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Investment share and economic growth in five Latin American Countries (1993-2017)

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Abstract

This work empirically analyzes the relationship between investment share and growth in the five largest Latin American economies – Brazil, Mexico, Argentina, Colombia, and Chile – from 1993 to 2017. The analysis is based on the Sraffian Supermultiplier (SSM) framework that establishes business investment as fully induced by the level and the trend of effective demand and that the long-run drivers of economic growth are the non-capacity-creating autonomous expenditures. Business investment follows the capital-stock adjustment principle, implying that the investment share adjusts to different rates of economic growth. In the fully adjusted position, the investment share is a positive function of the autonomous expenditures growth rate. Our econometric analysis involves two exercises using Granger causality tests within dynamic panel data models: one examines the relationship between the investment share and output growth, and the other between the investment share and the autonomous expenditures growth rate. The results suggest a unidirectional Granger causality relationship between autonomous demand and output growth rates, and the investment share, supporting SSM results. These findings show that the SSM approach holds when extended to a broader range of countries, indicating the pervasiveness of such dynamics across diverse economic contexts.

Keywords: Sraffian Supermultiplier; demand-led growth models; investment share; non-capacity-creating autonomous demand; Latin America

Resumo

Taxa de investimento e crescimento econômico em cinco países latino-americanos (1993-2017)

Esse trabalho analisa empiricamente a relação entre crescimento e taxa de investimento para as cinco maiores economias da América Latina – Brasil, México, Argentina, Colômbia e Chile – de 1993 a 2017. A análise é baseada no arcabouço do supermultiplicador sraffiano (SSM) que estabelece o investimento das firmas como plenamente induzido pelo nível e tendência da demanda efetiva e que os gastos autônomos que não criam capacidade produtiva lideram o crescimento econômico. O investimento das firmas segue o princípio do ajustamento do estoque de capital, implicando que a taxa de investimento se ajusta a diferentes taxas de crescimento econômico. Na posição plenamente ajustada, a taxa de investimento é uma função positiva da taxa de crescimento dos gastos autônomos. A análise envolve dois exercícios econométricos usando testes de causalidade Granger em modelos de dados de painel: um examina a relação entre taxa de investimento e crescimento econômico, o outro a relação entre taxa de investimento e crescimento dos gastos autônomos. O resultado sugere uma causalidade Granger unidirecional entre as taxas de crescimento do produto e dos gastos autônomos e a taxa de investimento, corroborando os resultados do SSM. Essas descobertas mostram que a

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abordagem do SSM é válida quando estendida a uma gama mais ampla de países, indicando a abrangência dessa dinâmica em diversos contextos econômicos.

Palavras-chave: Supermultiplicador sraffiano; Crescimento liderado pela demanda; Taxa de investimento; Demanda autônoma; América Latina.
JEL: B51, E11, E22, N16, O11, O41.

1 Introduction

Latin America has a long-standing tradition of identifying capital accumulation as the main (internal) constraint for sustainable growth[4]. Prebisch (1949), in his ECLAC manifesto, pointed out the necessity of increasing capital accumulation to improve the quality of life in Latin American countries. In this tradition, structuralist authors identify a resource trade-off between investment (*productive* expenditures) and non-capacity-creating expenditures (*unproductive* expenditures), particularly the consumption by the wealthy. Prebisch (1949) pointed out that the consumption pattern of part of Latin-American societies is not compatible with a higher degree of capital formation. Similarly, Furtado (1961) asserted that economic performance depends on how the capitalist class allocates its income toward productive or unproductive uses[5]. In a later work, Furtado (1972) noted that Latin-American wealthy classes emulate consumption patterns of developed countries, diverting resources that could otherwise be invested, thereby hindering capital accumulation and development.

The message from this tradition is clear: unproductive expenditures are detrimental to growth and should be restricted. Reducing it would increase the investment share and capital accumulation, promoting higher economic growth[6].

In this work, however, we follow an alternative theoretical framework. The Sraffian Supermultiplier (SSM) approach to growth establishes that business investment is fully induced by the level and trend of effective demand and that the long-run drivers of economic growth are non-capacity-creating autonomous expenditures (Serrano, 1995)[7]. The latter are characterized as autonomous from the production process and do not create capacity for the business sector of the economy. Exports, government spending, residential investment, credit-financed consumption, and discretionary consumption by the wealthy are components of aggregate demand that have these features. Business investment follows the capital-stock adjustment principle, which means that the output's investment share[8] adjusts to different economic growth levels for a given income distribution. In the fully adjusted position, the investment share is a positive function of the growth rate of autonomous expenditures, and the degree of capacity utilization converges to the normal one (Serrano, 1995; Freitas; Serrano, 2015). The causality between capital accumulation and growth is the opposite of the one proposed by structuralist authors.

(4) The main constraint for growth and development for these countries is the external constraint (Prebisch, 1949; Bielschowsky, 2020; Vernengo; Caldentey, 2020).

(5) For structuralist authors, in general, workers receive a subsistence wage, so they do not save.

(6) For a critique of the structuralist view on investment, unproductive expenditures and growth, see Serrano (2001).

(7) Since autonomous capacity-creating expenditures do not exist in the SSM approach (see Section 2), we will refer to them in the rest of the paper just as autonomous expenditures.

(8) Whenever we mention "investment share" through this paper, we mean the business investment share.

Empirical research examining the validity of the SSM approach has grown recently. These studies analyzed either single economies or groups of high-income countries. For instance, Girardi and Pariboni (2016), Haluska, Braga, and Summa (2021), and Summa, Petrini, and Teixeira (2023) tested the SSM model for the U.S. economy. Pérez-Montiel and Erbina (2020) and Gallo and Goes (2023) tested the SSM approach for European countries, while Girardi and Pariboni (2020) did the same for OECD countries. The only works evaluating the SSM for developing economies are Braga (2020) for Brazil, Medici (2011) and Dvoskin and Medici (2024) for Argentina and Barbieri Góes, Gahn and Gallo (2024) for Mexico. The literature review indicates a gap in the existing body of research since there is a lack of work examining the validity of the SSM approach for groups of non-rich countries.

The present work aims to contribute to this discussion in this specific direction by empirically analyzing the relationship between investment share and growth for the five largest economies in Latin America from 1993 to 2017: Brazil, Mexico, Argentina, Colombia, and Chile.

We address the challenge of differentiating induced business investment from total investment expenditures using the Penn World Table (PWT) database, which disaggregates investment data. With this database, we conducted two econometric exercises employing Granger causality tests within dynamic panel data models to evaluate the SSM approach. The first examined the relationship between investment share and output growth, while the second examined the relationship between investment share and autonomous expenditures growth.

The results indicate a unidirectional Granger causality relationship from autonomous expenditures and output growth rates to the investment share. These findings corroborate the SSM's theoretical claims. Notably, the SSM approach main results are valid to a broader spectrum of countries, underscoring its potential to offer valuable insights into the dynamics of growth and accumulation in diverse economic contexts.

The paper includes five more sections. Section two briefly introduces the SSM theoretical model. Section three reviews empirical SSM literature. Section four presents the data and critical observations. Section five details our estimation strategy, reports econometric results and examines its adherence to the SSM approach. Section six briefly concludes the paper.

2 Theoretical model

The SSM model, independently developed by Serrano (1995) and Bortis (1997), is a demand-led growth model that asserts business investment as an induced expenditure and autonomous expenditures play a significant role in determining both output level and growth. In this model, the capacity utilization rate tends to the normal level, and the business investment share of output is flexible, accommodating different growth rates for a given income distribution (Serrano, 1995; Freitas; Serrano, 2015).

This approach states that some expenditures are induced by firms' decisions to produce (Serrano, 1995; Cesaratto et al., 2003). Current production decisions entail contracting and paying workers, who will spend part, if not all, of the wages received. Firms' decisions to produce in the future inherently involve the anticipation of demand, necessitating the expansion of productive capacity in advance. Since building capacity is time-consuming, firms must invest in the present to ensure future production can meet future demand. Thus, according to the SSM, at least part of the consumption and the business investment are considered induced expenditures (Serrano, 1995; Summa et al., 2023).

The remaining components of aggregate demand are typically considered autonomous: residential investment, government spending, exports, credit-financed consumption, and discretionary consumption by the wealthy. Significantly, none of these expenditures create productive capacity within the business sector. In summary, SSM establishes the existence of induced non-capacity-creating expenditures (part of aggregate consumption), autonomous non-capacity-creating expenditures (described in this paragraph), induced capacity-creating expenditures (business investment) and the non-existence of autonomous capacity-creating expenditures (Cesaratto et al., 2003).

The model can be outlined as follows. It assumes an economy that produces a single homogeneous output using a fixed-coefficient production technique, operating under an elastic labor supply. In this sense, full-capacity output (${Y_t}^K$) is determined by capital stock (K_t) and the capital-output technical coefficient (v), according to Equation (1).

$$ {Y_t}^K = \frac{1}{v} \cdot K_t \tag{1} $$

Aggregate demand (AD) is obtained by summing up all demand components previously mentioned (Equation 2):

$$ AD = {C_t}^{ind} + {I_t}^{ind} + Z_t \tag{2} $$

$$ {C_t}^{ind} = (1 - s)\, Y_t \tag{3} $$

$$ {I_t}^{ind} = h_t\, Y_t \tag{4} $$

The term ${C_t}^{ind}$ represents induced consumption determined through the tax-adjusted marginal propensity to consume[9] $(1 - s)$ and aggregate income (Y_t), as shown in Equation (3). ${I_t}^{ind}$ is the induced investment determined by the marginal propensity to invest (h_t, equivalent do the investment share) and income level (Y_t). Z_t is the aggregation of all autonomous expenditures.

By equating supply and demand (Equation 5) and considering that total imports are induced by income level and a marginal propensity to import (m, Equation 6), Equation (7) shows that the output level is determined by the level of autonomous expenditures (Z_t) and the size of the supermultiplier ($\frac{1}{s + m - h_t}$).

$$ M_t + Y_t = {C_t}^{ind} + {I_t}^{ind} + Z_t \tag{5} $$

$$ M_t = mY_t \tag{6} $$

$$ Y_t = \frac{Z_t}{s + m - h_t} \tag{7} $$

From Equation (7) we can derive that the rate of growth of autonomous expenditures (${g_t}^Z$) determines the output growth rate (${g_t}^Y$) for a given tax-adjusted marginal propensity to save, marginal propensity to import, and marginal propensity to invest (Equation 8).

(9) "s" is the tax-adjusted marginal propensity to save.

$$g_t{}^Y = g_t{}^Z \tag{8}$$

The capital stock rate of growth ($g_t{}^K$) determines productive capacity growth as we consider a scenario of a given capital-output ratio (no technical progress). The former can be expressed in the following way:

$$g_t{}^K = \frac{h_t\ u_t}{v} - \delta \tag{9}$$

where u_t is the actual degree of capacity utilization and δ is the depreciation rate. Whenever supply and demand grow at the same rate, the economy will present a constant capacity utilization rate that can be of any value between the minimum and the maximum capacity utilization.

As previously stated, the marginal propensity to invest is not a fixed parameter for the SSM. Its flexibility results from the operation of the principle of capital stock adjustment with a flexible accelerator, as firms adjust their accumulation rate whenever there are persistent changes in effective demand, seeking to produce using the planned portion of their productive capacity (Serrano, 1995; Freitas; Serrano, 2015).

The SSM literature shows different ways of presenting this mechanism. For instance, Freitas and Serrano (2015) and Serrano and Freitas (2017) posit that the marginal propensity to invest adjusts to discrepancies between the current degree of capacity utilization and the normal degree of capital utilization. Serrano, Freitas and Bhering (2019) and Haluska, Braga and Summa (2021) present a model where the investment share reacts to the discrepancy between the actual and the expected growth rate. Regardless of the specific mechanism, all of them ensure that capacity will adjust to demand and that there will be an ever-present tendency for the degree of capacity utilization to converge to normal capacity utilization. This tendency arises from capitalist competition since firms do not want to operate permanently with very low or high capacity utilization.[10]

In the fully adjusted position, firms achieve the normal capacity utilization (μ) so we can establish that the investment share of output (h^*) presents a positive relation with and is determined by output growth rate for a given capital-output technical coefficient, normal degree of capacity utilization and depreciation rate (Equation 10):

$$h^* = \frac{v}{\mu}(g_t{}^Y + \delta) \tag{10}$$

Since the supermultiplier components are constant in this scenario, it is easy to establish that autonomous expenditures' growth rate determines economic growth.[11] Considering it, we can write Equation (11) in the following way, where h^* is the fully adjusted value for the investment share:

$$h^* = \frac{v}{\mu}(g_t{}^Z + \delta) \tag{11}$$

Therefore, despite the combination of exogenously determined distribution and induced investment, the Sraffian supermultiplier model can produce a stable growth path, replicating well-documented scenarios such as the convergence of the degree of utilization of productive capacity to

(10) For a detailed discussion on the concept of normal capacity utilization, see Ciccone (1986).

(11) See Freitas and Serrano (2015) for a formal presentation of the SSM.

the normal one[12]. The investment share is adjusted by firms' attempts to accommodate their productive capacity to effective demand, seeking to operate at a planned fraction of their capacity (Serrano; Freitas, 2017)[13].

3 Literature review

In recent years, the debate surrounding the SSM model has expanded to include empirical evaluations of its key outcomes. These studies primarily focus on analyzing two distinct relationships. (Haluska, Braga, and Summa, 2021; Dvoskin and Médici, 2024) The first is the long-term relationship between autonomous demand and output, with causality running from the former to the latter. The second relationship is the causality from growth to investment level, share or growth rate.

Medici (2011) applied a vector error correction model (VECM) to Argentine data from 1980 to 2007, identifying a cointegration relationship and establishing causality running from autonomous demand components to output.

Girardi and Pariboni (2016) analyzed the connection between autonomous demand, output and investment share for the U.S. (1947-2014). They estimated a VECM and found a long-term cointegration and bidirectional causality between autonomous demand and output. After dealing with endogeneity issues, they found a long-term unidirectional causality from autonomous demand to output, while short-term interactions suggested bidirectional causality.[14]

The authors used two samples (1947-2014 and 1960-2014) to assess the relationship between autonomous demand growth and the variation in investment share. For the former, they find Granger causality in both directions. For the latter, the analysis reveals Granger causality stemming solely from demand to investment share variability, with no evidence of reverse causality. Therefore, Girardi and Pariboni (2016) confirmed that the SSM theoretical predictions receive empirical support from the U.S. data.

Haluska et al. (2021) employed vector autoregression (VAR) models and the Toda Yamamoto method for the U.S. data from 1985-2017, confirming Granger causality from output growth to investment share and vice versa. They also found causality from final and autonomous demand to the investment share without reverse causality, supporting the Sraffian supermultiplier model predictions.

Girardi and Pariboni (2020) expanded the research to 20 OECD countries from 1960-2016 using panel data and found bidirectional Granger causality between autonomous demand and investment share. After addressing endogeneity using instrumental variables, they confirmed a unidirectional causal influence from demand to investment share. Pérez-Montiel and Erbina (2020) also studied a large group of countries (16 European countries, from 1995 to 2017), finding

(12) On this topic, see Gahn (2021), Gahn and González (2022) and Deleidi, Gahn and Pariboni (2022).

(13) Although we present here the SSM model, it is important to note that the main results we test in this paper are also achieved in the neo-Kaleckian version of the Supermultiplier demand-led growth model (Allain, 2015; Lavoie, 2016).

(14) As Girardi and Pariboni (2016, p. 13) point out, "Z [autonomous demand] does not fall from the sky: it is socially and historically determined; among the various social and economic factors that influence autonomous spending, economic growth certainly plays a major role".

unidirectional causality from autonomous demand to output and from output growth to investment growth.

Braga (2020) investigated the causal link between output growth and investment share and whether investment growth is driven by non-capacity-creating demand in Brazil[15]. Using annual data from 1962 to 2015 for the former and quarterly data from 1996 to 2017 for the latter, the author found evidence of Granger causality from output growth to the investment share without any reverse causality. Furthermore, Braga (2020) uncovered evidence that non-capacity-creating demand determines business investment, both cyclically in the short run and trend-wise in the long run.

Gallo and Barbieri Góes (2023) built upon the work of Girardi and Pariboni (2016) by examining Eurozone data from 1991 to 2018. They employed a VEC model and confirmed the long-term relationship between autonomous demand and output. However, they noted ambiguous short-term dynamics due to bidirectional influences between autonomous demand and output. The authors suggested that this may be attributed to endogeneity related to exports, a key element of autonomous demand, although they do not empirically verify it.

Summa, Petrini, and Teixeira (2023) found a unidirectional relationship from capacity utilization to investment share for the U.S., as established by the principle of capital stock adjustment. Analyzing quarterly data from the U.S. economy between 1967 and 2020, they employed a VAR model and uncovered that capacity utilization accounts for over 50% of the fluctuation in the investment share. On the other hand, the investment share has no impact on capacity utilization, which is likely determined by other factors, such as autonomous expenditures.

Dvoskin and Medici (2024) explored two aspects of the Sraffian supermultiplier for Argentina from 1993 to 2021. Initially, they used a VEC model, informed by the Johansen cointegration method, to analyze the long-term dependency of output on autonomous expenditure, confirming that the former adjusts to the latter long-term shifts. They then examined how productive capacity adjusts to demand, applying the flexible accelerator principle. A VAR model revealed that output Granger causes the investment share. Their findings validate the SSM model, demonstrating its applicability to the Argentine economy.

Barbieri Góes, Gahn and Gallo (2024) estimated a VECM for the Mexican economy (1993-2019). They found that autonomous demand and output present a long-run relationship. They also found that increased autonomous demand has a positive, lasting, and statistically significant impact on the output level through impulse response functions.

These studies point toward a general validity and adequacy of the supermultiplier's results, as summarized in Table 1. However, most empirical studies have concentrated on advanced economies, with exceptions like Medici (2011) and Dvoskin and Medici (2024) for Argentina, Braga (2020) for Brazil and Barbieri Góes, Gahn and Gallo (2024) for Mexico. This study aims to fill this literature gap regarding some of the Sraffian supermultiplier main results in a group of developing countries.

(15) Braga (2020) uses Garegnani's (1962) concept of final demand, that excludes investment from total aggregate demand.

Table 1
Empirical studies on the Sraffian supermultiplier

Source	Sample	Method	Results
Medici (2011)	Argentina 1980-2007	VECM	1. Long-term relationship between Z and Y. 2. Causality from Z and external competition on Y.
Girardi and Pariboni (2016)	USA 1947-2014	VECM ARDL	Causality: 1. $Z \leftrightarrow Y$. 2. $Z \rightarrow Y$ in the long-term. 3. Z Granger causes h.
Haluska, Braga and Summa (2021)	USA 1985-2017	VAR	Causality: 1. $g^Y \rightarrow h$. 2. $g^{FD} \rightarrow h$. 3. $g^Z \rightarrow h$.
Girardi and Pariboni (2020)	20 OECD countries 1960-2016	TWFE IV-TWFE	Causality runs from $g^Y \rightarrow h$.
Pérez-Montiel and Erbina (2020)	16 european countries 1995-2017	Panel VEC	Causality: 1. $Z \rightarrow Y$. 2. $g^Y \rightarrow I$. 3. $g^Z \rightarrow h$.
Braga (2020)	Brazil 1962-2015 1996-2017	VAR VECM	Causality: 1. $g^Y \rightarrow h$. 2. $g^{DF} \rightarrow g^I$.
Gallo and Barbieri Góes (2023)	Euro Area (EA-19) 1991-2018	VECM	Cointegration between Y and Z.
Summa, Petrini and Teixeira (2023)	USA 1967-2020	VAR	Causality runs from $u \rightarrow h$.
Dvoskin and Medici (2024)	Argentina 1993-2021	VEC VAR	1. Z and Y long-term relationship. 2. Y adjusts itself at new equilibrium. 3. Granger causality from Z on h.
Barbieri Góes, Ghan and Gallo (2024)	Mexico (1993-2019)	VEC	Causality: $Z \rightarrow Y$.

Source: Authors' elaboration.

4 Data presentation and stylized facts

One major challenge in empirically evaluating the Sraffian Supermultiplier (SSM) approach is the limited availability of macroeconomic databases that disaggregate investment expenditures, as their various components exhibit distinct behaviors. To overcome this problem, we use the Penn World Table database, which contains national accounts data from several countries over a long period, such as data on household consumption, government consumption, exports, imports, gross fixed capital formation and gross domestic product. More importantly, PWT also provides the Capital Detail database, which contains capital stock data, capital consumption by asset and disaggregated investment data. The latter is categorized into four components: i) structures (residential and nonresidential); ii) machinery and equipment (non-transport); iii) transport equipment; and iv) other assets.

As discussed in Section 2, the SMM approach establishes that autonomous demand growth determines the long-term growth of output and productive capacity. According to the capital stock adjustment principle, output growth determines the investment share (Equation 10), which, in turn, is determined by autonomous expenditures growth (Equation 8). So, the ultimate determinant of the investment share is autonomous expenditures growth.

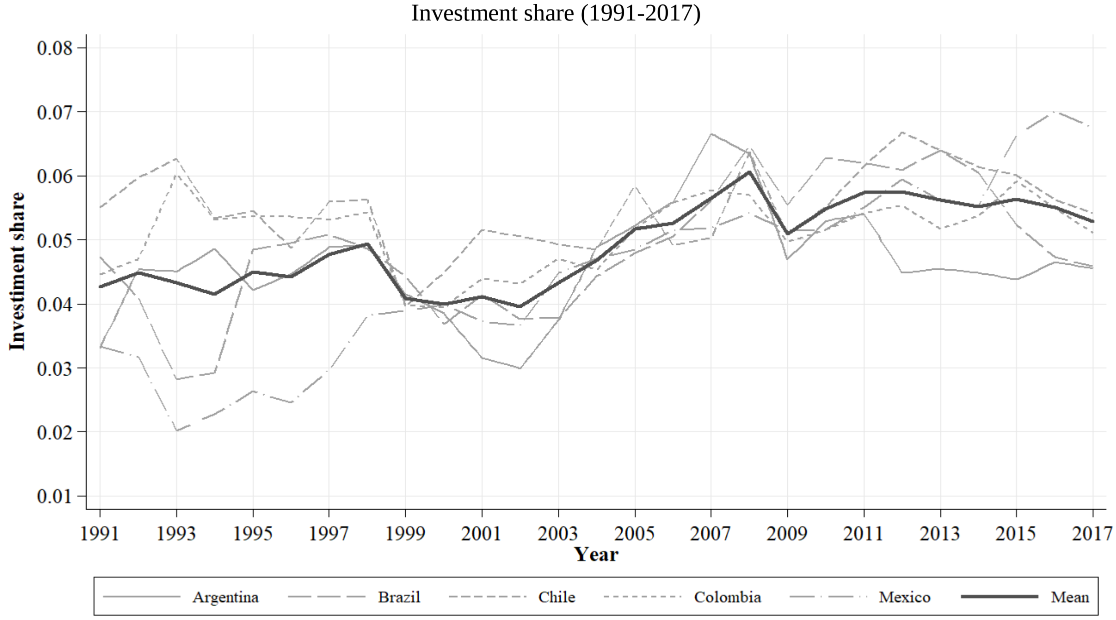
To test these relationships, we select the five largest economies in Latin America, Argentina, Brazil, Chile, Colombia, and Mexico, for 1991-2017. Since our model uses growth rates with at least one lag, the largest possible time series should start in 1993.

The SSM approach defines the ratio of business investment to gross domestic product as the pertinent investment share. Following Braga's (2020) suggestion, we use investment in machinery and non-transport equipment as a proxy for this variable. This method excludes investment in structures, which encompasses residential investment considered autonomous, and transport equipment, which may be influenced by public policy and may not adhere to purely business logic.

Our proxy for autonomous expenditures incorporates government spending, exports and non-business investments (investments in structures, transportation equipment and other assets). However, we do not include autonomous private consumption into autonomous demand due to data limitations preventing the disaggregation of private consumption into induced and autonomous parts.

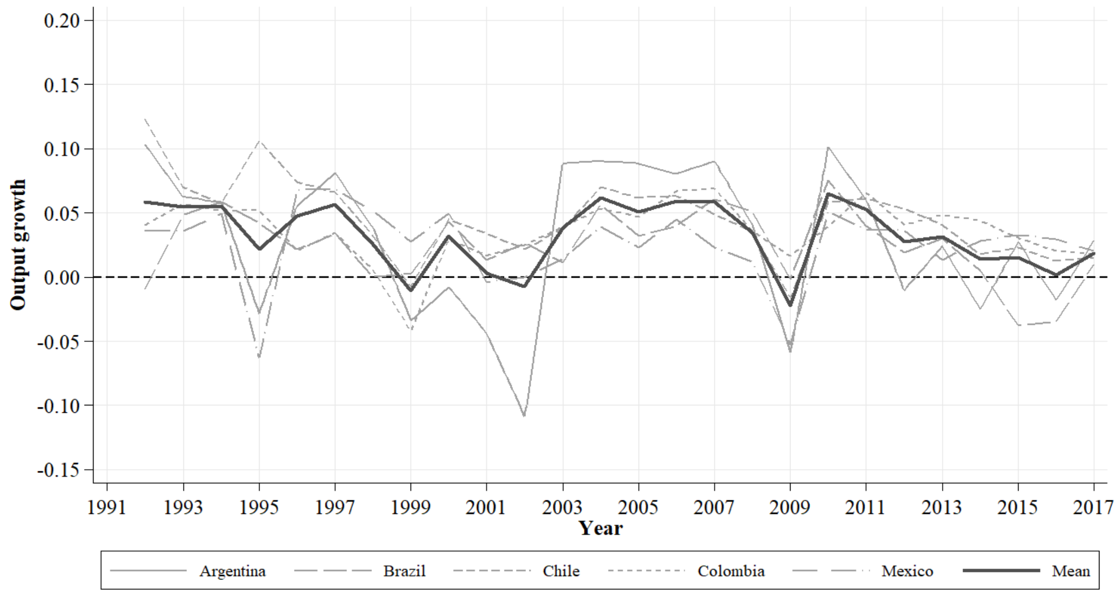
Figures 1, 2, and 3 show the time series for each country's investment share, output growth rate, and autonomous demand growth rate. These figures reveal three distinct periods: 1991-2002, 2003-2008, and 2009-2017.

Figure 1
Investment share (1991-2017)



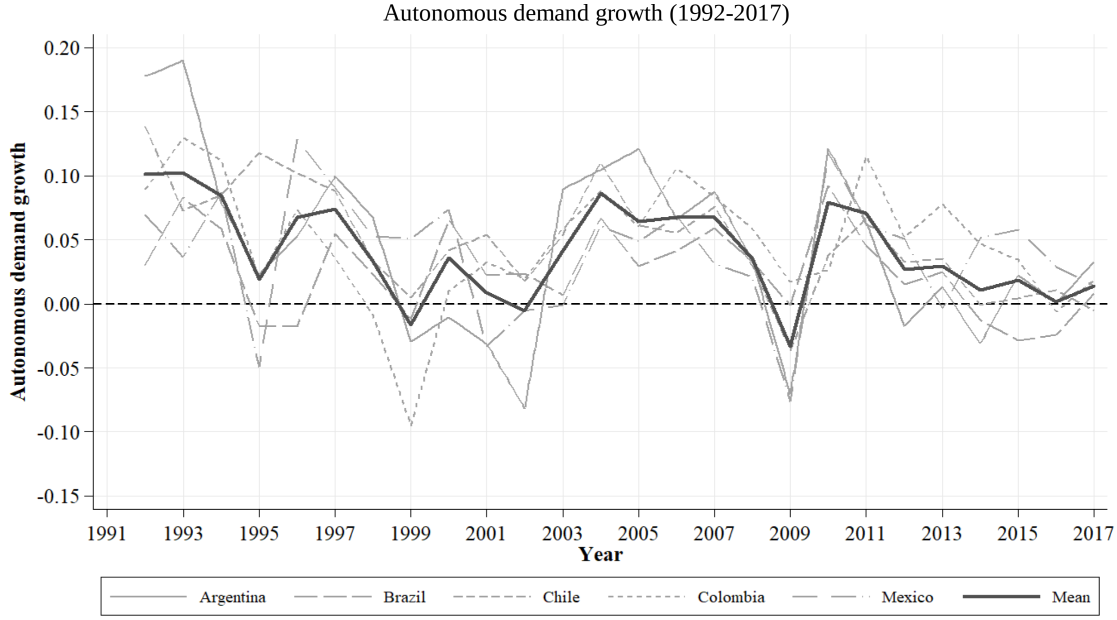
Source: Penn World Table. Authors' elaboration.

Figure 2
Output growth (1992-2017)



Source: Penn World Table. Authors' elaboration.

Figure 3
Autonomous demand growth (1992-2017)



Source: Penn World Table. Authors' elaboration.

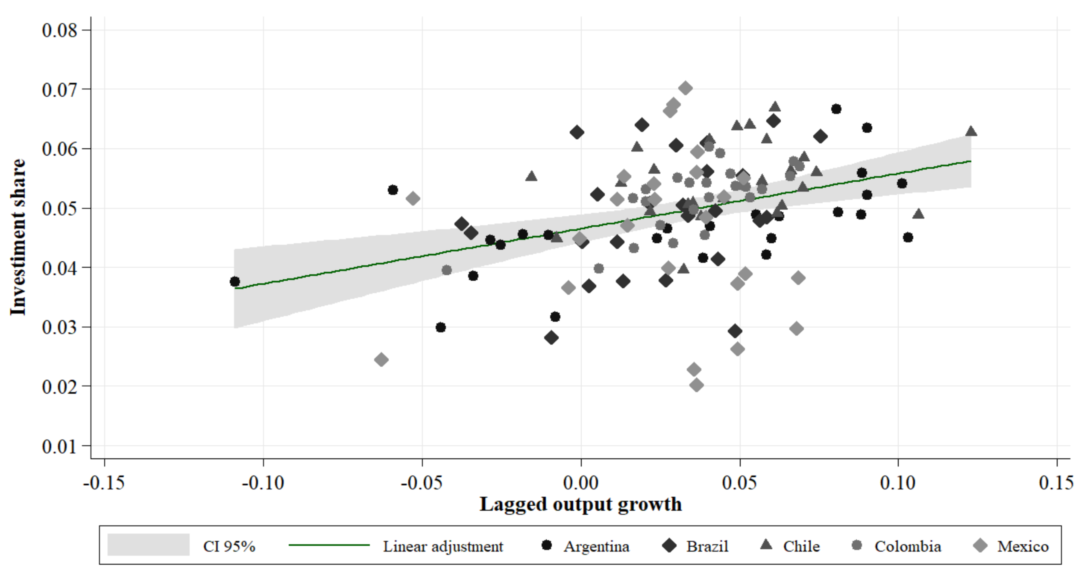
The first period is characterized by an almost stagnant average investment share, relatively high but declining growth rate. Up to 2002, these countries, in general, pursued stabilization policies to deal with chronicle high inflation and hyperinflation and followed the Washington Consensus agenda for economic reform, with privatization of state-owned enterprises and opening the economy for international trade and financial flows (Penido de Freitas; Prates, 2000). The result was a series of economic crises, Mexico (1994), Brazil (1999) and Argentina (2002), and poor economic performance (Ocampo, 2022; Passos; Morlin, 2022).

The second period (2003-2008) was an economic bonanza. It shows the highest growth rate of autonomous expenditures and output, with a continuous upward trend for the investment share. It was a period of significant international trade growth – especially in commodities, due to Chinese demand –, high commodities prices and overall external stability (Ocampo, 2009). The external sector was both a source of demand and a relief from balance-of-payment constraints. Combined with the pursuit of pro-growth economic policies in the region, it was possible to achieve a path of higher growth (Serrano; Summa, 2012; Dvoskin et al., 2024). According to Passos and Morlin (2022), Chile and Mexico were more dependent on the external sector, while the State played an important role for Argentina and Brazil. Alves-Passoni and Neria (2023) found the same result for Mexico and Brasil.

The international financial crisis interrupted this process in 2008 by reducing growth and initiating the third period (2009-2017). Its effects hit the countries of the region hardest in 2009 when four of the five countries saw a decline in output levels – Colombia was an exception. In 2010, a robust recovery was observed across all countries, which was not maintained in the following years, with an almost uninterrupted drop in average growth, with Argentina and Brazil being negative highlights (Serrano and Summa, 2015, 2022; Rossi and Mello, 2017; Passos and Morlin, 2022; Portales et al., 2021). As a consequence of this growth trend, the investment share stagnated.

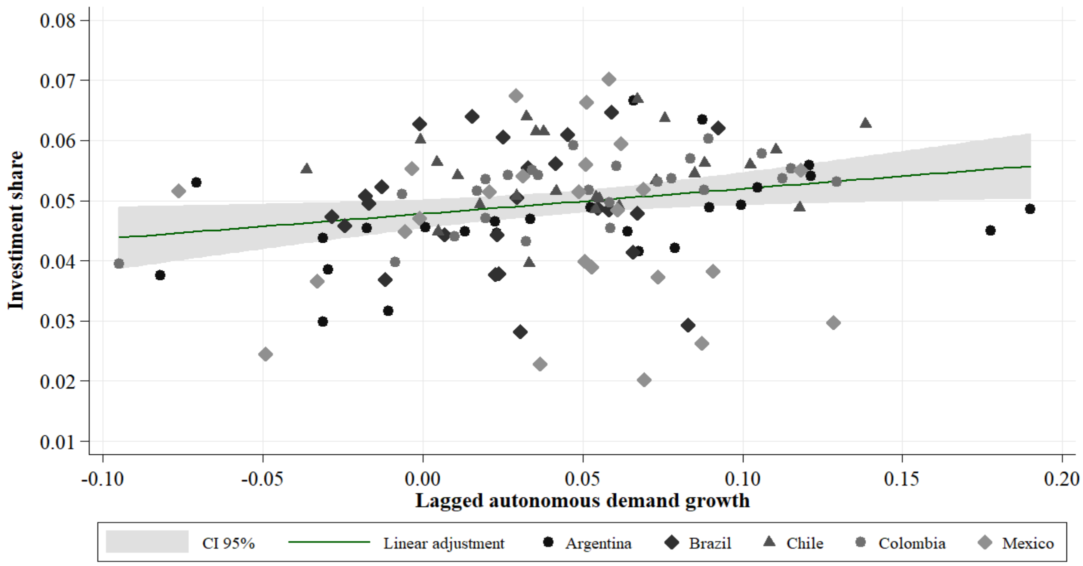
Figures 4 and 5 illustrate the relationship between the investment share and the lagged output and autonomous demand growth rates through scatter plots with a linear fit and a 95% confidence interval.

Figure 4
Correlation between investment share and the lagged output growth ($h_t \times g^{Y}{}_{t-1}$)



Source: Penn World Table. Authors' elaboration.

Figure 5
Correlation between investment share and the lagged autonomous demand growth ($h_t \times g^Z{}_{t-1}$)



Source: Penn World Table. Authors' elaboration.

In both cases, visual inspection indicates a positive correlation. The graphs comparing the investment share with the lagged growth rates indicate temporal precedence from the growth variables to the investment share, consistent with the SSM model predictions. However, this correlation alone is insufficient to establish causality between the variables. The following section addresses this issue through Granger causality tests in panel data models.

5 Econometric model and results

5.1 Estimation strategy

This paper's estimation strategy is to employ two-way fixed effects dynamic panel data models to adequately test the Granger causal relationship between the investment share and both growth rates (output and autonomous expenditures). Before exploring causality, we must first confirm the stationarity of the time-series data by using the Im, Pesaran and Shin (2003) (IPS) and Levin, Lin and Chu (2002) (LLC) panel unit root tests. Table 1A (see Appendix) presents the test outcomes. Given that the test statistics produce a p-value below 0.01, we can reject the null hypothesis for all three time series under examination, indicating that each series is stationary.

Two-way fixed effects dynamic panel data models are distinguished by their incorporation of lagged dependent variables as explanatory factors, which introduces a dynamic component to the analysis. Additionally, these models account for unobservable heterogeneity through fixed effects, thereby controlling for time-invariant and country-specific characteristics that could otherwise impact the results. Equation (12) represents the model for examining causality from growth-related variables to the investment share. Equation (13) outlines the auxiliary model that explores the possibility of reverse causality, ensuring the relationship between the investment share and growth is not spuriously driven by the former.

$$h_{i,t} = \alpha_i + \theta_t + \sum_{j=1}^{q} \gamma_j \cdot h_{i,t-j} + \sum_{j=1}^{q} \beta_j \cdot g_{i,t-j}^{x} + \varepsilon_{i,t} \tag{12}$$

$$g_{i,t}^{x} = \alpha_i + \theta_t + \sum_{j=1}^{q} \beta_j \cdot g_{i,t-j}^{x} + \sum_{j=1}^{q} \gamma_j \cdot h_{i,t-j} + \varepsilon_{i,t} \tag{13}$$

In our econometric model, h denotes the investment share, while g^x represents a growth rate, which is specified differently across models: output growth rate (g^Y) and autonomous expenditures growth rate (g^Z). The index i refers to the country, and t refers to the year. The parameters α_i and γ_t correspond to the fixed effects for each country i and year t, respectively, accounting for characteristics that do not change over time within a country and common trends across countries. The index q reflects the number of lags for the dependent and independent variables. Lastly, $\varepsilon_{i,t}$ represents the idiosyncratic error term for each country i in each year t, capturing variations in the dependent variables that the model does not explain.

According to Box et al. (2015, pp. 14-15), our goal is to develop a parsimonious model that captures the essence of the studied phenomenon with the fewest parameters required. To achieve this, we employ a backward elimination process for variable selection. Initially, we include all potential variables, as specified in Equations (12) and (13). We then refine the model iteratively, discarding fixed effects variables with the least statistically significant coefficient – those with the highest p-values. This process is repeated until only statistically significant variables remain (Royston; Sauerbrei, 2008).

After selecting the models' specifications, we employ Granger causality tests to investigate the relationships between the variables of interest. These tests determine whether the coefficients of lagged independent variables significantly predict the dependent variable, testing if they significantly differ from zero. The methodology involves an F-test, where null hypothesis rejection indicates a temporal causality from the independent to the dependent variable (Granger, 1969, p. 431).

We examine whether causality flows from the two distinct growth rates – output growth rate and autonomous expenditures growth rate – to the investment share (Equation 12). Additionally, we analyze whether there is a feedback effect between the variables using the auxiliary model (Equation 13). This analysis is crucial to ascertain whether the interaction between the investment share and growth rates is unidirectional or bidirectional.

We apply two different estimation methods for each relationship analyze to address issues of heteroskedasticity and autocorrelation, using models with one or two lags of the variables of interest. First, we use the Within Fixed Effects (WFE) estimator with robust standard errors, also known as HAC (heteroskedasticity and autocorrelation consistent), to account for unspecified forms of heteroskedasticity and autocorrelation (Wooldridge, 2013). We also employ the three-stage Feasible Generalized Least Squares (FGLS) estimator, as Bai, Choi, and Liao (2021) recommended, which further controls for heteroskedasticity, autocorrelation, and cross-sectional dependence.

The following subsections will present the results of the model estimations.

5.2 Causality between output growth and investment share

This subsection examines the relationship between the investment share and output growth. The models were initially estimated using two-way fixed effects, incorporating one or two lags of the investment share and output growth. Non-significant fixed effects were removed through a backward elimination process, resulting in the most parsimonious specification that retains only significant coefficients.

Table 2 presents the results for different model specifications (one or two lags) and estimation methods (WFE and FGLS). Each model specification is displayed in a column labeled with the corresponding estimation method and lag order. The p-values associated with the variable are in brackets, while the table's end shows model fit statistics.

Following the backward elimination process, all country-specific fixed effects were eliminated, with the intercept (α) remaining statistically significant. It suggests a consistent linear coefficient across all countries. Table 2A (see Appendix) lists all remaining annual variables that are statistically significant[16].

Table 2
Regressions between investment share (h) and output growth (g^Y)

Regressions	$h_{i,t} = \alpha + \theta_t + \sum_{j=1}^{q} \gamma_j \cdot h_{i,t} + \sum_{j=1}^{q} \beta_j \cdot g^Y_{i,t-j} + \varepsilon_{i,t}$			
	WFE		FGLS	
(q)	(1)	(2)	(1)	(2)
h_{t-1}	0.779***	0.770***	0.768***	0.765***
	(0.00)	(0.00)	(0.00)	(0.00)
h_{t-2}		-0.024		-0.045
		(0.77)		(0.52)
${g^Y}_{t-1}$	0.043*	0.043**	0.051***	0.051***
	(0.09)	(0.03)	(0.00)	(0.00)
${g^Y}_{t-2}$		-0.005		-0.007
		(0.67)		(0.55)
α	0.011*	0.013*	0.011***	0.013***
	(0.09)	(0.06)	(0.00)	(0.00)
Adjusted R^2	729	763		
Wald statistics (χ^2)			491	587
p-value			0	0
Observations	125	120	125	120

p-value in parentheses.
Statistical significance: ***1%; **5%; *10%.
Source: Authors' elaboration.

(16) The annual fixed effects were consistently found to be jointly significant.

The results reveal that the first-order lag of the investment share is statistically significant at a 1% level, while its second-order lag does not reach significance in any specification. The first-order lag for output growth (${g^Y}_{t-1}$) consistently achieves statistical significance across all specifications, notably at the 5% level for WFE (2) and the 1% level for all FGLS specifications. However, its second lag (${g^Y}_{t-2}$) is not significant in any of the models. The intercept (α) also emerged as significant at the 10% level for WFE and 1% for FGLS specifications. This parameter refers to the role of the depreciation rate, the normal rate of capacity utilization and the capital-output ratio in determining the investment share (Equation 10)[17].

The results imply that past investment shares predict current investment share, with influence from past output growth. The results also indicate that output growth has an estimated long-term effect on the investment share between 15% and 22.1%, statistically significant at 5% and 1%, respectively[18].

Table 3 presents the Granger causality test results, examining the influence of output growth on the investment share. The null hypothesis of no Granger causality is rejected at 10%, 5%, and 1% significance levels for WFE (1), WFE (2), and FGLS models, respectively. This provides evidence for the determination of investment share by output growth.

Table 3
Granger Causality Test of output growth (g^Y) on investment share (h)

Regression	WFE		FGLS	
(q)	(1)	(2)	(1)	(2)
Statistics	5.142*	12.13**	15.96***	15.33***
p-value	0.086	0.02	0.000	0.000
Statistical significance: ***1%; **5%; *10%.				

Source: Authors' elaboration.

We also analyze reverse causality to verify whether investment share has a causal effect on output growth (Equation 13). In the auxiliary model, output growth is designated as the dependent variable, while the other variables remain unchanged. The lag number and year fixed effects are the same as the main model.

Table 3A (Appendix) presents the four models' estimations. None of them shows statistical significance for the lagged investment share parameters. Furthermore, Table 4 reinforces this finding by demonstrating the absence of Granger causality from investment share to output growth in all models at any standard level of statistical significance.

(17) The results of LM test (Breusch-Pagan, 1980) indicate the non-rejection of the null hypothesis of cross-section independence. The p-values are 0.48 for WFE (1) and 0.77 for WFE (2).

(18) The long-term effect is given by:

$$LE = \left(\sum_{j=1}^{q} \beta_j\right) / \left(1 - \sum_{j=1}^{q} \gamma_j\right)$$

Table 4
Granger Causality Test of investment share (h) on output growth (g^y)

Regression	WFE		FGLS	
(q)	(1)	(2)	(1)	(2)
Statistics	3.03	1.85	1.28	2.48
p-value	0.157	0.269	0.258	0.290

Statistical significance: ***1%; **5%; *10%.

Source: Authors' elaboration.

The results of the models estimated via WFE and FGLS indicate evidence of Granger causality from output growth to the investment share. Furthermore, the evidence suggests no reverse causality from the investment share to output growth. It is also important to note that the parameters associated with lagged output growth are small enough, bringing evidence for a stable adjustment pattern (Freitas; Serrano, 2015). We can conclude that the causality between output growth and the investment share is unidirectional and follows the Sraffian supermultiplier model (Serrano, 1995).

5.3 Causality between autonomous demand growth and investment share

This subsection explores the relationship between the investment share and autonomous demand growth. Similar to subsection 5.2, we first estimate models using two-way fixed effects, incorporating one or two lags of the investment rate and autonomous demand growth, accounting for country- and year-specific factors. Following this, we removed non-significant fixed effects through the backward elimination process.

Table 5 shows the estimated parameters for the relationship between investment share and autonomous demand growth organized as in the previous section. Again, we estimated models using the same methods as the previous subsection (WFE and FGLS).

As a result of the backward elimination process, we removed all country-specific fixed effects, while the intercept (α) remained significant[19], suggesting a uniform linear coefficient across all countries. The annual fixed effects were jointly significant (see table 4A in Appendix for all significant years and their respective p-values).

The autoregressive component of the investment share plays a significant role in its determination for all models (see Table 5). This variable exhibits a degree of inertia over time, with its first lagged coefficient statistically significant at the 1% level. The coefficient of the first lag of autonomous demand growth (${g^Z}_{t-1}$) is statistically significant at the 5% level in all models. However, its second lag (${g^Z}_{t-2}$) does not achieve statistical significance in any of them[20].

(19) According to equation (11), we can interpret the intercept similarly as in the previous subsection. It represents the influence of normal rate of capacity utilization, capital-output ratio and the depreciation rate.

(20) Post-estimation analysis confirms that the models do not present cross-section dependence. The p-values for the LM test Breusch-Pagan (1980) are 0.209 for WFE (1) and 0.243 for WFE (2), so we do not reject the null hypothesis of cross-section independence.

Table 5
Regressions between investment share (h) and autonomous demand growth (g^Z)

Regressions	$h_{i,t} = \alpha + \theta_t + \sum_{j=1}^{q} \gamma_j \cdot h_{i,t} + \sum_{j=1}^{q} \beta_j \cdot g^Z_{i,t-j} + \varepsilon_{i,t}$			
	WFE		FGLS	
(q)	(1)	(2)	(1)	(2)
h_{t-1}	0.796***	0.803***	0.782***	0.788***
	(0.00)	(0.00)	(0.00)	(0.00)
h_{t-2}		-0.047		-0.059
		(0.59)		(0.39)
${g^Z}_{t-1}$	0.030**	0.036**	0.031***	0.034***
	(0.03)	(0.01)	(0.00)	(0.00)
${g^Z}_{t-2}$		-0.009		-0.010
		(0.38)		(0.18)
α	0.010*	0.012*	0.011***	0.013***
	(0.09)	(0.06)	(0.00)	(0.00)
Adjusted R^2	0.728	0.770		
Wald statistics (χ^2)			425	579
p-value			0	0
Observations	125	120	125	120

p-value in parentheses.
Statistical significance: ***1%; **5%; *10%.
Source: Authors' elaboration.

Table 6 presents the results of the Granger causality tests, which show that autonomous demand growth Granger-causes the investment share across all four models at a 5% level of statistical significance. Notably, for both FGLS models, this significance level is even more robust, at 1%.

Table 6
Granger Causality Test of autonomous demand growth (g^Z) on investment share (h)

Regression	WFE		FGLS	
(q)	(1)	(2)	(1)	(2)
Statistics	9.96**	11.09**	12.57***	14.94***
p-value	0.034	0.023	0.000	0.001

Statistical significance: ***1%; **5%; *10%.
Source: Authors' elaboration.

Once again, we examine the possibility of reverse causality between the variables. Specifically, we must determine whether the investment share influences autonomous demand growth. Table 5A (see Appendix) presents the results of the auxiliary models (Equation 13). We estimate these models for the same country and year fixed effects as those in Table 5, with the only modification being the dependent variable, changing from the investment share to autonomous demand growth.

Table 7 shows the result of a Granger causality test to evaluate the SSM claim that there is no feedback from the investment share to growth. Table 7 does not indicate any jointly significant coefficients across the models, bringing evidence for the lack of feedback effects from the investment share to autonomous demand growth.

Table 7
Granger causality test of investment share (h) on autonomous demand growth (g^Z)

Regression	WFE		FGLS	
(q)	(1)	(2)	(1)	(2)
Statistics	3.89	2.45	2.639	1.715
p-value	0.120	0.202	0.104	0.424

Statistical significance: ***1%; **5%; *10%.
Source: Authors' elaboration.

We can, therefore, establish that autonomous demand growth Granger-causes the investment share, while the inverse is not valid. This implies that autonomous demand growth exerts a unidirectional causality on the investment share. According to the model results, a 1 percentage point increase in the growth rate of autonomous demand in period $t-1$ will impact the investment share in the subsequent period, t, by between 0.03 and 0.036 percentage points (table 5). It is important to note that this parameter is low enough to provide evidence for a stable adjustment process, as required by theoretical analysis (FREITAS and SERRANO, 2015). We can also state that autonomous demand growth has a long-term effect on the investment share, ranging from 8.6% to 14.8%, which is significant at a 1% level.

These results corroborate the Sraffian supermultiplier hypothesis on determining the investment share by the autonomous demand growth (SERRANO, 1995; FREITAS and SERRANO, 2015).

6 Concluding remarks

This paper provides empirical evidence supporting critical aspects of the Sraffian Supermultiplier model for a selected group of Latin American countries: Argentina, Brazil, Chile, Colombia, and Mexico. The literature review revealed that previous empirical studies on the SSM model have predominantly focused on groups of developed economies or individual cases, with no applications identified for groups of developing countries.

From the theoretical discussion (section 2), we derived two testable hypotheses over the relation between investment and growth for the SSM approach. First, the investment share is determined by output growth and does not determine it. Second, the investment share is determined by autonomous expenditures growth and does not determine it.

We tested both hypotheses for the five largest Latin American economies using annual data from 1993 to 2017 from the PWT database. This database allowed us to disaggregate investment and use machinery and non-transport equipment as a proxy to calculate the investment share. We employed two-way fixed effects dynamic panel data models to test both hypotheses. We estimated models with one and two lags for each one using two different estimation methods (WFE and FGLS), finding robust evidence across the different models that output and autonomous demand growth rates granger-cause investment share without reverse causality. These results are not only integral to the Sraffian supermultiplier model but also serve to distinguish it from alternative theoretical frameworks, such as the Latin-American Structuralism, that postulate the opposite causality between these key variables.

These findings show that the SSM approach holds when extended to a broader range of countries, indicating the pervasiveness of such dynamics across diverse economic contexts.

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Appendix

Table 1A
Unit root tests

Variable	IPS		LLC	
	Statistics	p-value	Statistics	p-value
h_t	-2.59***	0.00	-2.62***	0.00
${g^Z}_t$	-4.92***	0.00	-5.48***	0.00
${g^Y}_t$	-4.90***	0.00	-5.53***	0.00

Statistical significance: ***1%; **5%; *10%.

Source: authors' elaboration.

Table 2A
Significant annual dummies for the regressions between investment share (h) and output growth (g^Y)

Regressions	$h_{i,t} = \alpha + \theta_t + \sum_{j=1}^{q} \gamma_j \cdot h_{i,t-j} + \sum_{j=1}^{q} \beta_j \cdot {g^Y}_{i,t-j} + \varepsilon_{i,t}$			
	WFE		FGLS	
(q)	(1)	(2)	(1)	(2)
1993			-0.004* (0.05)	
1994	-0.005* (0.08)	-0.006* (0.08)	-0.006* (0.00)	-0.006* (0.00)
1999	-0.009** (0.03)	-0.009** (0.02)	-0.010*** (0.00)	-0.010*** (0.00)
2002	-0.003** (0.01)	-0.004* (0.03)		-0.003* (0.05)
2008			0.004* (0.08)	
2009	-0.008*** (0.00)	-0.008*** (0.00)	-0.008*** (0.00)	-0.007*** (0.00)
2010	0.006* (0.07)	0.006* (0.08)	0.006*** (0.01)	0.005*** (0.00)
2015				0.004** (0.02)

Source**:** Authors' elaboration.

Table 3A
Regressions between output growth (g^Y) and investment share (h)

Regressions	$g^{Y}{}_{i,t} = \alpha + \theta_t + \sum_{j=1}^{q} \gamma_j \cdot h_{i,t-j} + \sum_{j=1}^{q} \beta_j \cdot g^{Y}{}_{i,t-j} + \varepsilon_{i,t}$			
	WFE		FGLS	
(q)	(1)	(2)	(1)	(2)
$g^{Y}{}_{t-1}$	0.280**	0.200	0.355***	0.344***
	(0.03)	(0.13)	(0.00)	(0.00)
$g^{Y}{}_{t-2}$		0.066		0.128
		(0.24)		(0.12)
h_{t-1}	-0.507	0.220	-0.288	-0.515
	(0.16)	(0.80)	(0.26)	(0.26)
h_{t-2}		-0.939		0.114
		(0.33)		(0.79)
α	0.050**	0.060**	0.037***	0.040***
	(0.01)	(0.03)	(0.00)	(0.00)
Adjusted R2	0.304	0.303		
Wald Statistics (X2)			71	77
p-value			0	0
Observations	125	120	125	120

p-value in parentheses.

Statistical significance: ***1%; **5%; *10%.

Source: Authors' elaboration.

Table 4A
Significant annual dummies for the regressions between investment share (h) and autonomous demand growth (g^Z)

Regressions	$h_{i,t} = \alpha + \theta_t + \sum_{j=1}^{q}\gamma_j \cdot h_{i,t-j} + \sum_{j=1}^{q}\beta_j \cdot g^Z{}_{i,t-j} + \varepsilon_{i,t}$			
	WFE		FGLS	
(q)	(1)	(2)	(1)	(2)
1994	-0.006*	-0.006**	-0.007***	-0.007***
	(0.06)	(0.04)	(0.00)	(0.00)
1999	-0.009**	-0.009**	-0.011***	-0.010***
	(0.02)	(0.01)	(0.00)	(0.00)
2002	-0.003**	-0.004*	-0.003*	-0.004**
	(0.03)	(0.05)	(0.09)	(0.03)
2008				-0.003*
				(0.07)
2009	-0.008***	-0.008***	-0.008***	-0.007***
	(0.00)	(0.00)	(0.00)	(0.00)
2010	0.005*	0.006*	0.005**	0.005***
	(0.05)	(0.09)	(0.03)	(0.00)
2015				0.004**
				(0.03)

Source: Authors' elaboration.

Table 5A

Regressions between autonomous demand growth (g^Z) and investment share (h)

Regressions	$g^Z{}_{i,t} = \alpha + \theta_t + \sum_{j=1}^{q} \gamma_j \cdot h_{i,t-j} + \sum_{j=1}^{q} \beta_j \cdot g^Z{}_{i,t-j} + \varepsilon_{i,t}$			
	WFE		FGLS	
(p)	(1)	(2)	(1)	(2)
$g^Z{}_{t-1}$	0.324*	0.188	0.412***	0.226***
	(0.07)	(0.20)	(0.00)	(0.01)
$g^Z{}_{t-2}$		0.040		0.064
		(0.39)		(0.40)
h_{t-1}		0.409	-0.560	0.103
	-0.715	(0.69)	(0.10)	(0.87)
h_{t-2}	(0.12)	-1.322		-0.580
		(0.27)		(0.35)
α	0.064***	0.075**	0.053***	0.053***
	(0.011)	(0.02)	(0.00)	(0.01)
Adjusted R2	0.317	0.313		
Wald Statistics (X2)			79	63
p-value			0	0
Observations	125	120	125	120

p-value in parentheses.

Statistical significance: ***1%; **5%; *10%.

Source: Authors' elaboration.