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TECHNOLOGICAL INVESTMENT AND GDP GROWTH IN LATIN AMERICA: EVIDENCE FROM A DYNAMIC PANEL MODEL

Daimi FONSECA HERNANDEZ[1]

Abstract: *This article analyses the effect of technological investment on GDP growth in selected Latin American countries using a dynamic panel model estimated through System-GMM. Although technology is commonly regarded as a major driver of economic growth, its aggregate impact in Latin America remains uneven and in some cases, weak or contradictory. The study adopts a macroeconomic perspective connected to previous evidence on innovation and productivity in SMEs, under the premise that technology contributes to growth only when it is effectively translated into productivity gains, productive linkages and sectoral diffusion. The results show that technological investment does not generate immediate or homogeneous increases in GDP growth across the countries analysed. Its estimated short-run effect appears to be constrained by structural and institutional conditions that limit the transformation of technological investment into aggregate value added. The findings suggest that technology is a necessary but not sufficient condition for economic growth. Policy implications are therefore interpreted cautiously, as theoretically informed extensions rather than as mechanisms directly tested by the empirical model.*

Key words: *technological investment, GDP growth, Latin America, System-GMM, productivity*

1. Introduction

Technological investment occupies a central place in development theory and in contemporary policy agendas aimed at promoting productivity, competitiveness, and economic growth (Hasan and Tucci, 2010; Fagerberg et al., 2010; Ramos and Cervantes, 2020). In principle, the incorporation of technology can expand production possibilities, improve efficiency, support innovation processes, and contribute to structural transformation. However, the relationship between technological investment and economic growth is not automatic. Its effects depend on the capacity of economies to absorb, adapt, and diffuse technological change across firms, sectors and territories.

[1] Transilvania University of Braşov, daimi.hernandez@unitb.ro, ORCID ID: 0009-0001-8955-1137

This issue is particularly relevant in Latin America, where technological investment has often coexisted with persistent patterns of low productivity, limited productive sophistication, weak intersectoral linkages, and insufficient absorptive capacity (Rodrik, 2011; Dutrénit et al., 2014; Rodrik et al., 2004). In this context, higher technological expenditure or greater access to digital and innovation-related resources does not necessarily translate into sustained GDP growth. For technology to generate aggregate economic effects, complementary mechanisms are required, including learning processes, human capital formation, productivity improvements, value-chain linkages and institutional support.

Previous studies have examined the relationship between innovation, technological infrastructure and economic performance from different perspectives, including telecommunications infrastructure, patents, ICT adoption, and innovation-led development (Guevara Vivanco and Nalvarte Atencia, 2022; Gyedu et al., 2021; Khanthawithoon et al., 2021). Other contributions have shown that innovation can improve firm-level productivity in Latin America, especially when firms possess the capabilities required to transform technological efforts into productive results (Crespi and Zuniga, 2012; Salas et al., 2023). Nevertheless, the specific macroeconomic relationship between technological investment and GDP growth in Latin American countries remains comparatively underexplored, particularly when technological investment is treated as a synthetic indicator that combines research and development efforts with ICT-related technological capacity.

This article addresses that gap by analysing the effect of technological investment on GDP growth in selected Latin American countries using a dynamic panel model estimated through System-GMM. The use of a dynamic specification allows the study to account for the persistence of economic growth and for potential endogeneity between technological investment and macroeconomic performance. Rather than assuming a direct and homogeneous effect, the article examines whether technological investment is associated with GDP growth in a context marked by structural heterogeneity and uneven institutional and productive capacities.

The paper makes two main contributions. First, it provides empirical evidence on a regional relationship that is frequently assumed to be positive, but whose behaviour in Latin America may be weak, delayed or heterogeneous. Second, it interprets technological investment not as an isolated driver of growth, but as part of a broader process mediated by productive structure, absorptive capacity, institutional conditions and the ability of firms and sectors to transform technological resources into productivity gains and sectoral diffusion.

The results suggest that technological investment does not generate immediate or homogeneous increases in GDP growth across the countries analysed. In the short run, its estimated effect appears negative and statistically significant, which should not be interpreted as evidence that technology is harmful to growth, but rather as an indication that technological investment requires complementary conditions to produce aggregate economic returns. Accordingly, the article argues that technology is a necessary but not sufficient condition for economic growth in Latin America.

2. Analytical Framework

2.1. Technological investment, innovation and economic growth

Literature on economic growth has consistently emphasised the role of technology as a source of productivity gains, output expansion and long-term economic transformation (Hasan and Tucci, 2010; Fagerberg et al., 2010; Gyedu et al., 2021). However, this literature has also shown that technological change does not operate in isolation. Its effects depend on complementary conditions such as human capital, institutional quality, macroeconomic stability, productive openness, and learning capacity. In this sense, technological investment should not be treated as an autonomous driver of growth, but as part of a broader process through which economies absorb, adapt, and diffuse knowledge across sectors and firms.

Recent evidence also emphasises that technological innovation increasingly operates through both formal knowledge creation and digital transformation. R&D investment and ICT-related capacity should therefore be understood as complementary dimensions of technological investment. While R&D reflects the generation of new knowledge, ICT supports connectivity, digitalisation, organisational efficiency, and the diffusion of information across firms and sectors. Recent studies on Latin America show that ICT adoption and digital infrastructure remain relevant for explaining economic performance, although their effects depend on the broader productive and institutional context in which they are embedded (González Bautista, 2024; OECD et al., 2024).

2.2. Absorptive capacity, productive diffusion and structural heterogeneity

The relationship between technological investment and GDP growth is especially relevant in Latin America, where structural heterogeneity remains a central feature of the productive system (Rodrik, 2011; Dutrénit et al., 2014; Ramos and Cervantes, 2020). Productivity gaps across sectors, firm sizes, and territories tend to weaken the broad diffusion of technological benefits. Even when investment in technology exists, its aggregate effect may be limited if it is concentrated in narrow segments of the economy, if it fails to generate significant productive linkages, or if firms lack the capabilities required to appropriate it. From this perspective, the relationship between technology and GDP growth is mediated by the quality of the mechanisms that connect innovation, productive structure and institutional context.

This interpretation is consistent with previous evidence showing that innovation improves firm-level productivity under specific conditions rather than uniformly (Crespi and Zuniga, 2012; Salas et al., 2023). At the micro level, innovation tends to be more effective when firms strengthen internal capabilities, especially in productive processes. At the territorial level, its effects depend on formality, support networks and the institutional environment. Therefore, technology may be a necessary condition for growth, but not a sufficient one.

Recent evidence on Latin American and Ibero-American SMEs supports this argument. Restrepo-Morales, Valencia-Cárdenas and García-Pérez-de-Lema (2024) show that technological innovation can strengthen SME resilience and performance, but its effects depend on firms' capacity to reorganise processes, adopt digital tools, and respond to external shocks. Similarly, the SME Policy Index for Latin America and the Caribbean highlights that innovation and technology policies have improved in several countries, although their scope and effectiveness remain heterogeneous across the region (OECD/CAF/SELA, 2024). These findings reinforce the argument that technological investment requires firm-level capabilities and supportive policy environments to generate broader productivity effects.

2.3. Technological investment in the Latin American context

Recent regional reports confirm the persistence of structural challenges that condition the impact of technological investment in Latin America. The Latin American Economic Outlook 2024 emphasises that low productivity continues to restrict long-term growth in Latin America and the Caribbean, with average labour productivity in the region remaining far below OECD levels (OECD et al., 2024). ECLAC (2024) also argues that Latin America faces a low growth trap associated with weak productivity performance and insufficient productive transformation.

From this perspective, technological investment should be analysed together with the institutional, financial, and productive conditions that determine whether innovation can be transformed into sustained economic growth. In contexts marked by weak linkages between firms, universities, and public institutions, limited financing for innovation and unequal access to digital infrastructure, technological investment may not translate immediately into GDP growth. This does not imply that technology is irrelevant for development, but rather that its economic impact depends on the existence of complementary mechanisms that enable its productive appropriation.

2.4. Research gap and analytical proposition

Although previous studies have examined the relationship between innovation, ICT, telecommunications infrastructure, patents, and economic growth, the specific macroeconomic relationship between technological investment and GDP growth in Latin America remains insufficiently explored. There is still limited evidence on whether a synthetic measure of technological investment, combining research and development efforts with ICT-related technological capacity, is associated with GDP growth in a dynamic panel framework.

This article addresses that gap by examining the relationship between technological investment and GDP growth in selected Latin American countries using System-GMM. The analytical proposition guiding the study is that technological investment contributes to economic growth only when it is effectively transformed into productivity gains, productive linkages and sectoral diffusion. In the absence of these complementary conditions, its short-run aggregate effect may be weak, delayed or heterogeneous. Therefore, the article does not assume a direct and automatic positive effect of technological investment on GDP growth, but tests whether such a relationship is empirically observable in the Latin American context.

3. Data and methodology
3.1. Data and variables

The empirical analysis is based on a balanced panel of 10 Latin American countries observed over a 10-year period, yielding a total of 100 country-year observations. The sample was defined according to the availability and comparability of data for the variables required in the empirical model, particularly GDP growth, technological investment components, real interest rate, inflation, and unemployment. The countries included in the sample are Cuba, Brazil, Argentina, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay, and Venezuela.

This country selection allows the study to examine a group of Latin American economies for which consistent information was available across the period analysed. However, the sample should not be interpreted as fully representative of Latin America as a whole. The region is highly heterogeneous in terms of productive structure, institutional capacity, macroeconomic conditions, and technological development. Therefore, the results should be understood as evidence for a restricted group of selected Latin American countries rather than as general conclusions for the entire region.

This limitation is particularly relevant because System-GMM estimators are generally more reliable in panels with a larger cross-sectional dimension. Since the present study uses a limited number of countries, the estimates should be interpreted with caution. The model is therefore used to identify a structured dynamic association between technological investment and GDP growth, rather than to claim definitive causal effects for the whole Latin American region.

GDP growth, measured as the annual growth rate of gross domestic product, is used as the dependent variable. The main explanatory variable is the technological investment index, constructed from research and development expenditure and ICT-related technological capacity. The model also includes three macroeconomic control variables: the real interest rate, inflation, and unemployment rate. These variables are included because they capture key macroeconomic conditions that may affect both technological investment and economic growth.

The data were obtained from UNCTAD, Refinitiv, and the World Bank Group.

Table 1 summarises the variables included in the empirical model, their measurement, and the corresponding data sources.

Variables, measurement and data sources Table 1

Variable	Acronym	Definition	Source
Dependent variable			
GDP growth	GDP	GDP growth measures the annual percentage growth rate of gross domestic product.	Refinitiv; World Bank Group

Variable	Acronym	Definition	Source
Independent variable			
Technological investment	TI	Synthetic index capturing national technological investment efforts and innovation-related technological capacity.	The United Nations Conference on Trade and Development (UNCTAD)
Real interest rate	RI	Interest rate adjusted for inflation, reflecting the real cost of borrowing or the real return on investment.	World Bank Group
Inflation	INF	Annual percentage change in the general price level of goods and services.	Refinitiv: World Bank Group
Unemployment rate	UNEMP	Percentage of the labour force that is unemployed and actively seeking work.	Refinitiv; World Bank Group

Source: Author's compilation based on UNCTAD, Refinitiv, and World Bank data.

3.2. Construction of the technological investment index

The technological investment index was constructed from two indicators obtained from UNCTAD: research and development expenditure and ICT-related technological capacity. These two variables were selected because they capture complementary dimensions of technological investment. Research and development expenditure reflects formal efforts devoted to knowledge creation, innovation and technological upgrading, while ICT-related capacity captures the digital infrastructure and connectivity conditions that support the adoption, diffusion, and use of technology across firms and sectors.

Principal Component Analysis (PCA) was used to combine these two indicators into a single synthetic index. PCA was preferred over alternative composite methods because it allows the weights of the index to be derived from the statistical structure of the data rather than being assigned subjectively. This is particularly useful when the purpose is to summarise correlated indicators into one measure while preserving the maximum possible variance contained in the original variables. In this study, PCA reduces the dimensionality of the technological investment components and generates a synthetic variable that can be incorporated into the dynamic panel model.

The use of only two indicators is justified by both theoretical and empirical considerations. Theoretically, R&D, and ICT represent two central dimensions of technological investment: knowledge generation and digital technological capacity. Empirically, the selection was also constrained by the availability of comparable data for the 10 countries and the 10-year period analysed. Other potentially relevant indicators, such as patents, human capital, innovation outputs or institutional quality, were not included in the index because they either capture different mechanisms or were not consistently available for all countries and years. Their exclusion is acknowledged as a limitation and provides an avenue for future research.

The adequacy of the PCA procedure was assessed using standard diagnostic statistics. The Kaiser-Meyer-Olkin (KMO) statistics were used to evaluate sampling adequacy, while eigenvalues and explained variance were used to determine the relevance of the retained component. Factor loadings were also examined to verify the contribution of each variable to the technological investment index. The first principal component was retained as the synthetic technological investment index because it explained the largest proportion of the common variance between R&D expenditure and ICT-related technological capacity.

Table 2 presents the components used to construct the technological investment index, while Table 3 reports the PCA diagnostic results.

Components of the technological investment index Table 2

Variables	Acronym	Definition	Source
Research and Development	RD	Expenditure and efforts devoted to research and development activities, usually expressed relative to GDP.	The United Nations Conference on Trade and Development (UNCTAD)
Information and communication technology	ICT	Indicator capturing the technological and digital dimension associated with information and communication systems and technological upgrading.	The United Nations Conference on Trade and Development (UNCTAD)

Source: Author's compilation based on UNCTAD data.

PCA diagnostic results for the technological investment index Table 3

Diagnostic	Value
KMO statistic	0.69
Eigenvalue of Component 1	1.529
Variance explained by Component 1 [%]	76.45
Cumulative variance explained [%]	76.45
Factor loading: R&D expenditure	0.75
Factor loading: ICT	0.54

Source: Author's calculations based on UNCTAD data.

The PCA results support the construction of the technological investment index. The KMO statistics are 0.69, indicating an acceptable level of sampling adequacy. The first principal component reports an eigenvalue above one and explains 76.45% of the total variance, which supports its retention as a synthetic measure of technological investment. The factor loadings show that R&D expenditure contributes strongly to the index, while ICT-related technological capacity also contributes as a complementary digital dimension. Therefore, the retained component is interpreted as an exploratory synthetic index that captures the common technological investment dimension represented by formal knowledge-generation efforts and ICT-related capacity. Given that the index is based on two indicators, it should not be interpreted as a complete measure of national innovation systems, but as a focused proxy for technological investment based on comparable R&D and ICT data.

3.3. Empirical specification

To estimate the relationship between technological investment and economic growth, the article uses a dynamic panel model in which GDP growth depends on its own lagged value, the technological investment index, and a set of macroeconomic control variables. The inclusion of the lagged dependent variable captures the persistence of economic growth over time, following the standard approach used in empirical growth models (Barro, 1991; Bond et al., 2001).

The empirical specification is defined as follows:

$$\boldsymbol{GDPGrowth_{it} = \alpha + GDPGrowth_{it-1} + \beta_1 TI_{it} + \beta_2 RI_{it} + \beta_3 INF_{it} + \beta_4\, UNEMP_{it} + \mu_i + \lambda_t + \varepsilon_{it}}$$

where: $GDPgrowth_{it}$ denotes the annual GDP growth rate in country i at time t; $GDPgrowth_{it-1}$ is the lagged dependent variable; TI_{it} is the technological investment index; RI_{it} is the real interest rate; INF_{it} is the inflation rate; $UNEMP_{it}$ is the unemployment rate; μ_i captures country-specific effects; λ_t captures time effects; and ε_{it} is the idiosyncratic error term.

The three control variables were selected because they capture macroeconomic conditions that may influence both technological investment and GDP growth. The real interest rate reflects the cost of financing and is relevant because technological investment frequently requires access to credit or external funding. Inflation is included as an indicator of macroeconomic instability, which may affect investment decisions, purchasing power, and growth performance. The unemployment rate captures labour market conditions and aggregate demand pressures, both of which are closely related to economic activity.

Other variables commonly used in growth models, such as human capital, trade openness, institutional quality, public expenditure or financial development, were not included due to data availability constraints and the need to preserve degrees of freedom in a small panel. Their exclusion is therefore acknowledged as a limitation of the empirical specification. Consequently, the model should be interpreted as a focused dynamic specification that examines the association between technological investment and GDP growth while controlling key macroeconomic conditions.

3.4. Estimation strategy

The model is estimated using the System-GMM estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998), building on the dynamic panel approach developed by Arellano and Bond (1991). This estimator is appropriate for dynamic panel models in which the dependent variable is persistent over time and where potential endogeneity may exist between the explanatory variables and the outcome variable. In the context of this study, GDP growth may depend on its own past values, while technological investment may be both a determinant and a consequence of macroeconomic performance.

System-GMM was preferred over static panel estimators because the inclusion of the lagged dependent variable may generate dynamic panel bias if estimated using ordinary fixed-effects or pooled models. It was also preferred over Difference-GMM because the variables used in the model may display persistence over time, which can weaken the instruments in first difference specifications. By combining equations in first differences with equations in levels, System-GMM improves efficiency and helps address potential endogeneity in dynamic panels.

However, the use of System-GMM in this article requires caution because the sample includes only 10 countries observed over a 10-year period. Since GMM estimators are generally more reliable when the cross-sectional dimension is larger, the results should not be interpreted as definitive causal estimates for the entire Latin American region. Instead, they should be understood as exploratory evidence of a dynamic association between technological investment and GDP growth in the selected countries.

To reduce the risk of instrument proliferation, the number of instruments was kept below the number of countries, following standard recommendations for dynamic panel estimation (Roodman, 2009). The validity of the specification was assessed using the AR(1) and AR(2) tests for serial correlation and the Hansen and Sargan tests for overidentifying restrictions. Attention is given to the AR(2) test, since the absence of second-order serial correlation is required for the validity of the instruments. The Hansen test is also interpreted cautiously, especially given the small sample size.

The estimation was implemented using a two-step robust procedure with finite-sample correction. This approach improves the reliability of the standard errors while maintaining a cautious interpretation of the results. Therefore, the empirical findings are presented as evidence of a structured dynamic relationship rather than as conclusive proof of a strict causal effect.

4. Results

4.1. Descriptive evidence

Before presenting the econometric estimates, it is useful to examine the descriptive behaviour of the main variables. Figure 1 displays the distribution of the technological investment index across the countries included in the sample. The figure reveals substantial heterogeneity across Latin American economies, with more stable patterns in some cases and greater dispersion in others. This suggests that technological investment is unevenly distributed across the selected countries and that cross-country differences are relevant for interpreting the aggregate growth effects of technology.

As shown in Figure 1, the technological investment index is unevenly distributed across the countries included in the sample. Some economies display relatively higher median values, while others remain at lower levels. The figure also reveals differences in dispersion and the presence of outliers, suggesting that technological investment is not only heterogeneous in magnitude but also in stability across countries. This descriptive evidence supports the argument that the growth effects of technological investment may vary across national contexts.

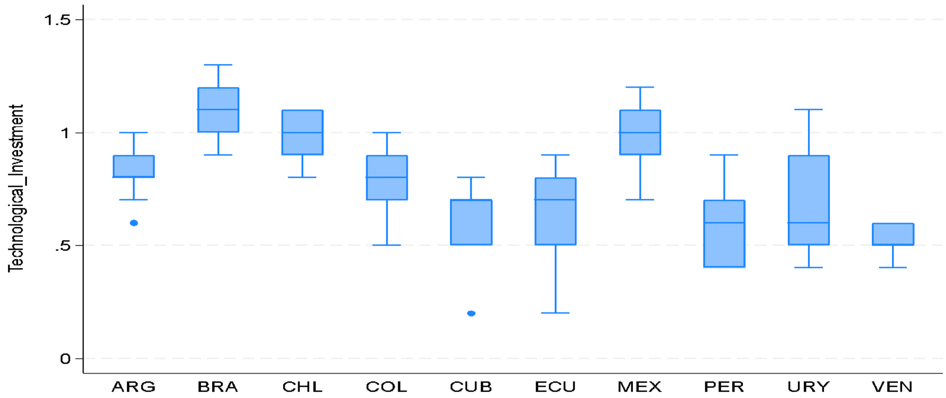

Fig. 1. *Distribution of the technological investment index across Latin American countries*
Source: Author's calculations based on UNCTAD data.

Table 4 reports the descriptive statistics and pairwise correlations for the variables included in the model. The descriptive evidence shows that GDP growth and technological investment vary across countries and over time. The technological investment index presents moderate average values but also noticeable dispersion, while inflation and the real interest rate display high variability, reflecting the macroeconomic heterogeneity of the region. At the descriptive level, GDP growth is positively correlated with technological investment and the real interest rate, whereas its correlation with inflation and unemployment is weak. These preliminary patterns justify further examination through a dynamic panel model.

Descriptive statistics and correlation matrix Table 4

Panel A. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
GDP growth	100	0.416274	0.295885	0.0553	1.37093
Technological investment	100	0.772857	0.236555	0.2000	1.3000
Real interest rate	100	6.373652	12.83488	-35.3145	46.4474
Inflation	100	15.87841	27.95378	-0.33887	254.9485
Unemployment rate	100	8.93999	4.372169	2.67	36.842

Panel B. Correlation matrix

Variable	(1)	(2)	(3)	(4)	(5)
(1) GDP growth	1.0000				
(2) Technological investment	0.4846	1.0000			
(3) Real interest rate	0.4557	0.2824	1.0000		
(4) Inflation	0.0028	-0.2658	-0.1958	1.0000	
(5) Unemployment rate	0.0227	-0.2899	0.0459	0.2464	1.0000

Source: Author's calculations based on UNCTAD, Refinitiv, and World Bank data.

4.2. Baseline System-GMM results

Table 5 presents the baseline System-GMM estimates for the relationship between technological investment and GDP growth in the selected Latin American countries. The results suggest that technological investment does not translate into immediate or homogeneous increases in GDP growth. At the regional level, the estimated coefficient of technological investment is negative in the short run. Rather than invalidating the relevance of technology, this finding suggests that its aggregate effect may depend on complementary structural and institutional conditions that are not equally developed across Latin American economies.

Baseline System-GMM estimates Table 5

Variable	**Coefficient**
Lagged GDP growth	0.09
	(0.198)
Technological investment	-21.392***
	(9.191)
Real interest rate	-4.121***
	(0.514)
Inflation	-0.958***
	(0.329)
Unemployment rate	-1.904***
	(0.22)
Model diagnostics	**Value**
Observations	100
Countries	10
Number of instruments	5
AR(1) test (p-value)	0.405
AR(2) test (p-value)	0.612
Hansen test (p-value)	0.050
Sargan test (p-value)	0.551
Time dummies	Yes

Notes: Robust standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.10.

In economic terms, a negative short-run coefficient may indicate that technological investment generates limited or delayed returns when it is not accompanied by sufficient human capital, complementary infrastructure, productive articulation, and absorptive capacity. It may also suggest that part of the observed investment is concentrated in partial modernisation processes or in technology acquisition that does not diffuse effectively across the broader productive system. Therefore, the estimates should be interpreted as evidence that technological investment alone is not sufficient to ensure higher aggregate growth.

The macroeconomic control variables also provide relevant information. Inflation and unemployment show negative coefficients, suggesting that macroeconomic instability and adverse labour market conditions may constrain growth performance. The real interest rate also presents a negative coefficient, which is consistent with the idea that higher financing costs may reduce investment and economic activity. These results reinforce the importance of considering the broader macroeconomic environment when analysing the relationship between technological investment and GDP growth.

The diagnostic tests provide cautious support for the specification. The AR(2) test does not indicate second-order serial correlation, which is necessary for the validity of the instruments. The number of instruments remains below the number of countries, reducing the risk of instrument proliferation. However, the Hansen test is borderline and should be interpreted with caution, especially given the small number of countries included in the sample. Consequently, the results should be understood as exploratory evidence of a dynamic association rather than as definitive causal estimates.

4.3. Structural interpretation of the results

The baseline estimates reinforce the view that technological investment contributes to economic growth only when it is effectively translated into sustained productivity gains and broader sectoral diffusion (Hasan and Tucci, 2010; Gyedu et al., 2021). A negative and significant coefficient for technological investment should not be interpreted as evidence that technology is harmful to growth per se. Rather, it suggests that, in the Latin American context, technological investment may generate weak, delayed, or even adverse short-run aggregate effects when complementary conditions are insufficiently developed. These conditions include absorptive capacity, human capital, productive articulation, institutional quality, and the availability of complementary infrastructure.

This interpretation is particularly relevant in Latin America, where structural heterogeneity remains a defining characteristic of the productive system (Rodrik, 2011; Dutrénit et al., 2014). Wide gaps persist between leading and lagging sectors, between large firms and SMEs, and across territories with unequal access to finance, knowledge, infrastructure, and institutional support. Under these conditions, technological investment may remain concentrated in narrow segments of the economy, without generating strong multiplier effects on output, value added, or employment. In this sense, the aggregate return of technological investment depends not only on the amount invested, but also on the capacity of the economic structure to absorb, articulate and diffuse technological change.

The macroeconomic findings are also consistent with previous evidence at the micro and territorial levels (Crespi and Zuniga, 2012; Salas et al., 2023). Earlier work has shown that innovation improves firm-level productivity only under specific conditions, particularly when firms strengthen internal capabilities and operate within a supportive institutional environment. The macro-level evidence presented here extends that logic by showing that even when aggregate technological investment exists, GDP growth does not automatically increase unless effective mechanisms of absorption and diffusion are in place. Therefore, the results support a central claim of this article: technology promotes development only when it is embedded in an economic and institutional structure capable of appropriating it productively.

5. Discussion

The main implication of the analysis is that technological investment should not be interpreted as a guaranteed driver of economic growth in the absence of complementary productive and institutional conditions. The results show a negative short-run association between technological investment and GDP growth in the selected Latin American countries. This finding does not imply that technology is detrimental to growth. Rather, it suggests that technological investment may generate limited or delayed aggregate effects when the mechanisms required to transform it into productivity gains are weak or unevenly distributed.

However, the policy implications derived from these results must be interpreted with caution. The empirical model does not directly include variables measuring SME capabilities, university-industry linkages, digital infrastructure quality, institutional coordination, or productive financing. Therefore, recommendations related to these mechanisms should not be understood as direct empirical findings of the model. Instead, they are presented as theoretically informed extensions supported by the broader literature on innovation, productivity and technological diffusion in Latin America.

From this perspective, the results suggest that future development strategies should not focus exclusively on increasing aggregate technological expenditure. Broader evidence from the innovation and development literature indicates that technological investment is more likely to contribute to growth when it is accompanied by absorptive capacity, human capital formation, productive linkages, access to financing, digital infrastructure, and institutional support. These mechanisms are particularly relevant for SMEs, which often face greater barriers to adopting and transforming technological resources into sustained productivity gains.

The findings also highlight the importance of cross-country heterogeneity. In economies with stronger institutional density, better absorptive capacity, and more articulated productive systems, technological investment may generate more robust macroeconomic effects. In more fragile contexts, by contrast, technological investment may produce low or delayed returns if basic enabling conditions remain weak. Therefore, technological and innovation strategies should be adapted to the structural characteristics of each national context rather than designed as uniform policy prescriptions.

More broadly, the discussion supports a multiscale interpretation of development. The macroeconomic effect of technological investment cannot be separated from the firm-level and territorial conditions through which technology is absorbed, adapted, and diffused. Nevertheless, because these channels are not directly tested in the empirical model, they should be treated as hypotheses for future research. Future studies could incorporate explicit indicators of institutional quality, human capital, digital infrastructure, SME innovation capacity, and university-industry collaboration to test the mechanisms through which technological investment affects economic growth.

6. Conclusions

This article examined the relationship between technological investment and GDP growth in selected Latin American countries using a dynamic panel model estimated through System-GMM. The results show that technological investment is not automatically associated with higher aggregate growth in the short run. On the contrary, the estimated coefficient is negative and statistically significant, suggesting that technological investment does not immediately translate into GDP growth when complementary productive and institutional conditions are weak or unevenly distributed.

The main contribution of the article is to show that the relationship between technological investment and economic growth should not be interpreted as a simple and direct macroeconomic association. Rather, it is a mediated process shaped by absorptive capacity, productive articulation, institutional quality and the ability of economies to transform technological resources into productivity gains and sectoral diffusion. In this sense, the findings support the argument that technology is a necessary but not sufficient condition for economic growth in Latin America.

The article also contributes methodologically by constructing a synthetic technological investment index based on R&D expenditure and ICT-related technological capacity. The PCA diagnostic results support the use of the first principal component as an exploratory proxy for technological investment, although the index should not be interpreted as a complete measure of national innovation systems. It captures two relevant and comparable dimensions of technological effort, but it does not include other important aspects such as human capital, patents, institutional quality, or innovation outputs.

The study has several limitations. First, the sample includes only 10 Latin American countries over a 10-year period, which limits the representativeness of the results and requires caution when interpreting the System-GMM estimates. Second, the aggregate nature of the data does not allow the model to directly identify the specific mechanisms through which technological investment affects growth. Third, the empirical specification does not include variables measuring SME capabilities, university-industry linkages, digital infrastructure quality or institutional coordination. Therefore, the policy implications discussed in the article should be understood as theoretically informed extensions rather than as direct empirical findings of the model.

Future research could extend the analysis by incorporating a larger group of countries, longer time periods and additional indicators related to human capital, institutional quality, digital infrastructure, productive financing, and innovation outputs. Sectoral or firm-level data would also allow a more precise examination of the channels through which technological investment is absorbed, diffused, and transformed into productivity gains. These extensions would help clarify under what conditions technological investment can become an effective driver of sustained economic growth in Latin America.

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