Pseudo Maximum Likelihood (PPML). For exports of high-technology products, variables related to the Brazilian

population, the existence of a geographical border between countries, and mutual participation in trade agreements showed positive effects. Exports of medium-high technological intensity, in turn, showed positive impacts from GDP, tariffs on imports from the trading partner, and the existence of a treaty between the countries. Negative effects stem from the size of the Brazilian population, the distances, both absolute and relative, between countries, and dummy variables representative of the 2007 and 2008 crises.

Seeking to understand the determinants of exports of high-technology products from countries in the Organization for Economic Co-operation and Development (OECD), Zapata, Arrazola, and De Hevia (2024) estimated two models using GMM. In one of them, with exports in absolute values, R&D spending, *dummy* location, population, and imports showed positive and significant effects at 5%. Similarly, another model, with exports in terms of total employment, confirmed the results, also indicating FDI as a positive and significant factor for exports.

Farid et al. (2023) studied the influencing factors on the Pakistani sectors of motor vehicles, trailers and automotive components; chemicals and pharmaceuticals; cement; food, beverages, cigarettes and tobacco; and textiles. The effects of FDI on these sectors were positive and significant only in the long term. In the short term, they were not very significant. Among the other variables used – human capital, domestic investment and domestic sales – only domestic sales were significant, and only in the short term.

Ganai et al. (2023) adopted the strategy of using the Revealed Comparative Advantage (RCA) indicator as the dependent variable to analyze the factors that affect export competitiveness. Their investigation was conducted for India and China, from 2001 to 2020. The random effects model used indicated positive relationships between FDI, R&D expenditure, and the number of mobile phones. There were significant contrasts between India and China regarding gross fixed capital formation, which was significant and positive only for the latter country. Furthermore, the exchange rate, wages, and the relative price of exports showed opposite signs between the countries, being negative, positive, and negative, respectively, for India.

Drapkin, Vasilyeva, and Kandalintseva (2024) estimated a gravity model for a large sample of 80 high-income countries from 1996 to 2019. Their results showed that variables such as inflation, unemployment, tax levels, and the country's resource endowment were negative for high- and medium-technology-intensity exports. In contrast, external financing, available human capital, and the institutional environment had positive impacts.

Şaşmaz (2025) estimated fixed-effects and random-effects models for Turkish manufactured goods exports, aiming to understand their competitiveness factors. The exported products analyzed were those from classifications 5, 6, 7, and 8 of the International Standard Trade Classification (ISTC), which correspond to "Chemicals and related products," "Manufactured goods," "Machinery and transport

equipment," and "Miscellaneous manufactured equipment." The competitiveness of division 5 showed positive effects from the GDP-weighted distance between economies, as in Balassa and Bawens (1987), and from trade openness (share of total trade in the product), while the partner's GDP had a negative impact. For division 7, another of SITC's most technologically advanced divisions, the partner's GDP also had a negative effect, as did the other country's R&D investments. Conversely, the relative distance between economies and the difference between their GDP per capita contributed to gains in competitiveness.

Studies such as those by Bortoluzzo, Campos and Cavalcanti (2021) and Ferraz et al. (2025) estimated the effects of FDI on the quality of Brazilian exports and on the economic complexity of Brazilian municipalities, respectively. The first study revealed that the effects of foreign investment are positive, but greater for industries with lower technological intensity. The second study indicated that the benefits of FDI are greater the higher the absorptive capacity (measured by the number of research and development directors) of municipalities to absorb technological spillovers.

Although studies such as those by Muratoğlu and Muratoğlu (2016), Gamariel and Hove (2019), Ganai et al. (2023), and Şaşmaz (2025) have used export competitiveness indicators, with the first two including FDI in their models, there is room for innovation and a better explanation of the determinants of high- and medium-technology competitiveness and the effects of FDI on it. Firstly, this study used a model that, in addition to being dynamic, as done by Gamariel and Hove (2019), allowed short-term mismatches and assessed the relationships between variables in the short and long term. Secondly, it proposed a non-linear relationship between FDI flows and the country's income level, along with an approximate estimation of this inflection point where the effect changes. Finally, it increased the control variables used by including the share of primary product exports in GDP, accounting for the effects of the commodities boom and the country's specialization, and a proxy indicator for maquiladoras, which can impact exports of more technologically intensive products.

3 METHODOLOGY

To achieve the objectives proposed in this article, the Autoregressive Distributed Lag (ARDL) model, estimated by Pooled Mean Group (PMG), was used with the available data for the largest number of countries in Latin America and the Caribbean. The following subsection presents the variables, and the next, the model used.

3.1 VARIABLES AND SOURCES USED

The study implemented determinant variables for high and medium technology intensity exports, such as external income, the real effective exchange rate, the countries' domestic income, and gross fixed capital formation as a proportion of GDP. In addition, variables of interest to the study were added, such as foreign direct investment as a proportion of GDP, the share of primary exports in the countries' GDP, and an interactive variable between FDI and GDP per capita, seeking to capture non-linear relationships of FDI based on the size of the country. To control for possible maquiladora effects, as present in countries such as Mexico, Honduras, and Guatemala, the study added a coefficient of intermediate imports on manufactured exports to the model. Caria, Troyano, and Martín (2017) suggested controlling for this effect, pointing to what they call the bias of the Economic Complexity Index (ECI) in some Latin American countries. As with the ECI, it is believed that this effect can influence the competitiveness of medium and high technology intensity exports, which aggregate by products of greater complexity.

The classification used for the technological intensity of exports is Lall (2000), which is made available by UNCTAD (2025). This classification is an attempt to develop the proposal of the Organization for Economic Co-operation and Development (OECD), also aggregating products according to Pavitt's taxonomy (1984), which organizes sectors based on resources, labor-intensive, scale-intensive, differentiated manufactures, and science-based manufacturing.

The Revealed Comparative Advantage (RCA) indicator used was proposed by Balassa (1965) and is based on the Theory of Comparative Advantage. This indicator is calculated as the "share" of a given product in the country's total exports relative to the product's share in world exports:

$$[(RCA)]_i = (X_{ij}/X_i)/(X_{mj}/X_m)$$

Where: X_{ij} is the export of product j by the analyzed individual i ; X_i , the total export of individual i ; X_{mj} , the export of product j by the world (m); and X_m are the total world exports.

The higher the indicator, the greater the country's competitiveness in exporting the product. A country is considered competitive when it has an index greater than one. Thus, this study verified the factors that influence the competitiveness of Latin American and Caribbean countries, with a special focus on FDI. The variables were collected using the UNCTAD database (2025). The real effective exchange rate for the countries was collected from the Center for Prospective Studies and International Information (CEPII, 2026), using the EQCHANGE database, for 30 partners and time-varying weights.

Table 1 presents the model variables and their expected signs, as described in the literature. To reduce the variance between monetary variables, indicators, and percentages, the first two types were logarithmized, as described in Table 1.

Table 1 – Variables, expected signs and their sources

Variable	Description	Expected Sign	Source of the expected sign
LRCA	Indicator of the country's comparative advantage in high and medium technology intensity products (in natural logarithm).	D.V.	-
LYWORLD	External income, calculated using world GDP minus the income of the country under observation, in constant dollars from 2015 (using natural logarithms).	+	Gamariel; Hove, 2019; Vieira; Reis, 2019
FDI	Foreign direct investment flow, as a percentage of GDP	+ or -	Muratoğlu; Muratoğlu, 2016; Gamariel; Hove, 2019; Zapata; Arrazola; De Hevia, 2024; Farid et al., 2023; Ferraz et al., 2025; Bortoluzzo; Campos Cavalcanti, 2021; Ganai et al., 2023
GFCF	Gross fixed capital formation, as a percentage of GDP	+	Ganai et al., 2023
LGDPPC	GDP per capita, in constant 2015 dollars (in natural logarithm)	+	Gamariel; Hove, 2019
COMM	Share of primary product exports in the country's GDP	-	Camargo; Gala, 2017; Drapkin; Vasilyeva; Kandalintseva, 2024
LREER	Real effective exchange rate (in natural logarithm)	+ or -	Ganai et al., 2023
LMAQ	Relationship between intermediate imports and exports of the manufacturing industry.	+	Caria; Troyano; Martín, 2017

Source: Author's own elaboration.

Notes: D.V.: dependent variable.

External income is generally positively related to exports due to the demand effects on the exporting country's products. The exchange rate, another influential variable in international trade, can have a positive or negative effect. On the positive side, currency devaluation against the dollar increases the competitiveness of goods, positively impacting exports. The negative effect may be linked to short-term

rigidity: with established contracts, devaluations can have a negative effect on competitiveness, given the import costs, which become relatively more expensive (Arruda; Castelar; Martins, 2019). As a rule, the negative effect prevails in the short term, while the positive effect prevails in the long term. This relationship between the short- and long-term effects of currency devaluation is known in the literature as the J-curve effect (Williamson, 1989, pp. 145-146).

The FDI can positively impact the productivity of countries through technological spillovers from multinational corporations to local companies – consequently leading to increased trade – and boosting exports of more technology-intensive goods, given the competitiveness of Multinational Enterprises (MNEs) in the international market (Markusen; Venables, 1999; Borensztein; De Gregório; Lee, 1998). Conversely, MNEs can displace local companies with low productivity when using market-seeking strategies or redirect trade towards goods with lower technological intensity in cases of resource-seeking (Saggi, 2002). According to Oreiro (2016), the utilization of technological spillovers from technologically advanced countries by lagging countries depends on the size of the technological gap between them and the absorptive capacity of the receiving country of the new technologies. In other words, the effect of technology entry and spillover is non-linear.

The strategy used in this study is to utilize the interaction between FDI inflows – new technologies – and the country's income – dependent on technology and the maturity of its companies (Blomström; Kokko, 1998). Fagerberg's research (1988) supports the inclusion of the FDI*LGDPPC interaction variable by postulating that international competitiveness is not determined solely by prices, but primarily by a nation's technological capacity and absorptive capacity (infrastructure and production scale). According to the author, there is a close correlation between the level of economic development and the technological level, such that a country's ability to exploit the technological gap and absorb external innovations depends on its social capacity to mobilize resources and transform institutional structures. By using the LGDPPC (GDP per capita) as a proxy for this development, the interactive variable in question serves to validate Fagerberg's (1988), which impact of external factors – such as FDI – on export performance is conditioned by the stage of productive maturity and the prior absorptive capacity of the recipient country.

Investments are essential for increasing productivity in the economy and for modernizing industrial capital, which leads to a positive effect on the competitiveness of the exports analyzed. GDP per capita also tends to show a positive relationship with competitiveness. The share of primary goods exports in the country's gross domestic product has a negative effect, since the market tends to redistribute the workforce among the sectors of the economy and, within the context of the appreciation of commodity prices after 2004 and the increase in primary exports from the region, it is expected that the variable played a statistically significant and negative role.

The lack of data for several countries in the region limited the sample size to 30 countries. The sample delimitation, therefore, was based on the availability of data for the real effective exchange rate and the ratio between intermediate imports and manufactured exports. Another limitation is the lack of consistent data for countries, over long periods, for investments in research and development, an important variable that is often used as resources for innovation.

3.2. SPECIFICATION OF THE ECONOMETRIC MODEL

The estimation of the effect of FDI on the competitiveness of the exports analyzed in the study was performed using the Pooled Mean Group (PMG), which allows the use of the Autoregressive Distributed Lag (ARDL) structure for panel data. The PMG estimator allows the estimation of the coefficients of the variables for panel data, based on the assumption that the estimated coefficients have a homogeneous relationship in the long term – that is, equal coefficients – and a heterogeneous relationship in the short term – different coefficients. The PMG estimation process differs from the Mean Group (MG) by "stacking" the individuals and estimating an equal coefficient for them, while the latter estimates different coefficients for each individual and takes a general average of these coefficients (Shin; Pesaran; Smith, 1998). In addition to these estimators, the Dynamic Fixed Effects (DFE) considers the homogeneity of the coefficients in both the short and long term. To ensure the adequacy of the PMG to the model compared to the MG and DFE, the Hausman test was used. This test estimates, under the null hypothesis, whether the difference between the coefficients is not systematic (Pesaran, 2015). In the long term, the PMG parameters are homogeneous, and the MG parameters are heterogeneous, which under the same null hypothesis, indicates that the PMG is preferable. Conversely, in the short term, the PMG parameters are heterogeneous and the DFE parameters are homogeneous, indicating that, under the null hypothesis, the DFE is preferable.

The ARDL structure is suitable for estimating the problem investigated, since it accounts for inertial effects of the dependent variable (export competitiveness), which are assumed to be significant, and lagged effects of the other explanatory variables. This model can be represented as an ARDL (p, q, q, \dots, q):

$$\begin{aligned} \Delta y_{it} &= \phi_i \left(y_{i,t-1} - \theta_i' x_{it} \right) + \sum_j \\ &= 1^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{k=1}^K \sum_j \\ &= 0^{q_k-1} \delta_{ijk} \Delta x_{k,i,t-j} + \mu_i + \varepsilon_{it} \end{aligned}$$

Where: x is a vector of explanatory variables for individual i over periods t (LYWORLD, FDI, GFCF, LREER, COMM, LGDPPC, LMAQ, the FDI*LGDPPC interaction and their lags) and y is the dependent variable (LRCA); μ are the fixed effects for each i ; λ are scalars representing the coefficients of the lagged dependent variables for each individual; δ are vectors of coefficients of the explanatory variables; θ is the vector of long-term coefficients; ϕ is the term of error correction (TEC); K is the number of the explanatory variables. Furthermore, it is possible to add deterministic terms such as seasonal *dummies* or trends.

The choice of p and q – the number of lags of the dependent and independent variables – is made based on the Schwarz Information Criterion (SIC), recommended to avoid specification errors, especially with small T panels (Shin; Pesaran; Smith, 1998).

The ARDL considers combined stationary and non-stationary variables, provided that the non-stationary variables are at most $I(1)$ and that the error correction term is negative and significant. The stationarity test was performed in the study using the Im-Pesaran-Shin (IPS) test, which tests the null hypothesis that all series are non-stationary against the alternative hypothesis of the existence of at least one stationary series, allowing for some heterogeneity between groups. Furthermore, the study tested for cross-sectional dependence between countries, which can bias both the traditional PMG and stationarity tests such as the IPS, using the Pesaran test (2004). If there is no dependence, the Kao cointegration test corroborates the error correction term in indicating cointegration in the model. This cointegration test starts from the null hypothesis of the absence of cointegration, while the alternative hypothesis is cointegration in all panels (Pesaran, 2015).

4. ANALYSIS AND DISCUSSION OF RESULTS

To understand the variables for each country, Table 1 presents their averages for the period investigated and the average for the region studied. The table is organized by the average inflow of foreign investment in relation to GDP (FDI), from 2002 to 2021. Grenada is the main recipient of investment, along with Saint Kitts and Nevis and Antigua and Barbuda. Besides this country, several other Caribbean nations showed a large flow of FDI, which can be explained by the region's lower regulation of these investments. Among the ten largest recipients of FDI, seven belong to this region.

Table 1 – Average, for each country, of the selected variables used in the model, from 2002 to 2021.

Country	FDI		RCA		COMM		REER		GFCF		MAQ		GDPPC	
	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#
GRA*	13,51	1	0,24	12	179,26	23	94,17	16	26,91	7	3,23	29	8204,90	16
SCN*	12,48	2	1,91	1	13,29	31	100,46	6	35,76	2	2,82	30	18443,55	4
ANB*	11,67	3	0,16	14	40,40	30	104,63	4	30,72	4	3,78	28	16214,30	6
GUI	11,16	4	0,03	24	845,14	10	89,99	21	22,86	15	16,33	23	5319,50	22
BAH*	10,96	5	0,03	25	46,07	29	98,88	8	27,56	5	24,14	21	30879,80	1
SAL*	8,48	6	0,41	7	154,90	24	99,34	7	24,03	12	4,76	27	10052,65	13
DOM*	7,54	7	0,50	5	152,15	25	93,11	18	19,27	22	2,11	31	7445,40	18
BAR*	6,94	8	0,48	6	102,86	27	95,64	12	17,15	29	13,07	24	18507,55	3
PAN	6,86	9	0,85	4	347,52	20	93,61	17	33,35	3	115,03	14	11474,25	10
CHI	6,48	10	0,04	21	1420,80	4	91,26	20	24,37	11	688,29	4	11983,05	9
NIC	6,28	11	0,03	29	1213,91	7	84,59	27	27,16	6	64,31	19	1841,50	31
BEL	5,35	12	0,07	19	1030,09	8	101,68	5	16,42	31	6,78	26	5957,10	20
TOT	5,24	13	0,32	9	664,59	14	95,91	11	23,36	13	431,51	7	10056,22	12
COS	5,19	14	1,72	2	591,85	16	88,41	25	19,39	21	189,47	11	10695,75	11
HON	5,10	15	0,03	27	1246,63	6	88,80	24	25,43	9	74,60	17	2165,65	30
JAM*	5,00	16	0,06	20	78,36	28	82,65	28	23,18	14	64,06	20	5130,30	26
COL	3,80	17	0,11	17	784,98	11	73,27	31	21,77	18	538,22	5	5459,55	21
PER	3,79	18	0,02	31	693,74	13	92,58	19	21,50	19	462,82	6	5281,05	24
RDO*	3,68	19	0,32	10	141,09	26	80,94	29	24,98	10	199,20	9	6063,40	19
URU	3,44	20	0,10	18	906,57	9	94,60	14	18,39	25	106,72	15	14136,10	7
BRA	2,70	21	0,28	11	390,32	19	74,79	30	18,40	24	2866,84	2	8367,95	15
MEX	2,59	22	1,19	3	405,03	18	95,35	13	22,72	16	5442,80	1	9702,65	14
ARU	2,38	23	0,19	13	434,58	17	89,82	23	26,24	8	10,26	25	30114,40	2
ELS	2,32	24	0,32	8	252,78	22	183,12	1	17,94	26	119,12	13	3575,10	28
BOL	2,09	25	0,02	30	1832,82	2	113,69	2	17,48	28	71,43	18	2642,45	29
TRI*	2,02	26	0,03	28	1851,40	1	94,44	15	18,89	23	124,35	12	16495,90	5
GUA	1,91	27	0,14	15	628,19	15	96,62	10	17,70	27	190,20	10	3678,35	27
ARG	1,86	28	0,11	16	719,86	12	86,60	26	16,95	30	760,70	3	13485,30	8

PAR	1,15	29	0,04	22	1317,28	5	106,19	3	21,98	17	83,73	16	5249,55	25
QUE	1,12	30	0,04	23	1808,35	3	98,31	9	20,78	20	241,63	8	5287,45	23
SUR	-0,64	31	0,03	26	307,36	21	89,91	22	41,57	1	16,64	22	7832,25	17

Source: Own elaboration based on research data.

Note:# country position or total average in the sample; * country located in the Caribbean FDI, COMM, GFCF as a percentage of GDP; REER, RCA and MAQ index or coefficient value ; GDPPC in monetary value; TOT - Total General GRA - Grenada; GUI - Guyana; ANB - Antigua e Barbuda; SCN – Saint Kitts and Nevis; BAH - Bahamas; SAL - Saint Lucia; DOM - Dominica; BAR - Barbados; PAN - Panamá; CHI - Chile; NIC -Nicaragua; BEL - Belize; COS - Costa Rica; HON - Honduras; JAM - Jamaica; COL - Colombia; PER - Peru; RDO - Dominican Republic; URU - Uruguay; BRA - Brazil; MEX - Mexico; ARU - Aruba; ELS - El Salvador; ARG - Argentina; BOL - Bolivia (Plurinational State of); GUA - Guatemala; TRI - Trinidad and Tobago; PAR - Paraguay; EQU - Ecuador; SUR – Suriname.

Regarding the share of primary product exports in GDP, a certain pattern can be observed, with countries receiving larger amounts of FDI showing a lower share of primary products in their export portfolio. It is important to emphasize that FDI employs diverse strategies, making each country unique in relation to these investments (Blomström; Kokko, 1998; Markusen; Venables, 1999; Ferraz et al., 2025). Countries rich in natural resources, for example, can be exploited to a greater extent by companies with resource-seeking strategies; thus, companies can use these markets for the extraction and export of primary products or use the resources to advance the production chain and the domestic or foreign supply of more sophisticated goods.

The RCA calculated for the countries showed Saint Kitts and Nevis, Costa Rica, and Mexico as the most competitive in high and medium technology intensity products, as well as the only ones with an RCA greater than one, drawing attention to the region's specialization in lower technology intensity products. The control variable for maquiladoras pointed to Mexico as having the highest average, as expected. Brazil appeared with the second highest average, which was not expected; however, the high dependence on imported products and the low exports of Brazilian industry explain this high coefficient.

As a preliminary estimation, the cross-sectional dependence of the sample and the stationarity of the variables were tested. Table A1, in the Appendix, presents a fixed-effects model, similar to the model proposed in this research, but without dynamics. The Pesaran test, performed on this model, indicated that the cross-sectional dependence is not a cause for concern, allowing the estimation of ARDL by PMG, DFE, or MG. Table 2 presents the unit root test of the variables. The Im-Pesaran-Shin test indicated a stationary trend in the variables of world income and the proxy for maquiladoras, and that the country income and the real effective exchange rate were not stationary at the level but were in the first difference.

Table 2 – Im-Pesaran-Shin stationarity test

Variable	Level			Differentiated
	Constant	Constant and trend	Constant	
FDI		-4,73***	-	-
GFCF		-2,61***	-	-
COMM		-2,18**	-	-
LMAQ		-0,51	-2,77***	-
LREER		4,25	5,25	-4,57***
LRCA		-2,78***	-	-
LGPPC		-0,17	3,04	-5,16***
LYWORLD		5,69	-2,53***	-

Source: Author's own elaboration.

Note: *** significant at 1%; ** significant at 5%; * significant at 10%.

In addition to analyzing the error correction term to verify the existence of cointegration of the model variables, the study also uses the Kao test. The test statistics showed that it is possible to reject the null hypothesis of non-existence of cointegration in favor of the alternative of cointegration in all panels (Table 3).

Tabela 3 –Kao cointegration test

Kao tests	Test statistics
Modified Dickey-Fuller t	-8.4936***
Dickey-Fuller t	-12.6455***
Augmented Dickey-Fuller t	-5.2999***
Unadjusted modified Dickey-Fuller t	-22.3824***
Unadjusted Dickey-Fuller t	-16.8907***

Source: Author's own elaboration.

Note: *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 4 presents the results of the estimated models for the long and short term and the Hausman test. Due to the existence of a deterministic trend in LYWORLD and LMAQ, the estimated model showed a restricted constant trend in the short term. The signals, for the most part, followed the expected pattern based on the literature, although the real effective exchange rate (LREER) did not prove to be statistically significant at 5%. The Hausman test confirmed the Pooled Mean Group (PMG) as the most suitable model, as it is preferred over the Dynamic Fixed Effects (DFE) – with the null hypothesis being rejected – and the Mean Group (MG) – with the null hypothesis not being rejected at 5%.

Table 4 – Model estimation and Hausman test

Variable	PMG		MG		DFE	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard Error
LYWORLD	4,2058***	0,4499	-54,9325	44,6243	0,0305	2,5333
LGDPPC	-3,0497***	0,2845	28,6273	20,5449	-0,3204	0,4400
LMAQ	0,3145***	0,0447	2,3069	2,4289	0,1445	0,1878
LREER	0,0205	0,0252	1,2650	3,2261	-0,0550	0,1445
FDI*LGDPPC	0,0822***	0,0073	-2,7594	4,0702	-0,0121	0,0170
COMM	-0,0246***	0,0049	0,6255	0,4878	-0,0598*	0,0157
FDI	-0,7029***	0,0625	27,9842	38,1761	0,1381	0,1609
GFCF	0,0308***	0,0037	-0,1686	0,1869	0,0088	0,0100
ECT	-0,7424***	0,0967	-7,7739	6,5410	-0,5760*	0,0420
D1. LYWORLD	0,2768	3,3837	67,6746	56,9050	-0,0179	1,6088
D1. LGDPPC	0,1574	1,2402	-50,0870	59,9050	0,7290	0,5890
D1. LMAQ	-0,2933	0,3055	-14,8288	15,2518	-0,0814	0,1448
D1. LREER	-0,4811	1,2255	14,1967	14,8762	0,0379	0,1851
D1. FDI*LGDPPC	0,1887	0,1346	4,2116	6,0726	0,0165**	0,0082

D1. COMM	-0,0377	0,0739	-0,7173*	0,3873	-0,0385**	0,0113
D1. FDI	-1,4508	1,2141	-36,1620	52,2906	-0,1545*	0,0803
D1. GFCF	-0,0160*	0,0091	-0,1644	0,1602	-0,0056	0,0068
TEND	-0,0723***	0,0169	-1,0556	2,5191	-0,0065	0,0408
CONS	-81,8445***	10,5469	-203,9236	1435,234	-0,2844	45,7889

Hausman test (PMG x MG): $\chi^2 (8) = 14,66^*$

Hausman test (PMG x DFE): $\chi^2 (9) = 27,76^{***}$

Source: Author's own elaboration.

Note: *** significant at 1%; ** significant at 5%; * significant at 10%; ECT error correction term; CONS constant; TEND trend; D1 first difference of the variable; Schwarz's information criterion (SIC) indicated an ARDL (1, 1, 1, 1, 1, 1, 1, 1).

The lack of statistical significance of the real exchange rate in the long term for exports with higher technological intensity can be understood considering Kaldor's Paradox, as recently revisited by Oreiro (2025) and Ferreira-Filho and Oreiro (2026). In high-technology sectors, competitiveness is predominantly dictated by "non-price" factors – such as design, quality, and technical assistance – to the detriment of cost and price variations captured by the LREER (Long-Term Technology). In these cases, the exchange rate would only become an effective determinant if it reached the industrial equilibrium level, a level necessary to compensate for the technological gap of countries operating far from the knowledge frontier. Another relevant factor for the non-significant exchange rate coefficient is the exchange rate volatilities of the countries in the study period.

Additionally, Palazzo and Rapetti (2023) and Palazzo (2024a, 2024b) demonstrated that aggregate macroeconomic results with low exchange rate elasticity often mask profound sectoral heterogeneity. While differentiated products and labor-intensive manufactures have substantially high elasticities, the weight of commodities and homogeneous goods in Latin America's export basket generates a compositional effect that dilutes the exchange rate impact on the aggregate average. Thus, the insignificance of the LREER reflects a productive structure in which episodes of import substitution and surges in exports of higher value-added goods are limited by prior productive capacity and trade hysteresis, making isolated exchange rate stimulus insufficient to alter the RCA in a generalized way.

The error correction term (ECT) is negative and significant, as expected, indicating that there is cointegration of the variables and that the short-term deviations will be adjusted by approximately 74% in the subsequent year. Furthermore, the trend (TEND) introduced in the short term was also significant.

Unlike the long term, in the short term, no explanatory variable was statistically significant at the 5% level. Gross fixed capital formation was the closest, being significant at the 10% level. A possible explanation for this difference lies in the characteristics of the model. The Pooled Mean Group (PMG) considers that, in long-term equilibrium, variables have a homogeneous impact on countries, but in the short term, it allows for heterogeneity.

The 1% increase in the investment rate in the economy, as observed by the share of gross fixed capital formation in GDP (GFCF), contributes positively to competitiveness, by a magnitude of approximately 3.08%. Increased investment generates economies of scale in productive capacity, available infrastructure, and national productivity, triggering visible benefits in export competitiveness. Several studies have found the same result, such as Ganai et al. (2023) for the competitiveness of Chinese manufacturing exports; Muratoğlu and Muratoğlu (2016) for the competitiveness of manufactured goods exports from countries in the Organization for Economic Co-operation and Development (OECD); and Zapata, Arrazola, and De Hevia (2024) for high-technology exports.

As a control variable for maquiladoras impact – foreign companies established in special economic zones (SEZs) that benefit from low tariffs and incentives for export production – which have the effect of increasing exports of manufactured products without significant added value or spillovers, LMAQ revealed a positive effect on the competitiveness of high and medium technology intensity products. This effect was expected, since maquiladora companies tend to be vertically integrated in their production chain (producing and exporting), being major promoters of trade in their activities and influential, even, on the economic complexity of the country. Mexico stands out among the countries that seek in the maquiladora industry as a meaning of accessing foreign technologies, generating jobs and improving their trade integration. Caria, Troyano and Martín (2017), for example, investigated what they called the maquiladora bias on economic complexity indices. According to the authors, maquiladoras increase exports, in quantity and complexity, without a significant effect on the country's development, which explains differences between the economic complexity index and indices of human development, technological capabilities, income, and structural changes. Wu, Hong, and Muhammad (2020), studying the effects of Chinese Export Processing Zones (EPZs), concluded that companies near these zones benefit, especially those in activities covered by the EPZ. Another important finding is that EPZs focused on high-technology firms further enhance the economic performance of nearby companies.

The share of primary exports in the country's GDP has a negative impact, with a 1% increase in this variable leading to a 0.02% decrease in its competitiveness indicator. The shift of factors between sectors of the economy may be a possible explanation for this effect, since higher profits in primary sectors tend to attract workers or capital to that sector, to the detriment of others. The appreciation of the exchange rate, resulting from the greater concentration on natural resources, a phenomenon known as Dutch disease, is

also an explanation for the decrease in competitiveness. This effect – stemming from the so-called Dutch disease or resource curse – is discussed by Camargo and Gala (2017), who reported a similar relationship between the concentration of exports in natural resources and economic complexity. Hou and Karayalcin (2019) found negative effects of the expansion of primary products in exports on investment in human capital. According to the authors, the explanation for this phenomenon lies in the decrease in demand for skilled labor, in favor of a less skilled workforce, characteristic of primary goods. Döver and Middelanis (2023) analyzed whether intraregional trade could be a possible means of mitigating the effects of Dutch disease in developing countries dependent on commodities. Their results showed, in addition to a positive response from this trade, that commodity prices negatively affect both low- and high-technology exports. Drapkin, Vasilyeva, and Kandalintseva (2024) corroborated this by investigating the impact of mineral exports, fuel exports, and natural resource income on high-technology exports, which was negative for all three variables. Guedes and Arend (2025) adopted the perspective of Baumol's disease theory for Brazilian economic stagnation in the 21st century. This disease is characterized by a relatively greater increase in service costs compared to the manufacturing industry, which introduces innovations more frequently to overcome them. According to the authors, the Brazilian structural change consisted of the shift of the workforce from the primary to the tertiary sector, without establishing a foundation in the industrial (secondary) sector. The study corroborated the results of the COMM variable in the present research by highlighting the weight of low and medium-low technology intensity sectors – which, according to the authors, are closely linked to agricultural and industrial commodities – on structural change in the country,

Stimulating increased demand for manufactured goods from Latin American and Caribbean countries, the world income coefficient (LYMUND) showed a signal in line with expectations, as in Gamariel and Hove (2019). Fagerberg (1988) indicated the demand-pull effect of innovation, which exerts pressure and opportunities for innovations stemming from increased income of economic agents, who develop new needs.

Finally, the variables of greatest interest, the inflow of foreign investment (FDI), market size (LGDPPC), and their interaction (FDI*LGDPPC), revealed pertinent points. The inflow of FDI does not produce benefits for poor countries; in fact, this type of investment can compress their competitiveness. Deriving the estimated equation in relation to FDI and equating it to zero, the "pivot" value – from the GDP per capita at which FDI has positive impacts – is 8.5511, which corresponds to a GDP per capita of US\$ 5,172.44. Among the countries in the sample, only six had an average lower than this: Jamaica, Guatemala, El Salvador, Bolivia, Honduras, and Nicaragua, as seen in Table 1. Market development, with the increase in GDP per capita and institutional and infrastructure consequences, as well as the maturity of local companies and their capacity to absorb new technologies, is pointed out as an important conditioning factor of the possible benefits of FDI. New companies in the country may end up displacing local ones, given

their competitive advantages over companies from relatively small countries. Blomström and Kokko (1998) already indicated that more developed countries have a lower chance of having their companies "displaced" from the market with the entry of multinational corporations (MNCs). Borensztein, De Gregorio, and Lee (1995) also pointed out that the effects of FDI on economic growth are conditioned by the availability of human resources, with countries with low availability even showing negative effects. Also supporting this result, Fagerberg's study (1988) indicated that, although the relative unit value of exports is important, the country's technological competitiveness and its "delivery capacity" have even greater magnitudes in increasing the share of manufactured exports in relation to the world. The author even cited the use of GDP per capita as a proxy used by studies to capture technological development when the economic development of countries is heterogeneous.

More recently, Gamariel and Hove (2019) also verified relationships between FDI and the export competitiveness of sub-Saharan African countries. When conditioned on the countries' human capital, FDI inflows had greater results for those with greater availability of this capital. The same result was observed when the authors used export sophistication as the dependent variable.

5 FINAL REMARKS

This article verified the impacts of Foreign Direct Investment (FDI) inflows into Latin American and Caribbean countries on the competitiveness of their technological exports between 2002 and 2021. To achieve these objectives, the article used the Autoregressive Distributed Lag (ARDL) model.

The main result highlighted the significant and positive relationship between the inflow of FDI and GDP per capita. This suggested that FDI can bring benefits to a country's technological competitiveness as it advances in economic and technological development. Its negative coefficient in the isolated FDI variable indicated that a certain level of GDP per capita is necessary for these benefits to materialize. On the other hand, the entry of multinational enterprises (MNEs) into the country, without sufficient internal competitiveness, can lead to reductions in competitiveness due to the displacement of local companies and the redirection of resources and factors caused by EMNs.

The other variables comprising the long-term model are in line with expectations from the literature. Only the real effective exchange rate (LREER) did not show statistical significance. The rate of investment in countries (LGFCF) was an important factor in promoting export competitiveness. The creation and improvement of infrastructure and the accumulation of physical capital result in greater productivity and; consequently, greater competitiveness of high and medium technology products. World income (LYWORLD) indicated an important contribution to increasing the competitiveness of countries, since its demand increases the requisition of products from the countries analyzed, in addition to new possibilities and product requisitions. As a proxy for control of maquiladora companies, the LMAQ variable revealed a

positive effect on competitiveness. The export-oriented production aspect of these companies and their concentration in industries of greater relative complexity explains this effect. Finally, the share of primary product exports in GDP (COMM) negatively impacted on competitiveness, since the primary sector became more attractive to production factors and investments in economies, mainly due to the influence of rising commodity prices during the period. In the short-term model, the variables were not significant at the 5% level, probably due to the heterogeneity of the countries in their short-term adjustments.

Therefore, the study affirmed that there were non-linear effects of FDI in the Latin American and Caribbean countries analyzed. The utilization of these effects was greater the higher the per capita income of the recipient country, but below a certain income (approximately US\$ 5,172.44), the effect was negative. The capacity to absorb the foreign technologies that this investment brought to the country – through well-developed national innovation systems, mature companies with the capacity for internal and external competition, and national investment capacity – can be considered an important condition for the evolution of the country's technological competitiveness. It is up to governments and local regulatory bodies to propose direction for the influx of foreign investment towards the most competitive sectors of their economies. For nations below the estimated income threshold, the recognition of their sectors with greater and less competitive capacity and technological absorption is crucial for establishing restrictions, benefits, and requirements for foreign capital that may establish itself. For nations above this point, the process should be more favorable, due to the greater number of sectors at their maturity and the greater benefits reaped from FDI. However, maintaining and deepening the scientific and innovation infrastructure is crucial, promoting public-private cooperation and the independent or joint undertaking of research and development activities. The growth of projects in renewable energy sectors in recent years can be a strategic factor in attracting FDI by countries, seeking to take advantage of the natural capacities of the region, but also establishing requirements and incentives for technology transfer between foreign and domestic companies. Thus, countries, in addition to obtaining a source of productivity growth, can start from sustainable green development, allying themselves with new clean technologies.

The main limitation of this study is the unavailability of sectoral FDI information, which could be more suitable for the proposed objectives. However, it should be noted that the total flow of FDI is widely used in empirical studies, as evidenced by the literature review. Furthermore, reliable and more continuous information on variables related to education would be relevant for considering human capital. For future work, it is suggested that these new explanatory variables be included to account for the country's internal capacity for technological absorption, such as human capital. Another possibility for advancement is the use of non-linear models, such as threshold models, which improve estimation when there are regime changes depending on a variable (as was the case with the change in the effect of FDI on GDP).

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APPENDIX

TABLE A1 – Pesaran's test on the estimated model with fixed effects.

Variable	Coefficient	Standard error
LYWORLD	0,6847	1,2679
LGDPCC	-0,1313	0,2388
LMAQ	0,0806	0,1002
LREER	0,0163	0,0767
FDI*LGDPCC	0,0053	0,0078
COMM	-0,0548***	0,0079
FDI	-0,0320	0,0742
GFCF	0,0042	0,0052
TEND	-0,0281	0,0352
CONS	-22,776	39,7321
Teste de Pesaran: 0,403 (0,687)		

Source: Author's own elaboration.

Note: *** significant at 1%; ** significant at 5%; * significant at 10%; the value in parentheses indicates the probability of the Pesaran Test.