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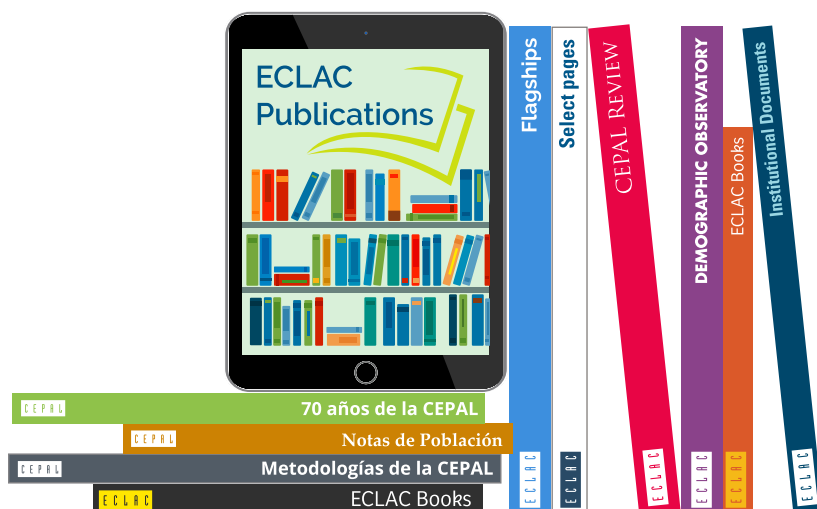
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Explanatory notes

The following symbols have been used in the tables in this publication:

... Three dots indicate that data are not available or are not separately reported.

— A dash indicates that the amount is nil or negligible.

A blank space indicates that the concept under consideration is not applicable or not comparable.

– A minus sign indicates a deficit or decrease, unless otherwise indicated.

. A full stop is used to indicate decimals.

/ A slash between years (e.g. 2022/2023) indicates a 12-month period falling between the two years.

- The use of an en dash between years (e.g. 2022–2023) indicates reference to the complete number of calendar years involved, including the beginning and end years.

Reference to “tons” indicates metric tons and the word “dollars” refers to United States dollars, unless otherwise specified.

Individual figures and percentages in graphs and tables may not always add up to the corresponding total because of rounding.

A stock-flow ecological model for Central America

Lorenzo Nalin, Esteban Pérez Caldentey,
Leonardo Rojas and Giuliano Toshio Yajima¹

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Abstract

This article presents a stock-flow consistent model for the Central American economies. It is part of a project to develop a stock-flow consistent workhorse model applicable to different country cases in Latin America and the Caribbean. The model's logical and behavioural relationships are based on a set of stylized facts characterizing the Central American economies. The model includes five institutional sectors (consumers, firms, the government, the central bank and the rest of the world). The five sectors trade in seven financial assets: (i) public debt issued in domestic and foreign currencies, (ii) private debt issued in domestic currency, (iii) debt issued by the rest of the world, (iv) bank loans to the private sector for investment and consumer credit, (v) government and private deposits, (vi) loans from the rest of the world borrowed by the domestic financial sector, and (vii) cash. Given the importance of climate-related effects for Central America, our stock-flow model includes an ecological module.

Keywords

Economic trends, economic conditions, macroeconomics, mathematical models, ecology, climate change, energy resources, energy policy, Central America

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I. Introduction

This article presents a stock-flow consistent model for the economies of Central America. The article builds on our previous work and is part of a longer-term project to develop a stock-flow consistent workhorse model for different country cases in Latin America and the Caribbean.²

The stock-flow modelling tradition builds on “a fundamental law of macroeconomics”: that stocks and flows must satisfy the constraints both of individuals and of the economy in the aggregate to ensure that all existing constraints are mutually compatible (Godley and Cripps, 1983, p. 18). This implies that only certain configurations of transactions can be mutually compatible for all economic agents considered in the model. The consistency framework does not require satisfying particular *ex ante* equilibrium conditions. There are no black holes or tacit assumptions in the model. As explained by Godley (1999, p. 394) “every flow comes from somewhere and goes somewhere”.

The logical and behavioural relationships specified in our consistent stock-flow model are largely based on a set of stylized facts characterizing the Central American economies. This builds on the notion that macroeconomic processes are dependent on the historical evolution of countries, their institutions, their productive structures and their international insertion patterns. Given the importance of climate-related effects in shaping the performance of smaller economies, including those of Central America, our stock-flow model includes an ecological and energy module.

The model includes five institutional sectors: (i) the private sector, comprising consumers and firms, (ii) the financial sector, (iii) the government, (iv) the central bank, and (v) the rest of the world. The five sectors trade in seven financial assets: (i) public debt issued in domestic and foreign currencies, (ii) private debt issued in domestic currency, (iii) debt issued by the rest of the world, (iv) bank loans to the private sector for investment and consumer credit, (v) government and private deposits, (vi) loans from the rest of the world borrowed by the domestic financial sector, and (vii) cash.

The paper is divided into eight sections. The second section explains the logic and main features of stock-flow modelling and our approach to modelling the Central American economies. The third section presents key stylized facts of Central American economies that are included in the model’s specification. The fourth section describes our stock-flow consistent model and its main equations by institutional sector. The fifth section delineates the working logic and causality of our model. Owing to space limitations, the paper does not include the specification of the full model, which comprises 214 equations.³ The sixth section incorporates the ecological module into the model through a damage function and makes explicit its linkages with real and monetary variables. The seventh section shows selected simulations of the model with climate change. The final section offers a series of conclusions.

II. Stock-flow consistent modelling and its underlying logic

Stock-flow consistent models have advantages over other modelling traditions and alternatives. The stock-flow modelling tradition builds on “a fundamental law of macroeconomics analogous to the principle of conservation of energy in physics” (Godley and Cripps, 1983, p. 18). Stocks and flows must satisfy both the constraints of individuals and of the economy in the aggregate, so that all the constraints are mutually compatible (Godley and Cripps, 1983, p. 18). Thus, only certain configurations of transactions are mutually compatible for all economic agents.

² See also Baltodano (2017) for an application of stock-flow models to Central America.

³ The authors can provide the full specification of the model on request.

The constraints placed on individuals and at the aggregate level are satisfied through the workings of one single behavioural axiom that states that the ratio of stock to flow variables, while not invariant, remains stable over time. Stock-flow norms have important implications for the model's internal working logic.⁴

One stock-flow norm is the average time the full effects of an expansion in aggregate demand are felt throughout an economy leading to the establishment of a steady state (Godley and Cripps, 1983). Another important stock-flow norm comes from treating the consumption function as a wealth function (Godley and Lavoie, 2007, pp. 74–75). In continuous terms, wealth accumulation $\left(\frac{dNW}{dt}\right)$ (where NW = net worth) is given by the difference between consumption (C) and disposable income (D), $C - D$.⁵ Consumption is specified as a function of disposable income and net worth, $C = \alpha_1 D + \alpha_2 NW$. $C - D = \alpha_1 D - \alpha_2 NW - D$. Rearranging terms we obtain: $C - D = D(1 - \alpha_1) - \alpha_2 NW \Leftrightarrow \alpha_3(\alpha_3 D - NW)$, where $\alpha_3 = \left(\frac{1 - \alpha_1}{\alpha_2}\right)$. As explained by Godley and Lavoie (2007, p. 75): “that wealth is being accumulated at a certain rate, determined by the partial adjustment parameter α_2 , towards some desired proportion α_3 of disposable income.” We set $C - D$ to obtain a target level of wealth \overline{NW} . The solution yields $\overline{NW} = \frac{\overline{D}(1 - \alpha_1)}{\alpha_2} = \alpha_3 \overline{D}$, where α_3 is the stock-flow norm for household consumption. A key implication of this stock-flow norm is that the level of savings depends on the difference between the target level of wealth (\overline{NW}) and the realized level of wealth (NW_R), $S = \overline{NW} - NW_R$.

Stock-flow norms are exogenous and, as a result, some of the model's major propositions are the result of logically inevitable conclusions. Logical relationships take precedence over behavioural ones. The former provide the framework for the functioning of behavioural relationships, making their specification in terms of microeconomic foundations redundant. The consistency between the plans and expectations of the different agents or sectors and the outcomes are reconciled through the financial system, which adapts endogenously to the demand for liquidity.⁶

Stock-flow consistent modelling begins by specifying transactions, flow-of-funds and balance sheet matrices that incorporate transactions between different agents (i.e. flows) and their corresponding balance sheet holding gains or losses (i.e. stocks).

The rows of the matrices represent money transactions between agents for each good, service or asset considered in the model. A negative sign in a row signifies a source of expenditure, and a positive sign indicates a destination of expenditure. As a result, as Godley (1999, p. 394) points out, “every flow comes from somewhere and goes somewhere”. To ensure the consistency of the macroeconomic framework, all rows must total zero. The columns are defined by the sectors or agents considered in the model and represent their budget constraint. For this reason, they must also total zero. The counterpart of each sector's budget constraint is the generation of changes in stocks of assets and liabilities. These appear as changes in agents' balance sheets.

Our paper focuses on smaller economies, exemplified by means of Central American country source cases.⁷ The analysis complements the existing literature on stock-flow models for Latin America and the Caribbean, which have focused mainly on the region's larger economies (see diagram 1).⁸

⁴ The following four are among the basic principles of stock-flow modelling: (i) flow consistency: every flow originates somewhere and goes somewhere; (ii) stock consistency: the liabilities of one sector are the assets of another sector; (iii) stock-flow consistency: end-of-period stocks include the accumulation of flows and capital gains; and (iv) every transaction implies a quadruple entry (Zezza, 2017).

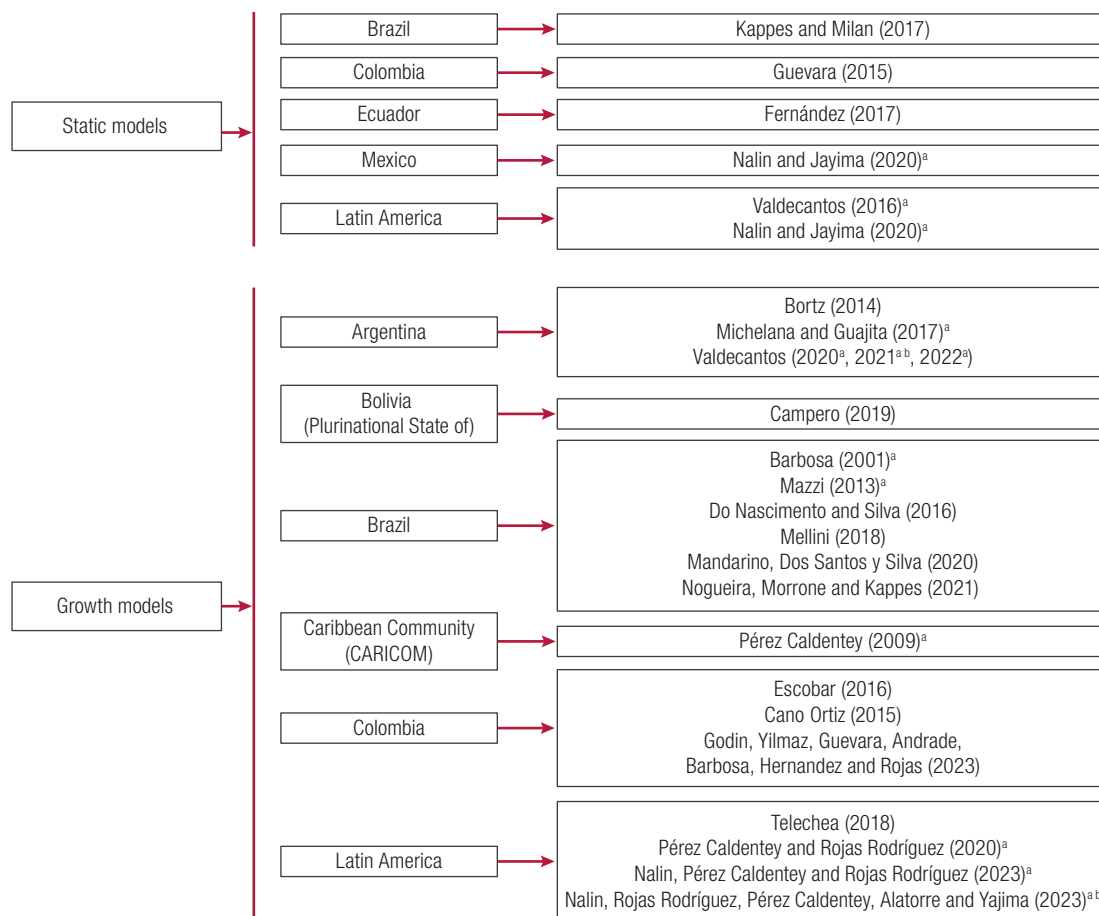
⁵ See Taylor (2008).

⁶ See Godley (2012). In neoclassical economics, the reconciliation of agents' consumption or production plans occurs in equilibrium through the workings of the anthropomorphic version of the invisible hand, the auctioneer. Trade does not occur in disequilibrium. Obviously, the financial system responds to the demand for loans, as long as they have collateral, so that there will be a “fringe of unsatisfied borrowers”.

⁷ Our analysis includes the Dominican Republic.

⁸ See annex A1 for a more complete description of these models.

Diagram 1
Stock-flow consistent models for Latin America and the Caribbean



Source: Prepared by the authors, on the basis of S. A. Kappes and M. Milan, "Fiscal policy rules in a stock-flow consistent model", *Brazilian Keynesian Review*, vol. 3, No. 2, January 2017; D. A. Guevara Castañeda, "Auge de las finanzas y desigualdad en la distribución del ingreso: un estudio desde la perspectiva de la financiarización para Colombia 1980-2008", doctoral thesis, National University of Colombia, 2015; J. Fernández, "Elementos de análisis para la sostenibilidad de una economía dolarizada", *Revista Economía*, vol. 69, No. 109, May 2017; L. Nalin and G. T. Yajima, "Balance sheet effects of a currency devaluation: a stock-flow consistent framework for Mexico", *Working Paper*, No. 980, Levy Economics Institute, 2020; S. Valdecantos, "Estructura productiva y vulnerabilidad externa: un modelo estructuralista stock-flujo consistente", *Studies and Perspectives series-ECLAC Office in Buenos Aires*, No. 46 (LC/L.4171-LC/BUE/L.225), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2016; P. G. Bortz, "Foreign debt, distribution, inflation and growth in a SFC model", *European Journal of Economics and Economic Policies: Intervention*, vol. 11, No. 3, December 2014; G. Michelena and N. Guaita, "Modelo de stock-flujo consistente para el análisis macroeconómico (SFARG)", *Documento de Trabajo*, Ministry of Production of Argentina, 2017; S. Valdecantos, "Argentina's (macroeconomic?) trap", *Working Paper*, No. 975, Levy Economics Institute, 2020; S. Valdecantos, "Grasping Argentina's green transition: insights from a stock-flow consistent input-output model", *Working Paper Series*, No. 4, Macroeconomic Methodology, Theory and Economic Policy (MaMTEP), Aalborg University Business School, 2021; S. Valdecantos, "Endogenous exchange rates in empirical stock-flow consistent models for peripheral economies: an illustration from the case of Argentina", *Journal of Post Keynesian Economics*, vol. 45, No. 4, August 2022; S. Campero Encinas, "Modelo stock flow consistent (SFC) aplicado al caso del sector de los hidrocarburos en Bolivia", master's thesis, Latin American Faculty of Social Sciences in Ecuador (FLACSO Ecuador), 2019; N. H. Barbosa, "International liquidity and growth in Brazil", *CEPA Working Paper*, No. 2001.4, New York, Center for Economic Policy Analysis (CEPA), 2001; C. T. Mazzi, "Um modelo stock-flow consistent (SFC) com crescimento restrito pelo balanço de pagamentos", master's thesis, University of Campinas (UNICAMP), 2013; P. F. Do Nascimento and A. C. M. Silva, "Financeirização e crescimento: alguns experimentos stock-flow consistent", *Anais do XLII Encontro Nacional de Economia*, National Association of Postgraduate Programs in Economics (ANPEC), 2016; A. Mellini, "Política fiscal, equilíbrio externo e déficits gêmeos em um modelo stock-flow consistent póskeynesiano com economia aberta", master's thesis, Federal University of Uberlândia, 2018; G. V. Mandarino, C. H. Dos Santos and A. C. M. Silva, "Workers' debt-financed consumption: a supermultiplier stock-flow consistent model", *Review of Keynesian Economics*, vol. 8, No. 3, July 2020; D. Nogueira Silva, H. Morrone and S. Kappes, "Assessing pension system outcomes in Brazil: a stock-flow consistent analysis", *Brazilian Keynesian Review*, vol. 7, No. 2, 2021; E. Pérez Caldentey, "Balance of payments constrained growth within a consistent stock-flow framework: an application to the economies of

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Note: See also Lage, Romero and Villarreal (2023) for a hybrid stock-flow model applied to the Cuban economy.

^a Stock-flow consistent models that include Thirlwall’s law.

^b Stock-flow consistent models that include variables related to environmental or climate-change phenomena.

The logical and behavioural relationships of our consistent stock-flow model are largely based on a set of stylized facts characterizing smaller economies. This builds on the notion that macroeconomic processes are dependent on the historical evolution of countries, their institutions, their productive structures and their international insertion patterns.

Given the importance of climate-related effects in shaping the performance of smaller economies, including those of Central America, our stock-flow model includes an ecological and energy module based on the work of Carnevali and others (2021) and Dafermos, Nikolaidi and Galanis (2017). Natural disasters lead to the destruction of capital and productive capacity, economic divergence with persistent negative effects over time and increased debt. Economies that are more vulnerable to recurrent disasters can enter a vicious circle in which they tend to converge, in the long run, on lower levels of economic growth and poverty traps.⁹ Countries affected by natural disasters see their debt levels increase in the three subsequent years by, on average, between 2.3 and 3.6 percentage points of GDP compared to countries that do not experience such disasters.¹⁰

In the Latin American and Caribbean region, analyses based on stock-flow consistent models that include the ecological dimension remain embryonic. Only three papers address this issue (Godin and others, 2023; Nalin and others, 2023; and Valdecantos, 2021).

III. Selected key stylized facts of smaller economies in Latin America and the Caribbean

A key feature of developing economies is that they do not issue reserve currencies. Also, in general, for this group of economies —and especially for smaller economies— the import elasticity of income is higher than the export elasticity of income. As a result, these economies face a binding long-run balance-of-payments constraint. This prevents them from attaining the maximum expansion of output from the supply side and entails the existence of excess capacity, low rates of accumulation and of technical progress and the presence of unemployment, underemployment and informality. Informality is present in all economic sectors and is a central determinant of tax evasion and avoidance.

Depending on the time period and the specific circumstances, the external constraint may bite on the current account or on the financial side of the balance of payments. Smaller economies traditionally present recurrent current account deficits. They also depend heavily on external financial inflows; i.e. on flows of external debt.

⁹ See Rivas Valdivia (2014).

¹⁰ See Fan and others (2022).

This exposes countries' performance and the evolution of their debt to changes in the determinants of interest rate differentials, including country risk. Insofar as causality exists between sovereign risk and non-financial corporate sector risk, a change in sovereign risk levels also pushes up the cost of borrowing for the public and private non-financial corporate sector. This tightens the financial constraint of both sectors, while negatively impacting gross fixed capital formation and, consequently, the capacity to raise revenues. Most Central American countries have speculative or highly speculative sovereign credit ratings.

A key consequence of a binding external constraint is that for a given ratio of the income elasticity of exports relative to the income elasticity of imports, the long-term domestic rate of growth of a country's GDP is determined by the rate of growth of its most important bilateral economic partner. In the case of Central America, the rate of GDP growth of the United States is the best proxy for that of the rest of the world.

In addition, the economic cycles of most Central American countries closely follow that of the United States. With the exception of Panama and Nicaragua, the correlation coefficients between the GDP growth rate of the Central American countries and that of the United States are statistically significant. When real gross national disposable income (RGNDI) is used instead of GDP as a measure of economic activity for the Central American countries, all the correlation coefficients — without exception — are statistically significant (see table 1).¹¹ The rationale for using RGNDI is explained below.

Table 1
Correlation coefficient between rates of change in GDP and real gross national disposable income of Central American countries and rate of change in real GDP of United States, 1961–2022

Country	Gross domestic product (GDP) 1961–2022	Real gross national disposable income (RGNDI) 1991–2021
Costa Rica	0.61**	0.37**
Dominican Republic	0.19*	0.59**
El Salvador	0.51**	0.55**
Guatemala	0.39**	0.25*
Honduras	0.67**	0.61**
Nicaragua	0.13	0.25*
Panama	0.15	0.30**

Source: Prepared by the authors, on the basis of World Bank, "World Development Indicators", 2024 [online database] <https://databank.worldbank.org/source/world-development-indicators> and data from the Economic Commission for Latin America and the Caribbean (ECLAC).

Note: The statistical significance of the correlation coefficient was determined using the formula $\rho = \frac{r(\sqrt{n-2})}{\sqrt{1-r^2}}$, where r is the simple correlation coefficient and n the number of observations. ρ follows a student- t distribution with $n-2$ degrees of freedom. ** and * denote significance at the 5% and 1% levels, respectively. The Dominican Republic is included as a Central American country.

The external insertion of the Central American countries is driven in part by the export of labour to the United States, the counterpart of which is remittance inflows. In 2022, remittances represented 9%, 24%, 19%, 27% and 21% of GDP for the Dominican Republic, El Salvador, Guatemala, Honduras and Nicaragua, respectively.

¹¹ In the case of the United States, since the net factor of payments to the rest of the world ($NPRW_t$) current transfers (CT_t) and the terms-of-trade effect (TTE_t) do not have any significant impact on the economy's performance, the choice between GDP or RGNDI makes little difference to the analysis.

The importance of remittances suggests complementing GDP-based analyses of economic and debt performance with analyses based on RGNDI.¹² Real gross national disposable income ($RGNDI_t$) equals the sum of gross domestic product (GDP_t), the net factor of payments to the rest of the world ($NPRW_t$), current transfers (CT_t) and the terms-of-trade effect (TTE_t).¹³ Formally:

$$RGNDI_t = GDP_t + NPRW_t + CT_t + TTE_t \quad (1)$$

The terms-of-trade effect equals the volume of goods and services exports (X_t) (or exports at constant prices) multiplied by the change in the trade price index:

$$TTE_t = X_t \frac{(P_x - P_m)}{P_m} = X_t \left(\frac{P_x}{P_m} - 1 \right) \quad (2)^{14}$$

Where P_x , P_m unit price indices for exports and imports. Substituting equation (2) into equation (1) yields:

$$RGNDI_t = GDP_t + NPRW_t + CT_t + X_t \left(\frac{P_x}{P_m} - 1 \right) \quad (3)$$

According to equation (3), other factors remaining equal, an improvement in the terms of trade $\left(\Delta \frac{P_x}{P_m} \right)$ translates into a rise in real gross national disposable income ($RGNDI_t$). Through equation (3), the difference between gross national disposable income ($RGNDI_t$) and gross domestic product (GDP_t) can be broken down into net factor payments to the rest of the world ($NPRW_t$) current transfers (CT_t) and the terms-of-trade effect (TTE_t).

The importance of including real gross national disposable income in our analysis can be seen by comparing the impact of the coronavirus disease (COVID-19) pandemic on the rate of growth of the economies of Central America and the Dominican Republic in 2020 using GDP and RGNDI. In all cases, the use of GDP overstates the economic impact of COVID-19 because it does not account for the countercyclical role of remittances (see figure 1). Between 2019 and 2020, with the exception of Costa Rica, remittance inflows increased in all the countries of the study subset. Moreover, Costa Rica is the country that registered the smallest difference in the impact of COVID-19 measured by GDP versus RGNDI.

¹² Godley and Cripps (1983) emphasize the use of RGNDI in an open economy.

¹³ All the components of RGNDI are expressed in real terms.

¹⁴ The terms of trade effect can be derived from:

$$TTE = \left(\frac{X-M}{P} \right) - \left(\frac{X}{P_x} - \frac{M}{P_m} \right) \quad (4)$$

Where:

X = value of exports of goods and services

M = value of imports of goods and services

P = price deflator

p_x = export price index using a base value of 1

p_m = import price index using a base value of 1

$$\Leftrightarrow TTE = x \left(\frac{p_x}{P} - 1 \right) + m \left(1 - \frac{p_m}{P} \right) \quad (5)$$

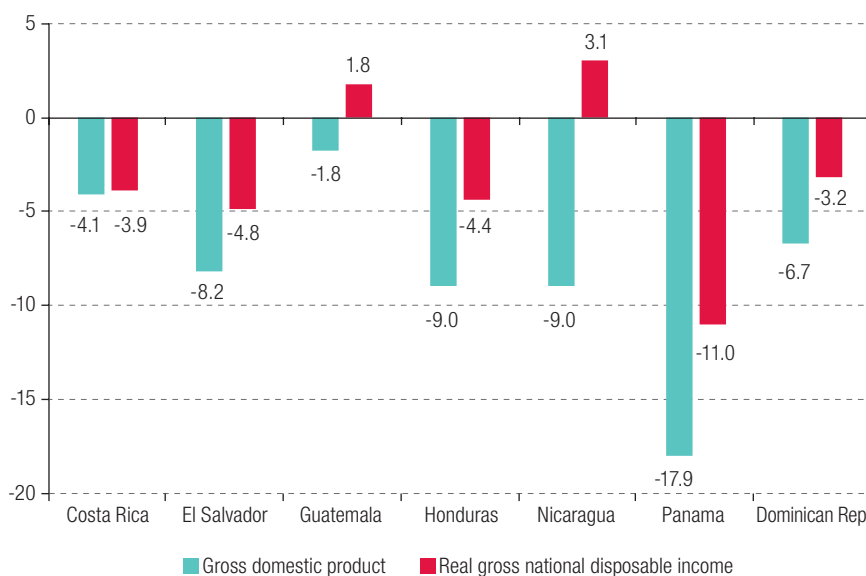
Where:

$$x = \frac{X}{P_x}; m = \frac{M}{P_m}$$

Assuming that the price deflator equals the price of imports, $P = p_m$, equation (4) can be simplified as:

$$TTE = x \left(\frac{p_x}{p_m} - 1 \right) \quad (6)$$

Figure 1
Rate of growth of GDP and real gross national disposable income
of Central American countries and the Dominican Republic, 2020
(Percentages)



Source: Prepared by the authors, on the basis of data from the Economic Commission for Latin America and the Caribbean (ECLAC).

The advantages of using RGNDI to complement GDP — or as an alternative to it— in gauging economic performance are also apparent when RGNDI is used to standardize the main macroeconomic ratios that are traditionally used to assess an economy's degree of disequilibrium or sustainability. These ratios include the fiscal deficit, account deficits and debt relative to output and income metrics (see table 2).

Table 2
Central America and the Dominican Republic: selected macroeconomic indicators, 1990–2021

Country	1990–2000	2000–2010	2010–2021
Rate of growth of real GDP			
Costa Rica	4.8	4.4	3.5
Dominican Republic	5.0	4.7	5.1
El Salvador	3.5	1.6	2.4
Guatemala	4.0	3.4	3.5
Honduras	3.2	4.4	3.4
Nicaragua	3.1	3.1	3.6
Panama	5.5	5.6	5.5
Rate of growth of RGNDI			
Costa Rica	4.7	4.3	3.2
Dominican Republic	6.8	4.5	5.4
El Salvador	4.1	1.3	2.2
Guatemala	4.8	4.0	4.3
Honduras	4.0	4.0	3.8
Nicaragua	3.9	3.0	4.1
Panama	4.5	4.8	4.8

Country	1990–2000	2000–2010	2010–2021
Current account as a percentage of GDP			
Costa Rica	-4.3	-4.5	-3.3
Dominican Republic	-2.4	-2.9	-3.3
El Salvador	-2.5	-4.3	-3.4
Guatemala	-5.1	-4.5	-0.4
Honduras	-4.8	-6.5	-4.9
Nicaragua	-17.6	-13.5	-6.2
Panama	-3.6	-4.8	-7.6
Current account as a percentage of RGNDI			
Costa Rica	-4.2	-4.6	-3.4
Dominican Republic	-2.3	-2.8	-3.2
El Salvador	-2.2	-3.7	-2.9
Guatemala	-4.8	-4.1	-0.4
Honduras	-4.8	-5.8	-4.4
Nicaragua	-17.9	-12.5	-5.7
Panama	-3.3	-4.8	-8.4
Government debt stock as a percentage of GDP			
Costa Rica	37.9	29.6	39.2
Dominican Republic	29.1	24.4	37.6
El Salvador	34.6	57.2	66.5
Guatemala	28.0	31.9	33.0
Honduras	96.4	49.5	35.7
Nicaragua	222.4	90.6	94.1
Panama	70.3	86.3	147.8
Government debt stock as a percentage of RGNDI			
Costa Rica	37.5	30.2	40.4
Dominican Republic	28.3	23.6	36.3
El Salvador	31.1	49.7	57.6
Guatemala	26.4	28.5	29.8
Honduras	95.8	44.8	31.4
Nicaragua	228.3	84.2	86.5
Panama	65.5	85.7	166.8

Source: Prepared by the authors, on the basis of World Bank, “World Development Indicators”, 2024 [online database] <https://databank.worldbank.org/source/world-development-indicators> and data from the Economic Commission for Latin America and the Caribbean (ECLAC).

Note: The figures in bold highlight the different results obtained when using GDP and RGNDI to assess the economic performance of an economy.

Besides playing a countercyclical role and thus dampening the impact of external shocks on the domestic economy, remittances are essential in maintaining nominal exchange rate stability. Generally, remittance recipients change United States dollars into local currency through the local banking system. In turn, the banking system must surrender a significant part of its foreign currency holdings to the central bank, allowing the latter to strengthen its international reserve stock and to intervene, when necessary, in the foreign exchange market.¹⁵

In smaller economies, such as those of the Central American isthmus, the nominal exchange rate plays the role of a “nominal anchor”. At the same time, the stability of the exchange rate is central in avoiding unwanted increases in the central government’s external debt and debt service payments, which could constrain its capacity to deliver public goods. Maintaining the stability of the exchange rate also helps maintain the financial stability of the non-financial corporate sector.

¹⁵ The percentage of foreign currency that banks must surrender to the central bank can amount to 50% or more of their total foreign currency holdings.

IV. The description of the stock-flow consistent (SFC) model

Our stock-flow consistent (SFC) model includes five institutional sectors: (i) the private sector, comprising consumers and firms, (ii) the financial sector, (iii) the government, (iv) the central bank, and (v) the rest of the world. These five sectors trade in seven financial assets: (i) public debt issued in domestic and foreign currencies, (ii) private debt issued in domestic currency, (iii) debt issued by the rest of the world, (iv) bank loans to the private sector for investment and consumer credit, (v) government and private deposits, (vi) loans from the rest of the world borrowed by the domestic financial sector, and (vii) cash.

The transactions among the five institutional sectors with their respective instruments are captured in the transactions flow matrix (see table 3). As explained in section II, all rows (money flows by expenditure categories) and columns (budget constraint plus savings or dissaving sources) must add up to zero. A minus sign indicates the use of funds and a plus sign indicates a source of funds. The main assumptions and behavioural relationships of each of the five sectors is described in the remainder of this section.

Table 3
Transactions and balance sheet matrices

	Production	Private sector		Financial sector		Government sector		Central bank		Rest of the world	Σ
		Current	Capital	Current	Capital	Current	Capital	Current	Capital		
Consumption	$+C_d$	$-C_d$									0
[Wage bill]	$[-WB]$	$[+WB]$									
Investment	$+I^k$		$-I^k$								0
[Taxes]		$[-T_p]$		$[-T_{fs}]$		$[+T]$					
Government spending	$+G_d$					$-G_d$					0
Imports	$-IM$									$+IM$	0
Exports	$+X$									$-X$	0
[GDP]	$[-Y]$	$[+Y]$									$[Y]$
Interest on											
Government bonds (domestic currency)		$+int_p^g$		$+int_{fs}^g$		$-int^g$		$+int_{bc}^g$		$+int_{row}^g$	0
Government bonds (foreign currency)		$+int_p^{sg}$		$+int_{fs}^{sg}$		$-int^{sg}$				$+int_{row}^{sg}$	0
Private debt		$-int^p$		$+int_{fs}^p$		$+int_g^p$				$+int_{row}^p$	0
Private debt in foreign currency		$-int^{sp}$								$+int_{row}^{sp}$	0
Bonds from the rest of the world		$+int_p^{row}$		$+int_{fs}^{row}$				$+int_{bc}^{row}$		$-int^{row}$	0
Public deposits						$+int_{mm_g}^{cb}$		$-int_{mm_g}^{cb}$			0
Private deposits		$+int_{mm_p}^{fs}$		$-int_{mm_p}^{fs}$							0
Consumption credit		$-intc^p$		$+intc_{fs}^p$							0
Advances				$-int^{afs}$				$+int_{cb}^{afs}$			0
Loans		$-int^{lp}$		$+int^{lp}$							0
Loans (foreign currency)				$-int^{slfs}$						$+int^{slfs}$	0

Production	Private sector		Financial sector		Government sector		Central bank		Rest of the world	Σ	
	Current	Capital	Current	Capital	Current	Capital	Current	Capital			
Financial gains (dividends)	$+F-fr-fdc$				$+FB_g^{bc}$		$-FB^{bc}$			0	
Remittances	$+rem$									$-rem$	
[Gross national income]	$[GNI]$		$[GNI_{fs}]$		$[GNI_g]$					$[GNI]$	
Taxes	$-T$		$-T$		$+T$					0	
Capital	$+K$									$-K$	
Inventories	$+IN$									$-IN$	
Government bonds (domestic currency)			$-B_p^g$		$-B_{fs}^g$		$+B^g$		$-B_{bc}^g$	$-B_{row}^g$	0
Government bonds (foreign currency)			$-B_p^{sg}$		$-B_{fs}^{sg}$		$+B^{sg}$			$-B_{row}^{sg}$	0
Private debt			$+D^p$		$-D_{fs}^p$		$-D_g^p$			$-D_{ro}^p$	0
Private debt (foreign currency)			$+D^s$							$-D_{row}^s$	0
Bonds from the rest of the world			$-B_p^{row}$		$-B_{fs}^{row}$				$-B_{bc}^{row}$	B^{row}	0
Public deposits							$-M^g$		$+M^g$		0
Consumption credit			$+Cc$		$-Cc$						
Advances					$+A^{fs}$				$-A^{fs}$		0
Loans			$+L_p^{fs}$		$-L_p^{fs}$						0
Loans (foreign currency)					$+L_{fs}^{srow}$					$-L_{fs}^{srow}$	
Private deposits			$-M^p$		$+M^p$						0
High power money			$+H^p$		$+H^{fs}$				$-H^{bc}$		
Σ	0	0	0	0	0	0	0	0	0	0	0

Source: Prepared by the authors.

1. Households

Household economic activity is circumscribed to consumption. Consumption depends on three factors. The first is past consumption, which implies that consumers' expenditure is partly driven by inertia. The second factor is the difference between actual disposable income and expected disposable income: consumers adjust their expenditures to the difference between those two amounts. The third factor is wealth.

As discussed in the first section, the consumption function can be modelled as a wealth accumulation function, which implies that households have a target level of wealth equal to $V^T = \alpha_4 y d^{h,*}$, where $\alpha_4 = \frac{1-\alpha_{1c}-\alpha_{2c}}{\alpha_2}$ ¹⁶. α_4 is the stock-flow norm of households in our model. The target level of wealth is a function of the difference between expected and actual disposable income.

Disposable income depends on wages, interest payments (deposits are assumed to be the only asset in the hands of households) and remittances. Households do not engage in arbitrage activities, and the interest rate relating to credit or deposits does not have a direct influence on determining real consumption. Households demand credit to finance consumption that exceeds disposable income (see table 4).

¹⁶ The target level of wealth takes on this specification in the steady state as long as expected disposable income equals realized income. For the sake of simplicity, we also assume that the environmental dummy is zero.

Table 4
Main equations for the household sector

Function	Specification	
Real consumption	$c = \alpha_{1c}c_{-1} + \alpha_{2c}c_{-1} * \left(1 + \alpha_{3c} * \frac{(y d^e - y d^h)}{y d^h}\right) + \alpha_2 v_{-1} + \alpha_2 \text{Dummy}$	(7)
Disposable income	$y d^h = WB + Fd_c + intfs_{mm} + rem$	(8)
Wealth	$v = mm - cc$	(9)

Source: Prepared by the authors.

Note: c = consumption; $y d^e$, $y d^h$ = expected and actual disposable income; WB = wage bill; Fd_c = profits distributed by firms to consumers; $intfs_{mm}$ = interest paid to households by the financial sector; rem = remittances; mm = stock of deposits held by households; cc = consumer credit.

Wealth is not only a key determinant of consumption; it is also an important channel through which the effect of climate change on the economy is transmitted (tables 10 and 13). Households may lose net wealth directly through damage suffered by physical capital as a result of extreme weather events. In addition, they may also suffer losses in net wealth from price drops in financial assets linked to sectors whose returns decrease with global warming (such as agriculture) or that come from activities that will be left stranded by transition policies.

In our model, households' loss of wealth leads to a demand shock in consumption, as agents tend to reduce consumption to compensate for the loss of wealth. Lower consumption will cause lower revenue inflows for firms, exacerbating the physical damage to their productive capacity caused by climate change.

2. Firms

Total production in the economy is determined by firms' activities. The equations depicting firms' behaviour are classified into four broad categories, relating to: (i) real output, (ii) costing decisions, (iii) pricing decisions, and (iv) the firm's financial relations (see table 5).

Table 5
Main equations for firms

Function	Specification	
Total production	$y = (1 - (D^y + \vartheta_y \text{ dummy})) \cdot (s^e + (in^T - in_{-1}))$	(10)
Target inventories	$in^T = \gamma \cdot s^e$	(11)
Expected sales	$s^e = \beta \cdot s_{-1} + (1 - \beta) \cdot \Delta Y_{row}$	(12)
Investment function	$i = ((dp + D^k + A) \cdot k_{-1}) \cdot p_d + i_{-1} \cdot ic$	(13)

Source: Prepared by the authors.

Note: y = production; s^e = expected sales; in^T = target inventories; in_{-1} = real inventories; Y_{row} = GDP of the rest of the world; i = real investment; p = price level; D^k = damage function impact on the capital stock; A = central bank advances to the private sector; p_d = price index of domestic sales; ic = confidence index.

Real output (the actual production of each year) is specified as a function of expected sales plus an adjustment between the target stock of inventories and the stock of inventories inherited from the end of the previous period. The target stock of inventories depends on the expected level of sales. In turn, the latter is determined by the past level of sales adjusted for GDP growth in the rest of the world.

Consumption, private investment, public spending and trade with the rest of the world determine firms' sales levels. In turn, firms' sales expectations depend on the previous level of sales adjusted for world GDP growth.

As the system does not operate at full employment, in each period there is a target of inventories that the production sector accumulates. Expected sales and the misalignment of inventories from their target determine the production level. Private sector consumption is specified as a function of expected private disposable income and households' wealth. The former is a proportion of household disposable income, which is in turn defined as the sum of wages and profits distributed from firms to households. Households' earnings determine the consumption level, the demand for money and the demand for financial assets.

Firms' profits are fundamental in determining investment and corporate debt issuance levels. A proportion of firms' net profits is retained for investment in physical capital. If retained profits exceed investment, the surplus will be used to acquire financial assets. In addition, a portion of non-retained profits is used for consumption. An important contribution of the model is the role of expectations in investment decisions. In each period, investment flows vary according to the evolution of capital depreciation and the performance of the investment confidence index.

Prospects of future returns, together with the growth rates of the domestic and foreign economies, are the determinants of the investment confidence index. Profit expectations are a function of two elements: the return on investment (ROI) and the corporate risk premium (CEMBI). The impact of profit expectations and domestic and rest-of-the-world growth rates on the investment confidence index depends on specific sensitivities, a non-linear function of a firm's leverage-to-output ratio and domestic and rest-of-the-world growth. If the investment level exceeds profits retained for investment, firms issue debt, and a proportion of that debt is issued in local currency and the remainder in foreign currency. Local currency debt can take the form of loans or corporate bonds.

3. Government

In this model, references to the government mean the central government. The government generates public expenditure but only through direct purchases from firms. There are no transfers to households, nor is cash held as an asset in the economy. The government issues bills to finance its deficits and buys foreign bonds (equivalent to international reserve assets) in which to invest its surpluses.

The most important equations for the government sector describe the public sector deficit trends (see table 6). The public sector deficit is determined by the difference between government sector expenditures (public spending and interest payments on bills issued in the previous period) and revenues (taxes and returns on foreign assets). The issuance of bonds is determined by the stock of public bonds plus the variation of the deficit if it is greater than zero. In turn, external bond purchases depend on the public deficit being less than zero (i.e. in surplus).

Table 6
Main equations for the public sector

Function	Specification	
Public sector budget restriction	$PSBR = G - T - int_B^g - int_{Bfx}^g + int_{dg}^p + int_{Bg}^{row} + -FB^{bc}$	(14)
Government debt supply (local currency)	$\Delta B = \zeta . PSBR$	(15)
Government debt supply (foreign currency)	$\Delta B^s = (1 - \zeta) . PSBR$	(16)

Source: Prepared by the authors.

Note: $PSBR$ = public sector borrowing requirement; G = public sector expenditure; T = taxes; int_B^g = interest paid by the government to the rest of the world; int_{Bfx}^g = interest paid by the government on bond issues to the rest of the world in local currency; int_{dg}^p = interest paid by the private sector for government deposits; int_{Bg}^{row} = interest paid by the rest of the world to the government for foreign bonds; FB^{bc} = central bank profits that are not invested; B = bonds issued by the government.

4. Rest of the world

The external sector —and, more precisely, the long-term sustainability of the balance of payments— places a long-term binding constraint on the domestic rate of growth (see table 7). We follow the balance-of-payments constrained growth literature and specify the export and import equation as functions of the rate of growth of income in the rest of the world and the rate of growth of domestic income, the real exchange rate and terms of trade. In its most simple expression, the balance of payments constrained growth is revealed by Thirlwall's law. Thirlwall's law states that the rate of growth of an economy is determined by the rate of growth of the world economy and the ratio of the income elasticity of export demand to the income elasticity of import demand of the national economy in question.¹⁷

Table 7
Main equations for the rest of the world

Function	Specification	
Growth of exports	$\Delta x = \eta_0 \cdot Y_{row}^{\eta_1} \cdot (TOT)^{\eta_2}$	(17)
Growth of imports	$\Delta_m = \eta_3 \cdot \frac{Y^{\eta_4}}{(TOT)^{\eta_5}}$	(18)
Balance of payments current account	$FCAB = X - M - int_{B_{row}}^g - int_{d_{FX_{row}}}^g - int_{d_{row}}^p - int_{d_{FX_{row}}}^p + int_B^{row} + rem$	(19)
Balance of payments capital account	$KAB = \Delta B_{row} + \Delta B_{row}^s + \Delta D_{row} + \Delta D_{row}^s - \Delta B^{row}$	(20)

Source: Prepared by the authors.

Note: x = level of exports in real terms; $Y_{row}^{\eta_1}$ = level of real GDP of the rest of the world; TOT = terms of trade; m = level of imports in real terms; Y^{η_4} = level of real domestic GDP; $FCAB$ = balance of payments current account; X = level of exports in nominal terms; M = level of imports in nominal terms; $int_{B_{row}}^g$ = interest paid by the government to the rest of the world; $int_{d_{FX_{row}}}^g$ = interest paid by the government on bonds issued in foreign currency; $int_{d_{row}}^p$ = interest paid by the private sector to the rest of the world for debt issued in local currency; $int_{d_{FX_{row}}}^p$ = interest paid by the private sector to the rest of the world for debt issued in foreign currency; int_B^{row} = interest payments received by the government from the rest of the world; rem = remittances; KAB = balance of payments financial account; B_{row} = total stock of government bonds held by the rest of the world (in domestic currency); B_{row}^s = total stock of government bonds held by the rest of the world (in foreign currency); B^{row} = stock of bonds issued by the rest of the world; D_{row} = demand for private debt (in domestic currency) by the rest of the world; D_{row}^s = demand for private debt (in foreign currency) by the rest of the world.

In the short term, movements in the balance of payments financial account affect the rate of growth. World financial inflows are equal to the sum of government and private bonds purchased by the rest of the world. The demand for government bonds issued in local currency depends on global GDP growth, interest spreads and exchange rate expectations. The demand for government bonds issued in foreign currency is determined by interest rate differentials. Our model postulates that the supply of financial flows always matches demand and that the international interest rate is exogenous, as the rate of economic growth of the world.

5. Financial sector

The financial sector's main function is to provide the private sector with loans. First, it provides consumer credit when households' wages are lower than their consumption. Second, it finances private sector investment through lending. In this case, the demand for loans depends on profits and capital expenditures. It is assumed, for simplicity, that the financial sector's supply of consumer credit and loans always matches demand. The sum of consumer credit and loans corresponds to the total volume of private sector deposits in the financial sector. Interest payments received on holdings of financial assets and foreign reserves represent the financial sector's inflows, while interest paid on foreign loans and central

¹⁷ In a simpler expression, the long-run growth rate of an economy compatible with a sustainable balance-of-payments position is given by the ratio of that economy's export growth rate to income elasticity.

bank advances makes up its outflows. The difference between inflows and outflows determines profits. A portion of those profits is used to accumulate wealth through financial assets: government bonds (in local and foreign currency), private debt (in local currency only) and foreign debt used as reserves. The demand for each type of asset reflects the arbitrage conditions postulated by Yilmaz and Godin (2020). The financial sector covers its financial needs by issuing two types of liabilities. These are advances from the central bank and foreign currency bonds bought by the rest of the world. The advances are calculated as a proportion of the sector's financial needs, which is exogenously given. The remaining financial needs are covered by bonds issued in foreign currency and sold to the rest of the world (see table 8).

Table 8
Main equations for the financial sector

Function	Specification
Financial sector profit	$f_{fs} = int_{fs}^g + int_{fs}^{sg} + int_{fs}^p + int_{fs}^{row} - int_{mm,p}^{fs} + int_{fs}^p + int^{ofS} + int^{lp} - int^{slS} + (CP_d - D_{CP_d}) + rem_f$ (21)
Demand for consumer credit	$Cc_d^p = cons + intcp_{fs} - fdc - wb - intfs_{mm} + rem_h$ (22)
Financial sector demand for government bonds (local currency)	$\Delta B_{fs,d}^g = \epsilon_{f_1} \cdot fa_{fs}$ (23)
Sensitivity of financial sector demand for government bonds (local currency)	$\epsilon_{f_1} = \epsilon_{f_{1o}} + \epsilon_{f_{1i}} \left(\frac{1+i^g}{1+i^{g^*}} \right)^{\theta_{fs}}$ (24)

Source: Prepared by the authors.

Note: f_{fs} = financial sector profits; $int_{fs}^g, int_{fs}^{sg}$ = interest paid by the government to the financial sector in domestic and foreign currency; int_{fs}^p = interest paid to the financial sector by the private sector in domestic currency; $int_{mm,p}^{fs}$ = interest on deposits paid by the financial sector; int_{fs}^p = interest on consumer credit paid to the financial sector; int^{ofS} = interest paid to the financial sector by the private sector for advances; int^{lp} = interest paid to the financial sector by the private sector for loans in domestic currency; int^{slS} = interest paid to the financial sector by the private sector for loans in foreign currency; CP_d = capital payments on loans to firms; D_{CP_d} = default of capital payments on loans to firms; rem_f = remittances received by the financial sector; Cc_d^p = demand for consumer credit; $cons$ = demand for consumption; $intcp_{fs}$ = interest paid on consumer credit; fdc = profits distributed to consumers; wb = wage bill; $intfs_{mm}$ = interest paid by the financial sector on consumer deposits; rem_h = remittances received by households; $B_{fs,d}^g$ = financial sector demand for government bonds; fa_{fs} = financial share of assets bought by the financial sector; i^g and i^{g^*} = government nominal interest rate on domestic and foreign currency; ϵ_{f_1} = sensitivity of financial sector demand for government bonds (local currency).

Empirical estimates (Hilscher and Nosbusch, 2010) suggest that the debt-to-GDP ratio, foreign debt-to-GDP ratio, reserves and exchange rate variations are the main determinants of sovereign premium (here defined by the emerging markets bond index (EMBI)). In turn, corporate risk is a function of EMBI, of the currency mismatch — a growing concern in the Latin American region (Pérez Caldentey, Favreau Negront and Méndez Lobos, 2019; Nalin and Yajima, 2021)— in the ratios of foreign liabilities to foreign assets, and of the loans-to-GDP ratio. The nominal exchange rate follows an autoregressive process of the first order, affected by foreign exchange traders' expectations — we include speculative versus fundamentalist traders (Lavoie and Daigle, 2011)— and by financial flows from the rest of the world, sovereign risk and the terms of trade. The domestic interest rate depends on the international rate and government risk (EMBI). It also varies according to the demand for and supply of bonds (Yilmaz and Godin, 2020): whenever excess demand exists, the interest rate will decrease as a consequence. The nominal interest rate on foreign-denominated debt is obtained by adding a premium to the international interest rate, where the latter is a function of EMBI. Private sector nominal rates on domestic and foreign debt work similarly.

6. Central bank

The central bank follows an augmented Taylor rule: it determines its desired monetary policy rate according to inflation and deviations in both output and exchange rate growth from their target levels. Monetary policy functions through government bond purchases. The central bank demands domestic bonds according to a target level, which depends on the behaviour of the credit market and exchange rates (see table 9).

Table 9
Main equations for the central bank

Function	Specification	
Taylor rule	$i^{cb} = \pi_t + i_t^{cb*} + \vartheta_1(\pi_t - \pi_t^*) + \vartheta_2(\Delta y_t - \Delta y_t^*) + \vartheta_3(\dot{e}_t - \dot{e}_t^*)$	(25)
Interest rate target	$i_t^{cb*} = i^{row} + \varphi^{cb}$	(26)
Central bank profits	$FB^{bcp} = int_{bc}^g + int_{bc}^{row} + int_{bc}^{g\$} + int_{bc}^{gfs} - int_{mm_g}^{cb} + dep_{cb} + rem_{cb}$	(27)
Rest-of-the-world supply of debt to the central bank	$\Delta B_g^{row} = -CAB + WFF + B_p^{row} \cdot E - depreciation_{Row}$	(28)

Source: Prepared by the authors.

Note: i^{cb} = monetary policy interest rate; π_t = inflation rate; i_t^{cb*} = target monetary policy rate; y_t = level of real GDP; y_t^* = target level of real GDP; \dot{e}_t = rate of change of the actual nominal exchange rate; \dot{e}_t^* = rate of change of the target nominal exchange rate; i^{row} = external nominal interest rate; φ^{cb} = private risk premium; FB^{bcp} = central bank profits; int_{bc}^g = interest paid to the central bank by the government in domestic currency; int_{bc}^{row} = interest paid to the government by the rest of the world in domestic currency; $int_{bc}^{g\$}$ = interest paid to the central bank by the government in foreign currency; int_{bc}^{gfs} = interest paid to the central bank by the financial sector for advances; $int_{mm_g}^{cb}$ = interest paid to the government by the central bank for deposits; dep_{cb} = change in the value of the central bank's foreign assets; rem_{cb} = central bank remittances; B_g^{row} = supply of the rest of the world's bonds to the government; B_p^{row} = supply of the rest of the world's bonds to the private sector; CAB = balance of payments current account; WFF = world fund flows; E = nominal exchange rate level; $depreciation_{Row}$ = rest of the world stock depreciation due to nominal exchange rate fluctuations.

As the interest rate is a function of interactions between the demand for and supply of bonds, an increase in the target of domestic bonds purchased by the central bank will put downward pressure on rates, which will adjust consequently, changing the demand for domestic bonds and influencing the behaviour of the exchange rate. The ideal amount of bonds the central bank is willing to hold depends on the differential between the current interest rate and the central bank's target rate and the observed volatility in the exchange rate (calculated as the moving average standard deviation of the nominal exchange rate).

When volatility exceeds three standard deviations, its coefficient will take a value of one and the demand for bonds will adjust accordingly. The amount of domestic government bonds allocated to the central bank is the maximum between its demand for bonds and the unallocated residual to the financial sector, private and external. The supply of international reserves to the central bank from the rest of the world is unlimited. Central bank profits are used to purchase financial assets. Central bank savings correspond to uninvested profits. Finally, the amount of money issued is the residual of the central bank's budget constraint; that is, it is issued to finance the difference between profits before portfolio investment and portfolio purchase.

V. Working logic and causality of the model with some simulation results

In line with our stylized facts, the workings of the model are largely driven by external factors, including rates of growth in the rest of the world and in remittances. Changes in the rest-of-the-world growth rate and in export demand and variations in international financial rates and/or financial flows directly affect the external sector. These impulses are transmitted to firms, employment and consumption levels and the government sector.

The transmission mechanisms include: (i) the close relation between sovereign risk and sovereign premium and the feedback between the two variables, (ii) the influence of the risk premium on the corporate risk premium, (iii) the role of currency mismatches in the private non-financial sector and their links with risk premiums and the nominal exchange rate, (iv) the importance of expectations for investment, which is registered by including an investment confidence index,¹⁸ (v) the non-linear relation that exists between debt and investment for the Latin American non-financial sector,¹⁹ (vi) the role of

¹⁸ See Pérez Caldentey, Nalin and Rojas Rodríguez (2022 and 2023).

¹⁹ See Pérez Caldentey, Favreau Negront and Méndez Lobos (2019).

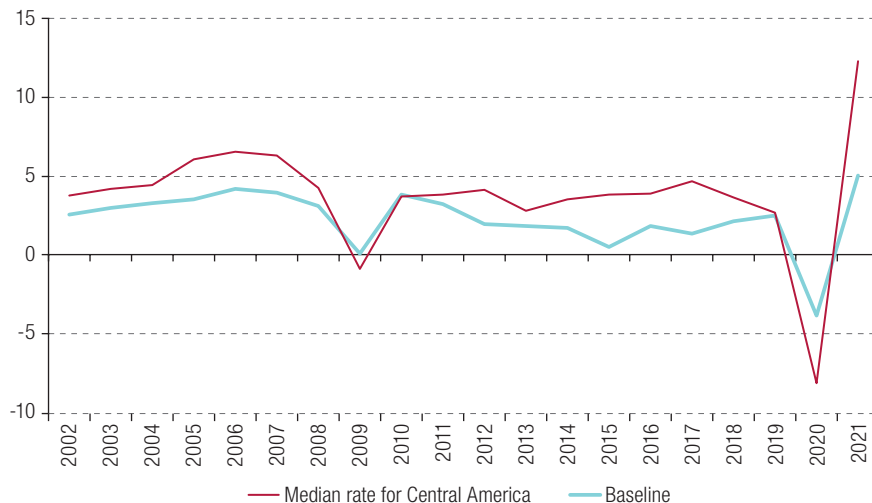
terms of trade in determining Thirlwall's law, nominal exchange rate (NER), short-term cross-border flows and risk premiums, (vii) the high penetration of foreign investors in domestic markets and whose shifts in preferences are often followed by outflows and currency depreciation, and (viii) the concern of central banks in Central America regarding the level of exchange-rate volatility, here indicated by means of a volatility index that, together with the Taylor rule, determines the target level for central bank bond holdings.

The model's dependency graph is provided in annex A3. Despite its dimensions (464 variables, 313 of them endogenous and 151 exogenous), it is possible to grasp the main nodes of our simulation, represented by the nominal exchange rate. Other important nodes include the corporate and sovereign risk premiums, which in turn are also influenced by the nominal exchange rate. As previously discussed, these premiums influence both real and financial variables. In particular, the corporate risk index (CEMBI) affects business confidence and therefore investment and accumulation decisions. Total output, disposable income and decisions regarding consumption (and savings) adjust accordingly. The sovereign risk index (EMBI) directly influences public finance as it raises (lowers) yields, thus increasing (decreasing) the debt burden and its servicing. In turn, the sovereign risk perception and the value of the currency is heightened (diminished), thereby triggering balance-sheet effects on the stock of foreign-denominated debt (both private and public). Conversely, demand from the rest of the world acts as an important (exogenous) transmission channel as it drives up (lowers) both export and remittances inflows, both of which act as a stabilizer (destabilizer) for the currency.

In the case of climate shocks, the channels are different: the damage function responds to global conditions (especially global temperature), but adaptation actions are local. For that reason, changes in the damage function primarily affect local variables (capital stock, labour, consumption, public spending and so on). Shocks or changes in global conditions affect both real variables (components of GDP) and financial variables (debt levels, EMBI, CEMBI and NER).

It should be noted that our model has been calibrated in accordance with our baseline assumptions for GDP growth in the rest of the world, foreign interest rates, terms of trade and — for the extended model with the environmental interactions — the occurrence of extreme weather events. The data used for calibration were drawn from the CEPALSTAT database (2024).²⁰ As shown in figure 2, our simulation captures some of the broad trends in the selected economies, which are exemplified by comparing the trend in median GDP growth for Central America with our model's baseline simulation.

Figure 2
GDP growth: baseline simulation and median rate for Central America, 2002–2021
(Percentages)



Source: Prepared by the authors.

Note: The median rate for Central America includes the Dominican Republic.

²⁰ See [online] <https://statistics.cepal.org/portal/cepalstat/index.html?lang=en>.

VI. Introducing ecological feedbacks in the stock-flow consistent model

Table 10 presents a graphical depiction of the first and second laws of thermodynamics, where the sum of material inputs (resources such as matter and both renewable and non-renewable energy) equals the change in the socioeconomic stock (such as the sum of CO₂ emissions, waste and dissipated energy). The fact that some energy inputs, such as fossil fuels, are dissipated introduces the second law of thermodynamics into the model. Table 10 depicts the evolution of the human-related stock of matter, for material and non-renewable energy reserves, atmospheric CO₂ concentration and the socioeconomic stock. Each year's opening stock of matter is augmented by its net additions, such as emissions (plus the absorption of the biosphere) or the conversion of reserves into resources (net use or extraction of energy and matter) to obtain the final stock. Similarly, the difference between the socioeconomic stock for each year is given by the production of material goods minus their disposal. Conversely, hazardous waste is accumulated over time by non-recyclables. In open economy conditions, the physical stocks and flows for the local economy or region and the rest of the world should be incorporated into the two matrices.

Table 10
Physical flow matrix of the two-area economy (consolidated)

	Worldwide material balance	Worldwide energy balance
Inputs		
Extracted matter	$+ mat_{CA} + mat_{row}$	
Renewable energy		$+ er_{CA} + er_{row}$
Non-renewable energy	$+ cen_{row} + cen_{CA}$	$+ en_{row} + en_{CA}$
Oxygen	$+ o2_{CA} + o2_{row}$	
Outputs		
Industrial CO ₂ emissions	$- (emis_{CA} + emis_{row})$	
Waste	$- (wa_{CA} + wa_{row})$	
Dissipated energy		$- (ed_{CA} + ed_{row})$
Change in socioeconomic stock	$- (\Delta k_{se}^{CA} + \Delta k_{se}^{row})$	
Sum	0	0

Source: Prepared by the authors.

Note: mat_{CA} , mat_{row} = extraction of matter in Central America and in the rest of the world; cen_{row} , cen_{CA} = carbon mass of (non-renewables) in the rest of the world and in Central America. $o2_{CA}$, $o2_{row}$ = mass of oxygen in Central America and in the rest of the world; $emis_{CA}$, $emis_{row}$ = industrial emissions of CO₂ in Central America and in the rest of the world; wa_{CA} , wa_{row} = waste generated by production activities in Central America and in the rest of the world; k_{se}^{CA} , k_{se}^{row} = socioeconomic stock in central America and in the rest of the world; er_{CA} , er_{row} = renewable energy in Central America and in the rest of the world; en_{row} , en_{CA} = non-renewable energy in Central America and in the rest of the world; ed_{CA} , ed_{row} = dissipated energy at the end of the period in Central America and in the rest of the world.

Looking at the behaviour of material resources and reserves, the production of material goods and the extraction of matter in each area depend on their respective activity levels. The recycled socioeconomic stock is a fraction of the discarded socioeconomic stock, which depends on flows of durable goods. The latter evolves according to local demand net of the trade balance. Hence, the accumulation of the socioeconomic stock is given by the production of material goods net of the depletion of the socioeconomic stock. Waste is given by matter extraction minus the change in socioeconomic stock. The conversion of material resources into reserves takes place at an exogenous rate. Finally, the mass of oxygen is given by emissions minus the carbon mass of non-renewable energy, which is also a fraction of the emissions.

The activity level gives the energy requirement for production in each area. Energy is both renewable and non-renewable, and the shares of both types within total energy demand are given exogenously. The evolution of the stock of energy reserves depends on their conversion minus the demand for non-renewables, as their conversion into reserves reduces the stock of energy over time. Industrial emissions are a function of non-renewable demand, while worldwide emissions are augmented by annual CO₂ emissions from land, which grow at an exogenous rate. CO₂ concentrations at the three global layers (atmosphere, biosphere or upper ocean and deep ocean) are interrelated but driven by the atmospheric concentration of CO₂, which depends on their emissions. Finally, the atmospheric temperature adjusts to its previous values corrected by the radiative forcing over pre-industrial levels, as lower ocean temperatures follow.

Energy and material resources feedback into the economic system via two channels: (i) they constrain investment decisions and thus output once the utilization of the matter- and energy-determined capacity surpasses their normal or equilibrium level, where the former is defined as the ratio of output over the matter- or energy-determined potential output; (ii) they affect prices via mark-ups on historical unit costs, which are modelled as a positive function of the utilization of both the matter- and energy-determined capacity.

Following Dafermos, Nikolaidi and Galanis (2017) and Carnevali and others (2021), we postulate a damage function similar to that given by Nordhaus (2018), which describes the impact of the increase in atmospheric temperature overflow variables such as real consumption, labour productivity and private investment (see table 11). All these variables are affected negatively by a rise in temperatures. Although the modelling of environmental variables must include an adaptation component, this method shows the resilience capability of economies to address the impacts of climate change.

Table 11
Damage function

$D = 1 - \frac{1}{1 + \pi_d T + \pi_{d_1} T^2 + \pi_{d_2} T^{3d_3}} \pi_1 ; \pi_2 ; \pi_3 ; \zeta_3 \geq 0$	(1)
$D^k := f_K \cdot Df_K \in (0;1)$	(2)
$D^l = f_l \cdot Df_l \in (0;1)$	(3)

Source: Prepared by the authors.

Note: D = damage function; D^k = damage function impact on the capital stock; D^l = damage function impact on the workforce. The parameters in the denominator are based on Bovari, Giraud and Mc Isaac (2018) relating temperatures to the potential damage inflicted on the economy.

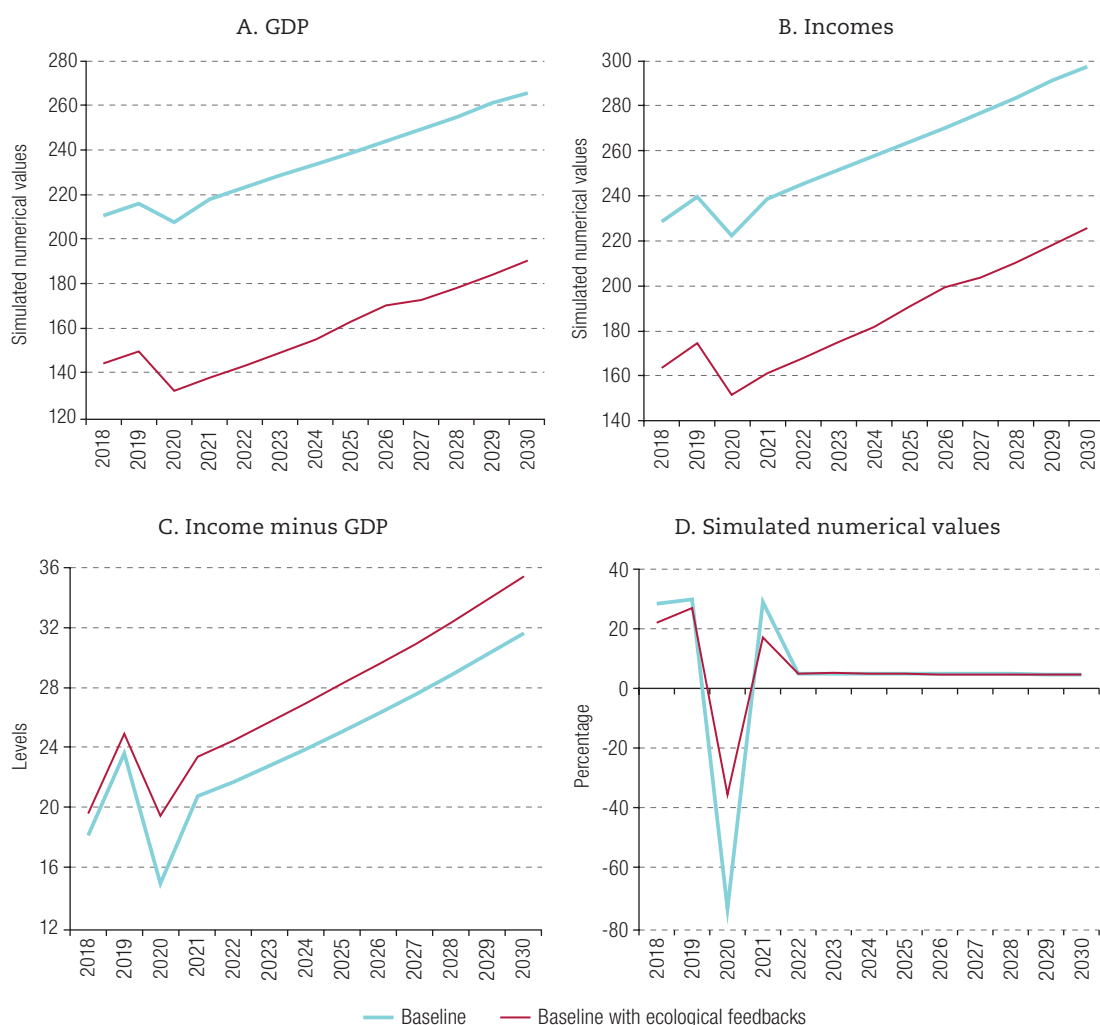
We recognize the limitations and criticisms of this methodology; most particularly, the issues highlighted by Keen and others (2021), who use the literature to highlight some economists' errors with respect to different assumptions, such as the idea that the tipping points would not come before 2100, notwithstanding that the global economy is currently at or above those limits (Lenton and others, 2023). Therefore, the Nordhaus (2018) damage function can underestimate the real effects of climate change in the short run. While we understand that an optimal approach to the relationship between economic and environmental variables would include tipping points, we see this as a reference approach for analysing risks and opportunities that would be modified by the real results.

One important innovation in the present model is the inclusion of a dummy variable that accounts for extreme weather events. The dummy variable takes a value from 1 to 5 according to the intensity of floods, hurricanes and drought. If included, the dummy negatively affects real consumption, business sales confidence and the elasticity of rest-of-the-world demand for government debt denominated in both local and foreign currency. The introduction of the dummy also allows the system to increase short-term government spending following disasters and the risk premiums for both the public and the private sectors.

VII. Model simulations including climate change

In this section, we will compare the performance of the two iterations of our model: i.e. with and without the ecological module. Both versions have been calibrated in accordance with our baseline assumptions for GDP growth for the rest of the world, foreign interest rates, terms of trade and —in the case of the extended model that includes environmental interactions— the occurrence of extreme weather events. As shown in figure 3, both GDP and RGNDI levels are lower in our baseline model with the ecological feedback. Nevertheless, RGNDI in level terms is consistently higher than GDP in the two baselines, as is the case for many Caribbean economies.

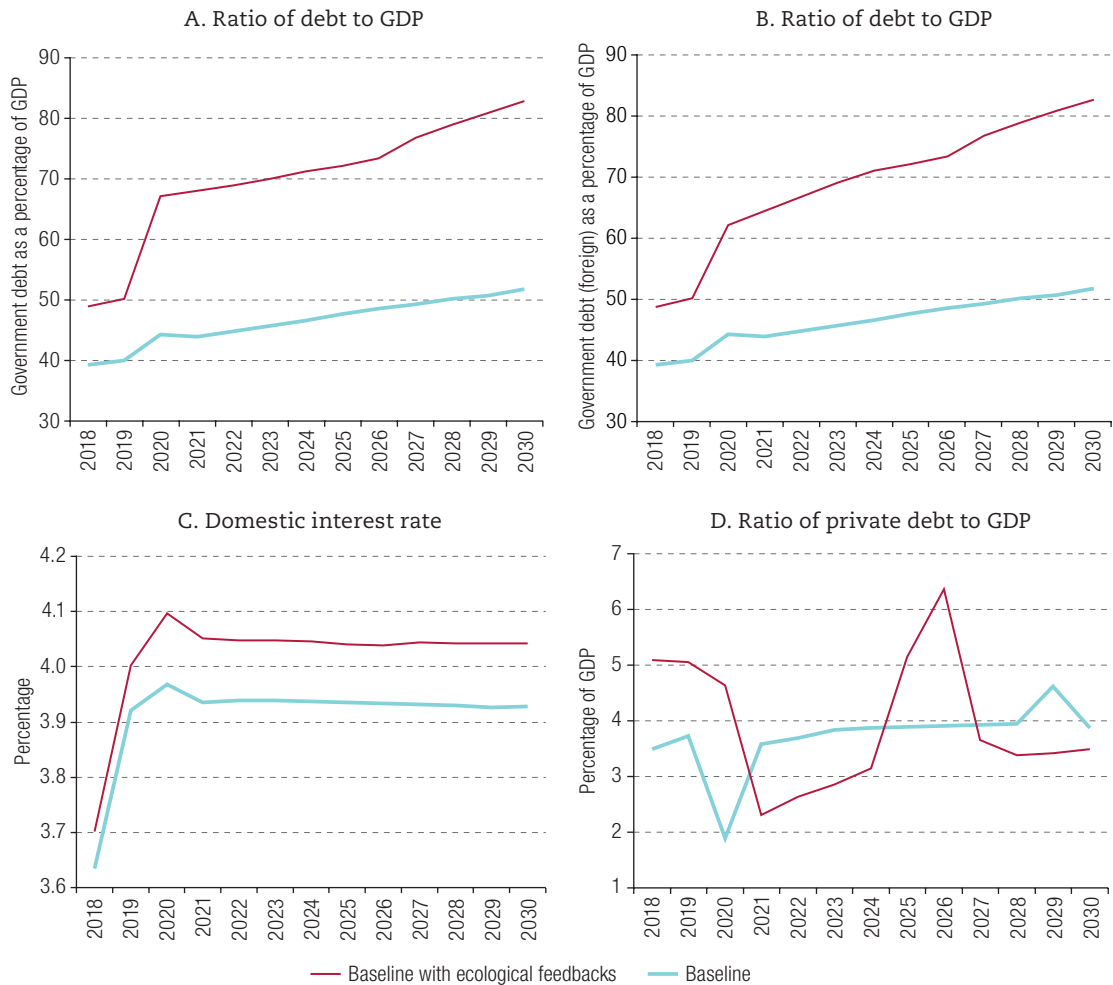
Figure 3
Comparison of GDP and income simulated with baseline model,
with and without climate change, 2018–2030



Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), “Geoportal”, CEPALSTAT [online database] <https://statistics.cepal.org/geo/geo-cepalstat/?lang=es>.

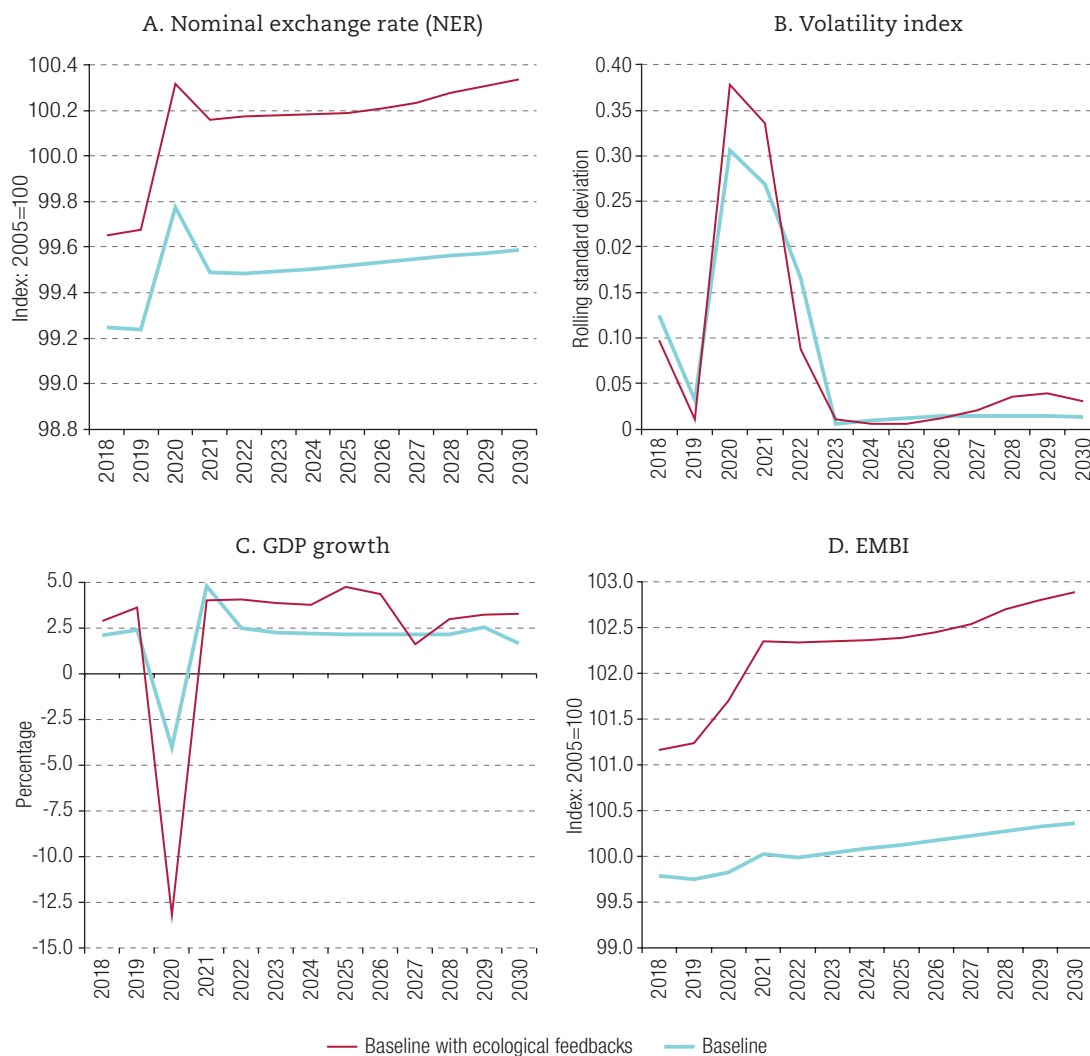
The differential between RGNDI and GDP growth — i.e. the sum of net factor payments from the rest of the world, remittances, donations and terms of trade adjustments— is consistently positive in terms of both levels and average growth. As argued in the previous section, RGNDI tends to be higher than GDP in Caribbean economies owing to remittance inflows. Furthermore, figure 4 captures the trend in debt-to-GDP ratios for both the government and the private sector. In our ecological model, government debt to GDP (both total and foreign denominated) tends to grow over time because of higher government outlays to compensate for the damage caused by climate change and the drop in private spending, especially investment (see figure 5).

Figure 4
Comparison of debt-to-GDP ratios simulated with baseline model, with and without climate change, 2018–2030



Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), “Geoportal”, CEPALSTAT [online database] <https://statistics.cepal.org/geo/geo-cepalstat/?lang=es>.

Figure 5
Comparison of nominal exchange rate, GDP growth, volatility index and EMBI
with baseline model, with and without climate change, 2018–2030

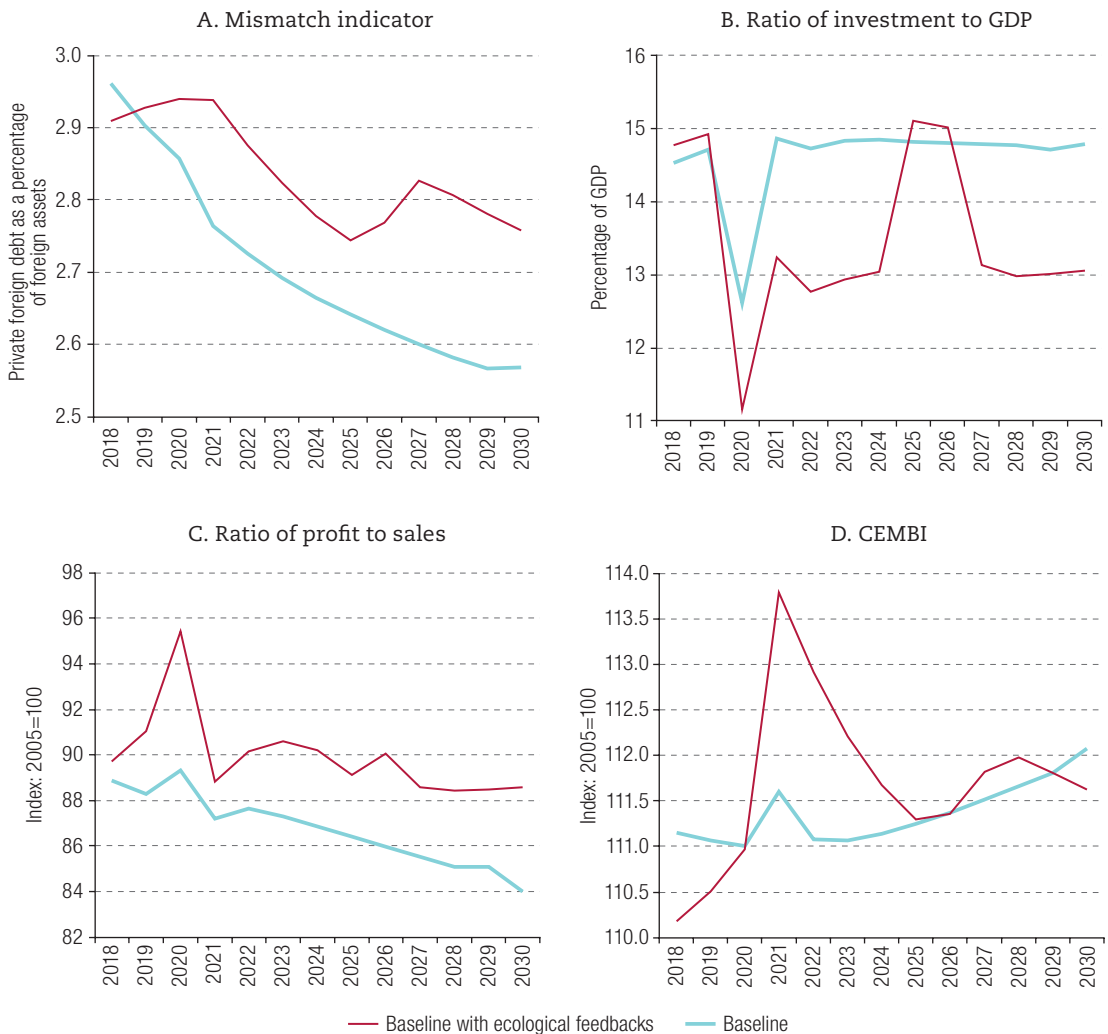


Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), “Geoportal”, CEPALSTAT [online database] <https://statistics.cepal.org/geo/geo-cepalstat/?lang=es>.

Depending on the likelihood of these events, private debt may also spike following the destruction of physical capital and the drop in business confidence. As a consequence, the domestic interest rate tends to be higher. External vulnerability is heightened once climate feedbacks are factored in, as shown in figure 5, where both NER and EMBI tend to rise over time as currency volatility increases. As a result, GDP fluctuations tends to be stronger, despite average GDP growth being higher when government outlays to cope with disasters are taken into account.

The consequences of climate change affect firms intensely, as the ratio of investment to GDP drops sharply, causing corporate premiums to spike and currency mismatches in their portfolios to rise. Both our mismatch indicator and CEMBI tend to decrease afterwards, partly because of lower economic activity and lower revenues (see figure 6). Interestingly, the ratio of profits to sales tends to remain stable in the ecological model, mainly on account of higher cash transfers from the government providing a backstop for the fall in private investment.

Figure 6
Comparison of selected indicators of non-financial corporate sector with baseline model, with and without climate change, 2018–2030



Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), "Geoportal", CEPALSTAT [online database] <https://statistics.cepal.org/geo/geo-cepalstat/?lang=es>.

VIII. Conclusions

This article applies a more general stock-flow consistent model to the economies of Central America in order to reveal and explain the broad macroeconomic trends of Latin America and the Caribbean. Following a recovery in the aftermath of the global financial crisis (2008–2009), regional GDP growth has, since around 2013–2014, tended to decline and to converge on a long-term rate of growth of about 2% (1% in GDP per capita growth).

This regional performance hides important differences from one country to the next. Whereas the region's larger economies did indeed record lower growth rates between 2010 and 2023, some of its smaller economies —including those of Central America— improved their growth performance. Growth differentials can be traced to real factors such as the evolution of labour productivity and the production structure.

The latter factor is incorporated into our model by distinguishing between GDP and RGNDI. In the case of Central America, the use of RGNDI captures the effects of remittances on the economy whereas GDP does not. The use of GDP can overstate the volatility of the business cycle, economic vulnerability and the degree to which economies are constrained in their policy space. The productive structure is tied to the pattern of international insertion. The business cycle of Central American economies generally correlates with that of the United States.

An explanation of the performance of Latin American and Caribbean economies since the end of the global financial crisis would not be complete without including the relationship between real and financial factors. We capture those linkages through several causal relationships including the relation between remittances and the nominal exchange rates, the EMBI and the CEMBI, leverage and investment.

The importance to these economies of factors related to climate change led to the inclusion of an ecological module in the model. Because of its cross-cutting effects across different sectors and agents, we believe that climate change related effects can only be captured through a model for an economy in the aggregate.

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Annex A1

Table A1.1

Review of selected literature on stock-flow modelling in Latin America and the Caribbean

Author	Region/country	Model type	External sector	Conclusions
Barbosa (2001)	Brazil	Growth	Thirlwall's law with liquidity constraint	Small open economies tend to adjust their current account, especially their trade balance, to the availability of external finance.
Bortz (2014)	Argentina	Growth	Two economies	The results point towards the dismissal of the "twin deficit" view, and support an active management of the exchange rate, in light of contradictory effects of fixed and flexible exchange rate regimes, according to the circumstances.
Campero Encinas (2019)	Bolivia (Plurinational State of)	Growth	...	External hydrocarbon and mineral shocks have a low impact on the economy because of the industrialization of those sectors.
Cano Ortiz (2015)	Colombia	Growth	Rest of the world linked with elasticities	A fiscal rule over the government's structural deficit reduces the effect of external shocks on fiscal balances but amplifies the effect of demand shocks.
Do Nascimento and Silva (2016)	Brazil	Growth	...	The results obtained indicate that they depend both on the neo-Kaleckian investment functions and on the simplifying assumptions that, <i>a priori</i> , create nirvanic financial conditions for the rentier class.
Escobar (2016)	Colombia	Growth	Rest of the world linked with elasticities	A twin deficit is observed between the private and external sectors. There is no evidence that improvements in the United States economy will improve the Colombian economy's export figures.
Fernández (2017)	Ecuador	Static	Rest of the world with the same currency	The observed effects of fiscal policy are as expected, but reduced public spending has more impact on aggregate demand.
Guevara Castañeda (2015)	Colombia	Static	...	Rising interest rates produce a redistribution of income from low-income households to the households with the highest incomes.
Kappes and Milan (2017)	Brazil	Static	...	The <i>a priori</i> more expansionist (or less contractionist) rules present higher growth rates, <i>ex post</i> ; there is an inverse relationship between government debt and firms' debt, with the former being higher under the first rule, and lower in the balanced budget rule, the opposite happening in the case of firms' debt.
Mazzi (2013)	Brazil	Growth	Thirlwall's law with capital flows	The impact of capital inflow on the economy is dependent on the kind of capital.
Mellini (2018)	Brazil	Growth	Twin deficits	Corroborated the hypothesis of twin deficits is and refuted the possibility of negative consequences through an increase in fiscal stance.
Michelena and Guaita (2017)	Argentina	Growth	Thirlwall's law	Increased public spending has positive effects on economic growth, but those increases are restrained by external constraints.
Pérez Caldentey (2009)	Caribbean Community (CARICOM)	Growth	Thirlwall's law	The model highlights the binding character of the external constraint and argues that government expenditures do not necessarily result in low growth or high debt levels. The outcome depends on the interaction between government, external, and the private sector, an interaction that is the basis for stock-flow modelling.
Telechea (2018)	Latin America	Growth	Twin deficits	The outcomes confirm the twin deficit hypothesis, with causality from the external balance to the fiscal balance.
Valdecantos (2016)	Latin America	Static	Thirlwall's law	The impact of different kinds of external shock on Latin American economies is dependent on their type of productive structure.

Source: Prepared by the authors, on the basis of the references cited.

Annex A2

Environmental physical matrix

Table A2.1
Physical stock-flow matrix of two-area economy (consolidated)

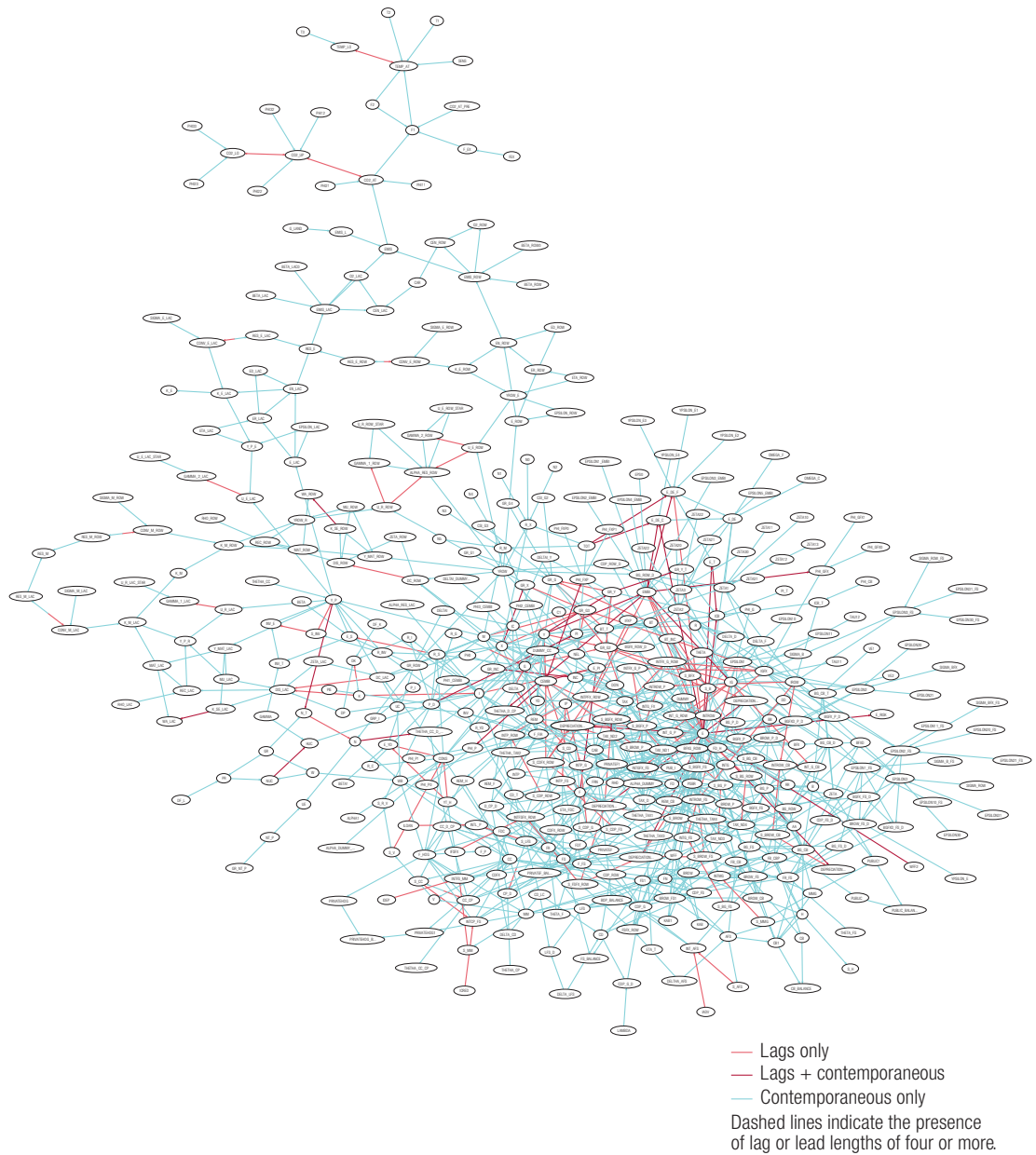
	Global material reserves	Global non-renewable energy reserves	Global atmospheric CO ₂ concentration	Global socioeconomic stock
Initial stock	$+k_{CA,(-1)}^m + k_{row,(-1)}^m$	$+k_{CA,(-1)}^e + k_{row,(-1)}^e$	$+co2_{at,(-1)}$	$+k_{se,(-1)}^{CA} + k_{se,(-1)}^{row}$
Resources converted into reserves	$+conv_{CA}^m + conv_{row}^m$	$+conv_{CA}^e + conv_{row}^e$		
CO ₂ emissions (global)			$emis_{CA} + emis_l + emis_{row}$	
Production of material goods				$+y_{CA}^{mat} + y_{row}^{mat}$
Extraction/use of matter/energy	$-(mat_{CA} + mat_{row})$	$-(en_{row} + en_{CA})$		
Net transfer to oceans/biosphere			$(phi_{11} - 1)*co2_{at(-1)} + phi_{21}*co2_{up(-1)}$	
Destruction of socioeconomic stock				$-(dis_{CA} + dis_{row})$
Final stock	$+k_{CA}^m + k_{row}^m$	$+k_{CA}^e + k_{row}^e$	$+co2_{at}$	$+k_{se}^G + k_{se}^B$

Source: Prepared by the authors.

Note: $k_{CA,(-1)}^m, k_{row,(-1)}^m$ = stock of material reserves in Central America and in the rest of the world; $conv_{CA}^m, conv_{row}^m$ = material resources converted to reserves in Central America and in the rest of the world; mat_{CA}, mat_{row} = extraction of matter in Central America and in the rest of the world; k_{CA}^m, k_{row}^m = stock of material reserves in Central America and in the rest of the world; $k_{CA,(-1)}^e, k_{row,(-1)}^e$ = stock of energy reserves in Central America and the rest of the world; $conv_{CA}^e, conv_{row}^e$ = energy resources converted to reserves in Central America and in the rest of the world; en_{row}, en_{CA} = non-renewable energy in the rest of the world and in Central America; k_{CA}^e, k_{row}^e = stock of energy reserves in Central America and in the rest of the world; $co2_{at(-1)}, co2_{up(-1)}$ = atmospheric CO₂ concentration; $emis_{CA}, emis_l, emis_{row}$ = industrial emissions in Central America, annual emissions of CO₂ from land, and industrial emissions from the rest of the world; $co2_{at(-1)}, +co2_{up(-1)}$ = atmospheric CO₂ concentration and upper ocean or biosphere CO₂ concentration; $k_{se,(-1)}^{CA}, k_{se,(-1)}^{row}$ = socioeconomic stock in Central America and in the rest of the world; $y_{CA}^{mat} + y_{row}^{mat}$ = production of material goods in Central America and in the rest of the world; dis_{CA}, dis_{row} = discarded socioeconomic stock in Central America and in the rest of the world; k_{se}^G, k_{se}^B = global socioeconomic stock at the end of the period (year) for Central America and the rest of the world.

Annex A3

Diagram A3.1
Dependency graph



Source: Prepared by the authors.

Progressivity and redistributive power of income tax on wage earners in El Salvador: a microsimulation analysis¹

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Abstract

This work analyses the effects of wage earners' income tax on vertical equity and income distribution in El Salvador, by assessing the two most recent changes in income tax —the 2011 reform and the 2015 amendment— in light of a comparative methodology based on indices of tax progressivity and redistributive power. The impact of these measures is estimated using microsimulation techniques. The results show that the tax structure in 2017 is weakly progressive and has no impact on income distribution in El Salvador. On the contrary, the differential treatment that the tax system affords to high incomes undermines any possible effect of the income tax on vertical equity and income distribution.

Keywords

Taxation, income tax, fiscal policy, income distribution, equality, measurement, mathematical models, El Salvador

JEL classification

H22, H23, H24, D31

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I. Introduction

The analysis of the implications of tax policy and its effects on income distribution has been a recurring theme in economic literature (Cetrángolo and Gómez Sabaini, 2007; Mahon, 2012). Contrary to the neoclassical theory on the distorting effects of taxes (Bird and Zolt, 2005; Bird, 2003), authors such as Cornia, Gómez Sabaini and Martorano (2011), Alesina and Rodrik (1994) and Aghion, Caroli and García-Peñalosa (1999) have shown that equitable income distribution has positive impacts on economic growth, especially in developing countries.

Countries like El Salvador, whose prevailing economic conditions are fiscal instability, high rates of public debt and sustained fiscal deficit, combined with low rates of economic growth, need tax reforms to promote equality and drive development objectives (Agosin and others, 2005; Moreno, 2004).

This research analyses and evaluates the ways in which wage earners' income tax affects tax equity and income distribution, considering the tax reform of 2011 and the amendment of 2015. Although income tax on natural persons in El Salvador is levied on both wage earners and non-wage-earners, this research is focused exclusively on the income tax of wage employees, because its association with families' formal disposable income means that its payment can be tracked through gross monthly wage in the Multipurpose Household Survey (EHPM), which is not the case for the non-waged.

The study is organized into five sections after this introduction. Section II reviews the theoretical potential of income tax to improve progressivity and income distribution, and section III explains the configuration of the tax according to the normative framework adopted in 1991, its main reforms and the efforts to modify its progressive brackets. This is followed by the methodology set forth in section IV, and section V, which presents a comparative empirical analysis evaluating the amendments to income tax and its effects on progressivity and income distribution in El Salvador. This is the main contribution of this research, given the prior absence of specific studies of this type on tax matters in the country. Lastly, section VI concludes.

II. Background

Analysis of tax progressivity stems from the concept of tax equity. Although equity is a term that can be interpreted in a multidimensional manner (Jiménez, Gómez Sabaini and Podestá, 2010), in taxation theory it concerns the actions taken by the public sector to ensure equal and fair treatment for citizens.

The principle of tax equity is rooted in two basic criteria that determine the application and distribution of taxes: the benefit criterion, which refers to the need to set taxes based on the benefits that individuals obtain from public powers, and the ability-to-pay criterion, which concerns the economic capacity of individuals to distribute tax burdens (Musgrave and Musgrave, 1989).

As Yáñez (1992) and Sevilla (2004) show, benefit-based taxation is ineffective and limited, given the complexity of defining the benefits that each individual citizen in particular receives from public spending. This principle also excludes the possibility of the public sector pursuing redistributive and stabilizing policies, since it disregards distributive criteria and the power of segmentation by the conditions of the individual.² These are captured by ability-to-pay taxation, which sets tax according to the taxpayer's income level. The tax system will be vertically equitable —and therefore progressive— if it levies more on higher incomes; otherwise, it will be regressive (Jorratt, 2011; Musgrave and Thin, 1948).

² This criterion proposes a solution analogous to that offered by the market as an instrument for resource allocation, which implies setting a market price based on the marginal utility of public goods to determine the distribution of the tax burden.

For Martín Seco (2010) and Arenas de Mesa (2016), vertical equity is increasingly important in terms of potential distributional effects. In this sense, ability-to-pay taxation can influence income distribution in the following ways: through the primary distribution of income (determined by market forces) via the capture of tax revenues that finance public policies aimed, for example, at increasing and strengthening human capital and improving health, education and infrastructure services; and through secondary distribution (determined by the application of fiscal policy) through a progressive tax system (Cetrángolo and Gómez Sabaini, 2007; Jiménez, Gómez Sabaini and Podestá, 2010). The evidence presented by Jorratt (2011), Gómez Sabaini and Morán (2016), Musgrave and Musgrave (1989) and Bittker (1979) shows that the redistributive characteristic of taxation is satisfied by a scheme that uses progressive taxation of income higher-income families, i.e. fulfilment of vertical equity.

Jiménez, Gómez Sabaini and Podesta (2010) and Morley (2000) argue that taxation should improve the income structure in countries that have considerable income concentration. Kaldor (1963), Lambert (2004), Gómez Sabaini (2005), Ahmed and O'Donoghue (2009) and the Economic Commission for Latin America and the Caribbean (ECLAC, 2018) concur that direct taxation —specifically, tax on personal income— has the greatest power to improve income inequality, since the application of progressive marginal rates by income levels will impact secondary income distribution. Accordingly, progressive income tax with sufficient redistributive power is needed to attack these disparities.

However, the theoretical potential of income tax depends on the use of differential treatment in its payment. Newbery and Stern (1987), Sicat and Virmani (1988), Alm, Bahl and Murray (1991), Arellano and Corbo (2013) and Bastagli, Coady and Gupta (2012) note that special regimes, exemptions, deductions, reduced brackets and differential treatment of income by source (wages, salaries, dividends, interest, capital gains, profits or others) all undermine the progressivity of the tax and its power to redistribute income.

According to Valle (2001), modern literature has reinforced tax equity within the principle of generality³ and, although moderate income tax progressivity is currently accepted, it tends to be based on exemption threshold setting rather than significant variations in marginal tax rates. This is due to the abiding concern over the supposed distorting effects of progressivity on basic economic decisions.

Accordingly, Stiglitz (2003) and Caballero and López (2012) see the concentrated income distribution pattern typical of developing countries as being associated with the supremacy of consumption taxes, and they advocate progressive tax reform based on income tax.

III. Income tax on wage earners in El Salvador

The income tax law that underpins the Salvadoran tax system was adopted on 21 December 1991 by virtue of Decree No. 134. It considers taxpayers to be natural persons (i.e. individuals) who obtain from their work income that includes wages, salaries, fees, commissions and all types of remuneration or compensation for personal services, counted from 1 January to 31 December each year.

The tax structure has an exempt bracket and marginal rates from 10% to 30%, plus a fixed payment. The payment is calculated using only income from work activity⁴ after deductions for expenditures on medical and hospital services, educational expenses, and donations, among others. Those whose income is below a certain threshold are also exempt (see table 1).⁵ Income from abroad is also exempt, as the principle of territoriality is taken as a fundamental criterion for income tax liability.

³ With equity focused on eliminating evasion and avoidance.

⁴ The Central American Institute for Fiscal Studies (ICEFI, 2012 and 2016) classifies this as a granular tax since it taxes the different types or categories of a single taxpayer's income separately (from wage work, interest on deposits, dividends on shares, etc.), which implies forgoing a part of the tax base that is of particular importance for higher-income individuals.

⁵ For 2016, only income over US\$ 9,100 stemming exclusively from work is taxed. This is equivalent to 2.4 times per capita GDP in El Salvador; a figure that is 2.5 in Honduras and 0.8 in Panama.

Table 1
El Salvador: income tax exemptions and deductions for wage earners

Income taxed
Salaries, wages, fees, commissions and all types of remuneration for personal services From this is deducted: payment into the Pension Fund Administrator (AFP) + payment to the Salvadoran Social Security Institute (ISSS), the Salvadoran Institute for Teacher Welfare or the Social Security Institute of the Armed Forces (IPSA)
Funds not constituting income
Amounts received as expenses for transportation, food and accommodation
Legacies or inheritances
Donations
Income not taxed
Remuneration, compensation and representation expenses of the diplomatic corps, consular agents and foreign officials residing in the country
Compensation for death, disability, accident or illness
Retirement pension, other pensions, widows' or orphans' benefit
Remuneration, compensation and representation expenses of Salvadorans in the foreign service
Interest, premiums and other returns flowing directly from deposits in financial institutions (up to US\$ 25,000)
Insurance contracts
Interest on loans extended abroad
Lottery winnings
Awards granted by the Legislative Assembly of El Salvador or extended to public servants for important services to the country
Deductions
Hospital services
Tuition or schooling payments
Employer contribution paid to ISSS for domestic work
Dues or contributions paid to unions, associations and professional groupings
Maximum legally allowed donation

Source: C. Galdámez, "Efectos de las reformas al impuesto sobre la renta de asalariados de 2011 y 2015 sobre la equidad tributaria, capacidad recaudatoria y distribución del ingreso en El Salvador", master's thesis in economics, National Autonomous University of Mexico (UNAM), 2017.

This structure has undergone few changes since its implementation in 1991, although the law establishes a periodic review of withholding tables by the executive body of the Treasury. The reform of 2011 made changes to marginal tax rates: by virtue of Decree No. 216 of the Ministry of Finance, the reform modified the taxable income brackets, setting a top rate of 30% and eliminating the progressive cut-off for effective tax burdens over 25%. It also expanded the exempt bracket to US\$ 487.60 per month and raised the fixed payment for each bracket,⁶ and increased the deductions allowed for expenses on hospital services and education by up to US\$ 1,600 annually.

In 2015, Decree No. 95 brought new changes to the income tax withholding tables for wage earners, with the introduction of a new deduction from taxable wage income: payment to the Salvadoran Social Security Institute (ISSS), whose upper limit was also changed.⁷

The empirical evidence presented by Barreix, Bès and Roca (2009) shows that wage earners' income tax in El Salvador has limited power to improve progressivity and income redistribution. These authors find that, in 2006, the tax did not substantially alter the income distribution of the richest 10%, whose share of total income went from 30.7% to 30.1%. Likewise, the work of Beneke, Lustig and Oliva (2015) confirms that, although the battery of direct taxes is afforded progressivity by personal income tax, together with direct transfers it reduces inequality by barely 1 percentage point, as measured by the Gini index for 2011.

⁶ Since 1990, additional fixed payments had gone from US\$ 4.76 to US\$ 288.57, but in 2012 the range was changed to US\$ 17.48 to US\$ 288.57.

⁷ The upper limit of payment to ISSS rose from US\$ 685.71 to US\$ 1,000, with no change to the percentage paid by wage earners, or 3% of wage income. Thus, maximum amount payable to social security is US\$ 30 and not US\$ 20.57 per month.

The authors, like Jorratt (2011) in the analysis of other countries in Central America, associate this result with the high non-taxable threshold of labour income and the exemption of capital income —interest, dividends and capital gains—, as well as the difficulties encountered by tax administrations in enforcing the tax.

These findings are corroborated by ECLAC/Oxfam, Jiménez (2015), Hanni, Martner and Podestá (2015) and Pérez Trejo (2014) for different years. They conclude that, in relative terms, the effective tax rate of the tenth decile was no higher than 5% in 2011 and 2012, which is low compared to the rates in Argentina and Mexico, which exceeded 8% in both years. Likewise, income tax was considered a weak instrument of redistribution, since in 2011–2012 it improved total income concentration by only around 2.5%. Meanwhile, countries such as Mexico or Uruguay report post-income-tax improvements in the Gini index of close to 6% and 4%, respectively.

Menkos (2013) analysed the effects of the 2011 income tax reform on tax equity and income distribution using the household income deciles in El Salvador's Multipurpose Household Survey. He argues that the reform of wage earners' income tax was progressive, insofar as the amount collected from the tenth decile represents 80% of all revenues from income tax. However, the changes in marginal rates compared to 2010 did not produce any drastic shift in income redistribution. On the contrary, income distribution became more unequal owing to the effects of the predominant tax, the value added tax (VAT), which is highly regressive.

IV. Methodology

According to Arenas de Mesa (2016), the changes made to income tax in 2011 and 2015 may be classified as tax reform and amendment, respectively. The changes made to the taxable income brackets, marginal rates and fixed rates in 2011 amounted to a tax reform, because they changed its structure. Meanwhile, the changes of 2015 amount to a tax amendment, with a parametric adjustment that did not affect the tax structure or create a new tax system.

Thus, in order to determine the impact of the 2011 income tax reform and the amendment adopted in 2015 on tax equity and income distribution in El Salvador, a comparative analysis was carried out to estimate the economic impact of the tax, before and after its application. The measure of well-being used is family or household income ordered by deciles, similarly to the analysis by Lustig and others (2013) and Barreix, Roca and Villela (2006).

Owing to the limited availability of disaggregated tax data, the analysis uses the wage and family income reported for 2017 in the Multipurpose Household Survey published by the Directorate General of Statistics and Censuses (DIGESTYC) of the Ministry of Economic Affairs of El Salvador. Salvia and Donza (1999), Villatoro (2015), Amarante (2013) and Jorratt (2011) argue that income and expenditure surveys suffer from limitations in this regard and that their scope is not equivalent to the real income tax base, owing to non-response bias (partial or total), underreporting of income and undercapturing of earners, especially among higher-income individuals. These surveys may also include measurement errors, bias or cognitive failures, on the part of both interviewees and interviewers. As Jiménez (2015) mentions, the sample design of the Multipurpose Household Survey produces a difference between the real income tax base and the estimated information from the survey, given the aforementioned limitations. For this reason, this research uses the percentage structure —of wage, family income or tax payments— reported by the survey, and does not involve nominal data.⁸

⁸ Total data presented in monetary terms corresponds to information published by the Ministry of Finance of El Salvador.

To calculate the income tax paid by individuals, the Multipurpose Household Survey variable used was monthly income from dependent work, which captures the monthly amounts that people receive as salaries or wages. This variable is used as a proxy for individuals' gross income, so that the net income on which income tax withholding rates will be applied can be calculated directly.⁹

With a view to assessing the situation before and after the 2011 reform, a pension fund contribution of 6.25% is deducted from gross income. To assess the 2015 amendment, meanwhile, the deduction is the percentage of the payment into the pension system, which in 2017 rose to 7.25%, added to the 3% deduction for the ISSS contribution. Next, the marginal rates and fixed payments per net income bracket are applied. The well-being indicator is the monthly family income variable in the Multipurpose Household Survey, which is used only to sort the results by decile, as a proxy for the purchasing power of the Salvadoran population.¹⁰

The Multipurpose Household Survey uses a cross-sectional sample; accordingly, its socioeconomic and demographic characteristics are constant. The estimates made to evaluate the income tax changes of 2011 and 2015 are based on the data from the 2017 survey, first because individual response behaviours are not taken into account and, mainly, to avoid any methodological disparity that may arise when using two surveys from different years (Barreix, Bès and Roca, 2009).

As Jorratt (2011) argues, this methodology is theoretical in nature, since it is not necessarily related to the tax that each person actually pays. In the absence of official data, however, it is a viable methodology aside from tax evasion or avoidance. Klevmarken (2008) and Absalón and Urzúa (2012) classify the model as a static microsimulation with specific coverage. On the one hand, it isolates the independent impact of variations in a single type of tax, and, on the other, it identifies the immediate impact of tax reforms, without touching on changes in individual behaviour; this may be termed “first-order change outcomes”.

In relation to the indicators, the concentration approach —the analysis of which is based on Lorenz curves and Gini indices— is used to measure the income tax vertical equity and redistributive capacity in El Salvador. According to Kakwani (1977), the Lorenz curve relates the cumulative proportion of income units to the cumulative proportion of income received once the units have been sorted in descending or ascending order (percentiles, quartiles, quintiles or deciles). From this may be obtained the measure created by Corrado Gini in 1912 (the Gini index), which shows the population's income distribution through the average differences between population groups. For discrete analysis, the Gini index may be defined as:

$$C_x = \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |x_i - x_j|}{2N^2 \mu} \right] \quad (1)$$

Where x_i is the income of unit i , x_j is the income of unit j , N is the number of units and μ is the average income distribution. The index takes values of between 0 and 1, which represent, respectively, maximum equality and maximum inequality (Sen, 1997).

Analogously to the Gini index, and with a view to calculating the degree of concentration of the tax burden in the population, the concentration index (IC_t) also known as the quasi-Gini coefficient, may be calculated from the curve of tax concentration, given by:

$$C_t = \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)|}{2N^2 \mu t} \right]; \quad 0 \leq t \leq 1 \quad (2)$$

⁹ See annex A1 for details of the income tax withholding tables.

¹⁰ The monthly family income variable includes all personal income from dependent or independent work, secondary employment, agricultural activities or other work activities, as well as other income, such as remittances, pensions and retirements, rents, interest and profits.

Where $t(x_{i,j})$ represents the tax burden on taxpayers i, j , while t is the average effective rate of the tax burden, which is given by:

$$t = \frac{\sum_{i=1}^n \sum_{j=1}^n t(x_{i,j})}{\sum_{i=1}^n \sum_{j=1}^n x_{i,j}} \quad (3)$$

As Medina (2001) mentions, this index weights the distances between the tax burdens of taxpayers, such that positive values indicate that the tax structure is progressive. That is, as the income scale rises, the absolute amount of tax payment increases and, as the income scale falls, the opposite occurs. The greater the IC_t index, the more concentrated the tax burden on higher-income individuals.

On this basis, the after-tax income concentration index (C_{x-t}) may be inferred as a measure to determine the effect of the tax burden on income distribution after tax, the aim being to draw comparisons with the pre-tax Gini index, which is given by:

$$C_{x-t} = \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |(x_i - t(x_i)) - (x_j - t(x_j))|}{2N^2 \mu (1-t)} \right] \quad (4)$$

This index weights the distances between income and the tax burden for each taxpayer (i, j). Thus, again, the larger the C_{x-t} index, the more concentrated the after-tax income, showing the distributional effects of tax application.

1. Measuring the vertical equity of tax reforms and amendments

The indicator most commonly used to measure taxation vertical equity is the Kakwani index (1977), which measures the progressivity (regressivity) of taxes based on the differences between the tax concentration index and the Gini index, or by the area between the after-tax income concentration curve and the Lorenz curve. The Kakwani index for discrete analysis is given by:

$$K = C_t - C_x = \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)|}{2N^2 \mu t} \right] - \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |x_i - x_j|}{2N^2 \mu} \right] \quad (5)$$

A tax burden proportional to income would yield an index equal to 0; a positive Kakwani index indicates a progressive tax burden, while an index below 0 indicates a regressive tax.

As discussed in Díaz de Sarralde, Garcimartín and Ruiz-Huerta (2010), the concentration approach is commonly used to identify and evaluate the effects of tax reforms or amendments on vertical equity. However, this approach considers only the pre-tax situation and the distribution of the reform's tax brackets across the population, not the changes in actual collection. Therefore, the indicators speak to the design of the reform (variations in proportions) and not its actual impact (changes in the level of revenue and effect of the tax rate).

Following Kakwani (1977), the possible effects of tax reform on vertical equity will be reflected as follows:

$$K = \frac{(1-t)}{t} (C_x - C_{x-t}) \quad (6)$$

Substituting from formula (4) into formula (6) gives:

$$K = \frac{(1-t)}{t} C_x \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |(x_i - t(x_i)) - (x_j - t(x_j))|}{2N^2 \mu (1-t)} \right] \quad (7)$$

Thus, vertical equity will be affected by the tax level or rate (which implies changes in total collection and revenue), by distributional shifts due to changes in after-tax income level and by the pre-reform income distribution structure. The methodology must therefore show these effects and capture them comprehensively. The aim is to avoid errors of interpretation, or even contradictions, if the source of the tax system's progressivity or regressivity is not accurately identified.

To demonstrate the inseparability of these factors, the methodology of Díaz de Sarralde, Garcimartín and Ruiz-Huerta (2010) was used. This considers changes in collection produced by a tax reform, explicitly identifying the effects of "tax level" and "distances between tax rates" on vertical equity. The aim is to show the absolute change in the Kakwani index, differentiating its magnitude before (K) and after (K^*) the reform. The reform is expected to add progressivity to the tax structure if $K^* > K$; otherwise, ($K > K^*$), the reform's effect is regressive, or if $K = K^*$ is true, the change is neutral. Thus:

$$K^* - K = (C_t^* - C_x^*) - (C_t - C_x) \quad (8)$$

Assuming that the Gini index (pre-tax) is the same before and after both reforms (which is true in this simulation study, since the same 2017 income structure is used to evaluate different reforms):

$$C_x^* = C_x \quad (9)$$

Therefore, formula (8) may be defined as:

$$K^* - K = C_t^* - C_t \quad (10)$$

Which may also be expressed as:

$$K^* - K = \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t^*(x_i) - t^*(x_j)|}{2N^2 \mu t^*} \right] - \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)|}{2N^2 \mu t} \right] \quad (11)$$

Applying the additive inverse of factor $\left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)|}{2N^2 \mu t^*} \right]$:

$$\begin{aligned} K^* - K &= \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t^*(x_i) - t^*(x_j)|}{2N^2 \mu t^*} \right] - \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)|}{2N^2 \mu t} \right] \\ &+ \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)|}{2N^2 \mu t^*} \right] - \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)|}{2N^2 \mu t^*} \right] \end{aligned} \quad (12)$$

Simplifying formula (12) gives:

$$\begin{aligned} K^* - K &= \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)|}{2N^2 \mu t} \right] \left(\frac{t}{t^*} - 1 \right) \\ &+ \frac{\left[\sum_{i=1}^n \sum_{j=1}^n |t^*(x_i) - t^*(x_j)| \right] - \left[\sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)| \right]}{2N^2 \mu t^*} \end{aligned} \quad (13)$$

If θ is defined as the rate of growth of the average tax rate:

$$\theta = \frac{t^*}{t} - 1 \quad (14)$$

and D and D^* are defined as the sum of the distances between the tax rate before and after the reform, respectively:

$$D = \sum_{i=1}^n \sum_{j=1}^n |t(x_i) - t(x_j)| \quad (15)$$

$$D^* = \sum_{i=1}^n \sum_{j=1}^n |t^*(x_i) - t^*(x_j)| \quad (16)$$

Therefore, formula (10) may be expressed as:

$$K^* - K = C_t \left(\frac{1}{1 + \theta} - 1 \right) + \frac{D^* - D}{2N^2 \mu t^*} \quad (17)$$

The variation of the Kakwani index will be the sum of two effects. On the one hand, the “level” effect represented by:

$$EN = C_t \left(\frac{1}{1 + \theta} - 1 \right) \quad \begin{array}{l} \text{If } \Delta t \text{ " } \theta > 0 \text{ " } EN < 0 \\ \text{If } -\Delta t \text{ " } -1 < \theta < 0 \text{ " } EN > 0 \\ \text{If } \theta = 0 \text{ " } EN = 0 \end{array} \quad (18)$$

Where Δt represents an increase in the tax rate, while $-\Delta t$ represents a fall in the rate.

Formula (18) reflects the effect on vertical equity given by changes in the average effective tax rate after the reform, maintaining constant distribution of the tax burden on the population, where the average effective rate may take values between 0 and 1.

And the “distance” effect is represented by:

$$ED = \frac{D^* - D}{2N^2 \mu t^*} \quad \begin{array}{l} \text{If } D > D^* \text{ " } ED < 0 \\ \text{If } D < D^* \text{ " } ED > 0 \\ \text{If } D = D^* \text{ " } ED = 0 \end{array} \quad (19)$$

This formula shows the effects on tax progressivity (regressivity) from a normative point of view, since it compares two tax structures and the deviation they generate, keeping the level of collection given by the average effective rate constant; this effect may also take positive or negative values. Therefore, the changes in overall vertical equity given by formula (8) can take positive signs, where progressivity is added, or negative signs, where regressivity is added.

As a function of the variation of the Kakwani index, the effect of the reform on tax equity may be identified based on the “distance-level” progressivity index I_K defined by:

$$I_K = \frac{\Delta K}{|\Delta K|} \left(1 + \frac{ED}{|EN| + |ED|} \right) \quad (20)$$

Where:

$$\frac{\Delta K}{|\Delta K|} = \pm 1$$

$$0 \leq \left(1 + \frac{ED}{|EN| + |ED|} \right) \leq 2$$

Thus, the classification of the reform based on indices I_K will be:

- Strongly progressive reform: if there is a positive change in the Kakwani index (ΔK) and the “distance” effect is positive ($ED > 0$), the “distance-level” progressivity index will be in the range $1 < I_K \leq 2$.
- Weakly progressive reform: if there is a positive change in the Kakwani index (ΔK), but the “distance” effect is negative ($ED < 0$), the “distance-level” progressivity index will be in the range $0 < I_K \leq 1$.
- Weakly regressive reform: if there is a negative change in the Kakwani index ($-\Delta K$), but the “distance” effect is positive ($ED > 0$), the “distance-level” progressivity index will be in the range $-2 \leq I_K < -1$.
- Strongly regressive reform: if there is a negative change in the Kakwani index ($-\Delta K$) and the “distance” effect is also negative ($ED < 0$), the “distance-level” progressivity index will be in the range $-1 \leq I_K \leq 0$.

2. Measuring the redistributive capacity of tax reforms and amendments

The redistributive power of taxation on income distribution is measured by the Reynolds and Smolensky index (1977), which measures the change in income inequality (in terms of Gini points) as a result of tax application. The index is given by:

$$RS = C_x - C_{x-t} = \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |x_i - x_j|}{2N^2 \mu} \right] - \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |(x_i - t(x_i)) - (x_j - t(x_j))|}{2N^2 \mu (1-t)} \right] \quad (21)$$

The Reynolds and Smolensky index will be positive when the Gini index is higher before than after tax, which indicates that the tax has improved income concentration and there is a positive redistributive effect. Conversely, a negative Reynolds and Smolensky index shows a deterioration in income distribution after the application of the tax and, therefore, negative redistribution. If the index is equal to 0, the tax neither improves nor worsens income distribution.

Analogously to the approach to measuring vertical equity, this methodology is also used to break down the redistributive effect of reform. The aim is thus to identify whether a change occurred in the Reynolds and Smolensky index (RS^*) post-reform, which will be given by:

$$RS^* - RS = (C_x^* - C_{x-t}^*) - (C_x - C_{x-t}) \quad (22)$$

Supposing that $C_x^* = C_x$:

$$RS^* - RS = (C_{x-t} - C_{x-t}^*) \quad (23)$$

This formula may be expressed as:

$$RS^* - RS = \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |(x_i - t(x_i)) - (x_j - t(x_j))|}{2N^2 \mu(1-t)} \right] - \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |(x_i - t^*(x_i)) - (x_j - t^*(x_j))|}{2N^2 \mu(1-t^*)} \right] \quad (24)$$

Applying the additive inverse of factor $\left[\frac{\sum_{i=1}^n \sum_{j=1}^n |(x_i - t(x_i)) - (x_j - t(x_j))|}{2N^2 \mu(1-t^*)} \right]$ yields:

$$RS^* - RS = \left[\frac{\sum_{i=1}^n \sum_{j=1}^n |(x_i - t(x_i)) - (x_j - t(x_j))|}{2N^2 \mu(1-t)} \right] \left(1 - \frac{1-t}{1-t^*} \right) + \frac{\left[\sum_{i=1}^n \sum_{j=1}^n |(x_i - t(x_i)) - (x_j - t(x_j))| \right] - \left[\sum_{i=1}^n \sum_{j=1}^n |(x_i - t^*(x_i)) - (x_j - t^*(x_j))| \right]}{2N^2 \mu(1-t^*)} \quad (25)$$

If β is defined as the rate of average net income growth after the application of the tax:

$$\beta = \frac{(1-t^*) - (1-t)}{(1-t)} \quad (26)$$

and D and D^* as the sum of the distances between net incomes before and after the reform, respectively:

$$D = \sum_{i=1}^n \sum_{j=1}^n |(x_i - t(x_i)) - (x_j - t(x_j))| \quad (27)$$

$$D^* = \sum_{i=1}^n \sum_{j=1}^n |(x_i - t^*(x_i)) - (x_j - t^*(x_j))| \quad (28)$$

Therefore, formula (22) may be expressed as:

$$RS^* - RS = C_{x-t} \left(1 - \frac{1}{1+\beta} \right) + \frac{D - D^*}{2N^2 \mu(1-t^*)} \quad (29)$$

The variation in the Reynolds and Smolensky index will be the sum of two effects. On the one hand, the "level" effect, represented by:

$$EN = C_{x-t} \left(1 - \frac{1}{1+\beta} \right) \quad \begin{array}{l} \text{If } \Delta t < -1 < \beta < 0 \text{ " EN } < 0 \\ \text{If } -\Delta t > \beta > 0 \text{ " EN } > 0 \\ \text{If } \beta = 0 \text{ " EN } = 0 \end{array} \quad (30)$$

where Δt represents an increase in the tax rate, while $-\Delta t$ represents a fall in the rate.

This reflects the effect on income distribution given by the changes in the rate of average income after the reform, keeping income distributions before and after the reform constant; values may be between 0 and 1.

And, on the other hand, the net income “distance” effect, represented by:

$$ED = \frac{D - D^*}{2N^2 \mu (1 - t^*)} \quad \begin{array}{l} \text{If } D > D^* \text{ " } ED > 0 \\ \text{If } D < D^* \text{ " } ED < 0 \\ \text{If } D = D^* \text{ " } ED = 0 \end{array} \quad (31)$$

This formula uses normative valuation to measure variation in the distribution, since it compares the differences in the two income distributions (before and after tax) in terms of proportionality, keeping the average net income constant, an effect that can also take positive or negative values.

Accordingly, changes in the distribution of total income given by equation (29) may take positive signs when income inequality improves after the tax reform, or negative signs when the post-reform effect on income inequality leads to greater income concentration.

As a function of the variation in the Reynolds and Smolensky index, the effect of the reform on income distribution may be defined on the basis of the “distance-level” redistribution index I_{RS} , defined by:

$$I_{RS} = \frac{\Delta RS}{|\Delta RS|} \left(1 + \frac{ED}{|EN| + |ED|} \right) \quad (32)$$

Where:

$$\frac{\Delta RS}{|\Delta RS|} = \pm 1$$

$$0 \leq \left(1 + \frac{ED}{|EN| + |ED|} \right) \leq 2$$

Thus, the classification of the reform based on the index I_{RS} will be:

- Strongly redistributive reform: if there is a positive change in the Reynolds and Smolensky index (ΔRS) and the “distance” effect is positive ($ED > 0$), the “distance-level” redistribution index will be in the range $1 < I_{RS} \leq 2$.
- Weakly redistributive reform: if there is a positive change in the Reynolds and Smolensky index (ΔRS), but the “distance” effect is negative ($ED < 0$), the “distance-level” redistribution index will be in the range $0 < I_{RS} \leq 1$.
- Weakly non-redistributive reform: if there is a negative change in the Reynolds and Smolensky index ($-\Delta RS$), but the “distance” effect is positive ($ED > 0$), the “distance-level” redistribution index will be in the range $-2 \leq I_{RS} < -1$.
- Strongly non-redistributive reform: if there is a negative change in the Reynolds and Smolensky index ($-\Delta RS$) and the “distance” effect is also negative ($ED < 0$), the “distance-level” redistribution index will be in the range $-1 \leq I_{RS} \leq 0$.

V. Findings

Between 2010 and 2017, income tax collection from wage earners in El Salvador did not follow a specific trend, despite being an important source of income for the State. The 2011 income tax reform was the measure that most reduced the number of taxpayers, because it increased the tax-exempt bracket and raised the minimum level for mandatory declaration; however, it also contributed most

to income tax collection in the reference period, which reached 2.92% of GDP in 2015. However, the amendment in 2015 reversed this trend and reduced the amount collected by 7.4% and the number of taxpayers by 1.8%. As a result, in 2017 income tax collection sank to its lowest level ever reported in GDP terms (2.55%) (see table 2).

Table 2
El Salvador: collection of wage earners' income tax, 2010–2017
(Millions of dollars and percentages)

Year	Collection (Millions of dollars)	Taxpayers (Number)	Collection/GDP (Percentages)	Value added tax (VAT)/income tax
2010	524.52	301 289	2.84	2.99
2011	575.71	314 406	2.84	3.13
2012	557.89	141 598	2.61	3.33
2013	606.01	166 590	2.76	3.14
2014	588.96	194 951	2.61	3.24
2015	685.20	216 575	2.92	2.82
2016	634.30	212 736	2.63	2.92
2017	634.89	234 428	2.55	3.06

Source: Prepared by the authors, on the basis of Ministry of Finance, *Informe de la Gestión Financiera del Estado 2012*, San Salvador, 2012; *Informe de la Gestión Financiera del Estado 2015*, San Salvador, 2015; and *Informe de la Gestión Financiera del Estado 2017*, San Salvador, 2017.

This finding is consistent with those of Menkos (2013), who defines the foregoing as evidence of the depletion of the fiscal space's ability to significantly increase revenues. Although the changes reduce the tax's administrative failures, they fail to impact the determinants of loss of income tax collection power.

Comparison with the collection of the main indirect tax, VAT, bears out the observations made by Pérez Trejo (2014). The immense number of measures aimed at boosting indirect taxes helps to undermine income tax collection, which puts the tax's capacities at risk.

Before the 2011 reform, income tax was levied from the fourth decile upward. The reform pushed the threshold to the sixth decile, which generated an increase of 13% in the contribution of the tenth decile. With the 2015 amendment, the sixth to ninth deciles seem to bear a lower tax burden than those applied by the 2011 reform, while the burden of the tenth decile rose by 3% (see table 3).

Table 3
El Salvador: contribution and effective rate of payment of income tax on wage earnings,
by household decile, 2010, 2011 and 2015
(Percentages)

Decile	Situation in 2010		Reform of 2011		Modification of 2015	
	Contribution	Effective rate	Contribution	Effective rate	Contribution	Effective rate
I	0.00	0.00	0.00	0.00	0.00	0.00
II	0.00	0.00	0.00	0.00	0.00	0.00
III	0.01	0.01	0.00	0.00	0.00	0.00
IV	2.33	0.81	0.00	0.00	0.00	0.00
V	3.76	1.22	0.00	0.00	0.00	0.00
VI	3.60	0.98	2.66	0.55	0.96	0.18
VII	5.96	1.26	5.63	0.90	5.18	0.75
VIII	8.42	1.56	7.85	1.10	7.11	0.90
IX	17.74	2.63	18.26	2.04	18.19	1.84
X	58.18	5.44	65.60	4.63	68.57	4.38
Total	100.00	2.46	100.00	1.86	100.00	1.68
Poorest 40% of the population	2.34	0.82	0.00	0.00	0.00	0.00
Richest 20% of the population	75.91	8.07	83.85	6.67	86.76	6.22

Source: Prepared by the authors, on the basis of Ministry of Economic Affairs, *Encuesta de Hogares de Propósitos Múltiples 2017*, Delgado, 2018.

At first glance, the 2011 reform and the 2015 amendment made the income tax substantially more progressive. The contribution made by the richest 20% came to 87% of total income tax collection. However, when progressivity is evaluated from the progressive effective rates approach (shown in table 3), the average effective rate is seen to go from 2.46% in 2010 to 1.68% after the changes that were made to the tax.

Although the effective rate is progressive, since it increases with income level, the tenth decile —in real terms— pays only 5% of wage income in tax, on average. Furthermore, the changes made to the tax decreased the effective tax rate. Although the exempt bracket was expanded, which to some extent contributes to tax progressivity, the effective rates are lower than in 2010 for all deciles and, with the introduction of the social security payment in the deductions, the total effective rate decreased by 20% for 2017.

As shown in ECLAC/Oxfam (2016), these differences between the contribution by deciles and the effective rates mean that the personal income tax is ineffective in taxing high incomes, since the effective rate paid by El Salvador's tenth decile is significantly lower than in countries such as Argentina and Mexico, where it exceeds 8%.

The foregoing is reaffirmed by analysis of the Kakwani index, showing that both the 2011 reform and the 2015 amendment are progressive in that they present an index greater than 0 (see table 4). These results coincide with the arguments of Gómez Sabaini (2005), Ahmed and O'Donoghue (2009) and ECLAC (2018) on the vertical equity effects generated by income tax.

Table 4
El Salvador: evaluation of progressivity of the 2011 reform
and the 2015 amendment of income tax
(Indicator points)

Indicator	Situation in 2010	Reform of 2011	Amendment of 2015
Gini index before income tax		0.379	
Income concentration index	0.701	0.777	0.796
Kakwani index	0.321	0.398	0.417
Difference		0.076	0.020
"Level" effect		0.227	0.083
"Distance" effect		-0.151	-0.063
I_k		0.046	0.011

Source: Prepared by the authors, on the basis of Ministry of Economic Affairs, *Encuesta de Hogares de Propósitos Múltiples 2017*, Delgado, 2018.

Note: I_k is defined as the "distance-level" index, which shows the effect (strong or weak) of the reform on tax equity.

On the one hand, the 2011 reform increased the progressivity index by 0.08 points. The reform's 54% increase in the exempt bracket lowered the average effective rate, so that the "level" effect contributed positively to tax progressivity. On the other hand, the "distance" effect reduces progressivity because, after the reform, the differences between the contributions paid by low-income and high-income taxpayers shrink. Taking into account both the reflections above and the findings for the "distance-level" progressivity index, the 2011 reform constitutes a weakly progressive reform.

The same occurs with the amendments of 2015. They were progressive, but the progressivity index increased by only 0.02 points compared to the 2011 reform (0.08 points). Likewise, the decline in the effective rate due to the introduction of a new deduction contributed to progressivity, but the reduction in the gaps between the payments of all taxpayers detracted from vertical equity and reduced the progressive effect of the reform. Therefore, the 2015 amendments are also classified as progressively weak, based on the "distance-level" progressivity index.

This reaffirms the findings of Jorratt (2011) for Ecuador, Guatemala and Paraguay, where, although the income tax is confirmed to have a progressive effect in both structures, the absolute contribution to vertical equity is small. Jorratt associates this with low tax collection, the differential treatment of income sources and the large income tax exemptions and deductions allowed. These results are also consistent with those of Valle (2001) from a historical perspective, insofar as tax progressivity has focused on the establishment of the minimum exempt bracket rather than on strong variations in marginal tax rates. Similarly, the study by Barreix, Bès and Roca (2009) found that income tax has limited power to improve progressivity in El Salvador owing to the high non-taxable threshold for labour income, as the present research has also demonstrated. Thus, the misguided simplification of tax treatment will prevent substantive changes in progressivity if lawmakers are reluctant to make changes to effective and marginal rates, especially for the upper income deciles.

Analysis of the redistributive capacity of income tax based on the reforms and amendments carried out shows that the tax improves income distribution compared to the distribution of gross income. This supports the arguments of Yáñez's (1992) and Sevilla (2004) regarding the importance of introducing tax reforms —from the ability-to-pay criterion— that improve market-determined income.

The resulting structure once the income tax is applied reduces the income concentration of the richest 20% by 1 percentage point (see table 5). This is reflected in the improvement of the Gini index —close to 2%— after tax. However, as indicated in ECLAC/IEF (2014), this is a relatively low redistributive rate compared to the levels attained in 2011 in Mexico and Uruguay, where income tax is able to improve the Gini index by 6% and 4%, respectively.

Table 5
El Salvador: distribution of wage income by household decile, 2010, 2011 and 2015
(Percentages)

Decile	Gross income	Income by structure in 2010	Income after 2011 reform	Income after 2015 amendment
I	1.53	1.58	1.57	1.57
II	3.18	3.27	3.25	3.25
III	5.11	5.26	5.22	5.22
IV	5.77	5.93	5.90	5.89
V	6.94	7.08	7.09	7.09
VI	9.33	9.51	9.54	9.53
VII	10.07	10.25	10.23	10.23
VIII	12.51	12.68	12.65	12.65
IX	16.68	16.68	16.72	16.72
X	28.88	27.75	27.84	27.85
Poorest 40% of the population	15.59	16.04	15.94	15.93
Richest 20% of the population	45.56	44.43	44.56	44.57

Source: Prepared by the authors, on the basis of Ministry of Economic Affairs, *Encuesta de Hogares de Propósitos Múltiples 2017*, Delgado, 2018.

Evaluating the redistributive capacity of each tax structure, table 6 shows that both the 2011 reform and the 2015 amendments worsened income distribution compared to the 2010 structure. This means that the progressivity achieved was unable to improve income distribution as such and, although both initiatives had redistributive power in general —reflecting the ability of income tax to improve income distribution—, they were not enough to accomplish this.

Table 6
El Salvador: evaluation of redistributive capacity of the 2011 reform
and the 2015 amendment to income tax
(Indicator points)

Indicator	Situation in 2010	Reform of 2011	Amendment of 2015
Gini index before income tax		0.3790	
Gini index after income tax	0.3714	0.3719	0.3723
Reynolds and Smolensky index	0.0081	0.0075	0.0071
Difference		-0.0006	-0.0004
"Level" effect		0.0020	0.0010
"Distance" effect		-0.0020	-0.0010
I_{RS}		0.0000	0.0000

Source: Prepared by the authors, on the basis of Ministry of Economic Affairs, *Encuesta de Hogares de Propósitos Múltiples 2017*, Delgado, 2018.

Note: I_{RS} is defined as the "distance-level" index, which shows the effect (strong or weak) of the reform on tax equity.

According to the differences in the Reynolds and Smolensky index before and after the 2011 and 2015 changes, income concentration rose in the richest 20% and fell in the poorest 40%.

The decrease in the average effective rate resulting from the broadening of the exempt bracket, as shown in table 3, produced an increase in the average income rate after tax ($1-t$), which is reflected in a positive "level" effect and indicates that the reform improved redistributive power by increasing taxpayers' average income after the measure was introduced. However, this effect is undermined by the "distance" effect, which shows that the gaps between average incomes increase after the reform, heightening the concentration of wage income in the upper deciles. Therefore, the "distance-level" redistribution index is very close to 0, which means that the 2011 reform is classified as strongly non redistributive.

For their part, the 2015 amendments to the income tax do not improve income redistribution either. The introduction of the social security payment as a tax deduction benefited the higher-income deciles, since the amount deducted is fixed (because of the upper limit) and not progressive, which is reflected in the negative "distance" effect. Therefore, the amendment to the income tax in 2015 may also be classified as strongly non-redistributive.

These results corroborate those presented by Barreix, Bès and Roca (2009) for Costa Rica and El Salvador, which testifies to the limited effect of the income tax structure in developing countries. The study by Menkos (2013) reaches the same conclusions for El Salvador and associates the weak redistributive power with the minimal or absent changes in marginal rates, which undermines tax progressivity and redistributive ability.

The results also confirm the arguments of Arenas de Mesa (2016) and Jiménez, Gómez Sabaini and Podestá (2010), who point out that tax adjustments will be unable to generate positive redistributive changes unless they tackle the structural weaknesses of the tax. Merely expanding the tax burden is not enough, its composition must also be addressed in order to influence income distribution levels.

VI. Conclusions

The findings obtained in this research reaffirm the power of direct taxes, such as income tax, to improve vertical tax equity and the redistribution of market-determined income, which makes it a desirable measure, especially in countries, such as El Salvador, where income is highly unequal. However, income tax has played a limited role in the country, mainly because the reforms and adjustments needed to develop this potential have not been made.

The methodology used to evaluate the reform of the wage earner income tax carried out in 2011 and its subsequent amendment in 2015 isolated the real and normative effects on the tax's progressivity and redistributive power in El Salvador, drawing on the differences in traditional indices (Kakwani index and Reynolds and Smolensky index) to analyse the resulting structures. The main source of data for the research was the 2017 Multipurpose Household Survey, which suffers from methodological limitations related to lack of response, underreporting of income and undercapturing of earners, especially in the higher income brackets. Accordingly, the population's income and effective payment of the tax are underestimated, as a result of avoidance at the levels where income is concentrated owing to the survey sample design.

On this basis, it is concluded that the measures introduced by both the 2011 reform and the 2015 amendment to the income tax turned out to be weakly progressive and strongly non-redistributive. This means that these changes did not enhance the tax's power, since the position on the income distribution scale of the upper deciles, especially the richest 20%, saw no deterioration after the reforms. Furthermore, capital income continues to be afforded preferential and differential treatment, which erodes personal taxation.

The income tax policies implemented in El Salvador are measures focused on the short term, based on apparent progressivity based on an exempt bracket. This has generated a feedback loop of low taxation and income concentration. The challenge in this regard is for the administration to engage actively and autonomously in tax policy formulation. Expansion and diversification into other direct taxes, such as wealth tax, may be options to improve both tax revenues and income inequities.

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Annex A1

Calculation of monthly income tax withholding

The following taxable brackets are used to calculate the monthly income tax withholding.

1. For the situation before the 2011 reform:

Table A1.1
El Salvador: monthly income tax withholding tables, 2010
(Dollars and percentages)

Bracket	From	To	Percentage applicable	On the excess	Fixed payment
Bracket I	0.01	316.67		Exempt	
Bracket II	316.68	469.05	10	316.67	4.77
Bracket III	469.06	761.91	10	469.05	4.77
Bracket IV	761.92	1 904.69	20	761.91	60.00
Bracket V	1 904.70	Upwards	30	1 904.69	288.57

Source: Legislative Assembly of the Republic, Decree No. 134 "Ley de Impuesto sobre la Renta", *Diario Oficial*, No. 242, 21 December 1991.

2. For the 2011 reform:

Table A1.2
El Salvador: monthly income tax withholding tables, 2011
(Dollars and percentages)

Bracket	From	To	Percentage applicable	On the excess	Fixed payment
Bracket I	0.01	487.60		Exempt	
Bracket II	487.61	642.85	10	487.60	17.48
Bracket III	642.86	915.81	10	642.85	32.70
Bracket IV	915.82	2 058.67	20	915.81	60.00
Bracket V	2 058.68	Upwards	30	2 058.67	288.57

Source: Office of the President of the Republic, Decree No. 216 "Tablas de retención del impuesto sobre la renta", *Diario Oficial*, No. 240, 22 December 2011.

3. For the 2015 amendment:

Table A1.3
El Salvador: monthly income tax withholding tables, 2015
(Dollars and percentages)

Bracket	From	To	Percentage applicable	On the excess	Fixed payment
Bracket I	0.01	472.00		Exempt	
Bracket II	472.01	895.24	10	472.00	17.67
Bracket III	895.25	2 038.10	20	895.24	60.00
Bracket IV	2 038.11	Upwards	30	2 038.10	288.57

Source: Executive Organ of the Republic, Decree No. 95 "Tablas de retención del impuesto sobre la renta", *Diario Oficial*, No. 236, 22 December 2015; and J. Guzmán, personal communication, 2016.

Note: The addition of the deduction of the payment to the Salvadoran Social Security Institute (ISSS) led to the fusion of brackets II and III into a single bracket, because the additional bracket in the old structure was due to the previous upper limit of the payment.

Evolution of cash transfers in Colombia

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Abstract

Social protection programmes have become an effective and indispensable tool for improving the living standards of the poor and vulnerable. This article examines the five main cash transfer programmes in Colombia and studies their history, targeting, coverage, operation and the fiscal commitments they demand. It also reviews the impact evaluations of these programmes and their results on various social indicators. The article is a first attempt to consolidate the information that exists on the subject in Colombia, in order to allow a comprehensive understanding of the scope and challenges of these programmes and to identify possible areas for research and improvement.

Keywords

Poverty, income, poverty mitigation, family, youth, ageing persons, programmes of action, subsidies, social security, Colombia

JEL classification

I38, L38, H5

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I. Introduction¹

Subsidies provided through conditional and non-conditional cash transfers are one of the main tools for combating poverty in the short term and for encouraging behaviours that allow for the increased accumulation of human capital. Conditional transfers are those that require a series of specific requirements to be met before they are disbursed to the beneficiary households in accordance with the targeting criteria set. Usually, the rules require that beneficiaries make some type of investment in human capital: for example, enrolling their children in school and ensuring their minimum attendance. In contrast, non-conditional transfers do not require that beneficiaries meet any additional requirements other than being entitled to them in accordance with the targeting instrument used.

Cash transfers have been adopted across the world, and their success in reducing poverty has been proven. They have also yielded positive outcomes in specific areas such as education and health, although the magnitude of the impact varies according to the programme's context and design (Loeser, Özler and Premand, 2021; Millán and others, 2019). In Colombia, the use of conditional cash transfers as a poverty alleviation strategy began with *Familias en Acción* in 2000, in response to the economic crisis faced by the country in the late 1990s (Urrutia and Robles Báez, 2018). Since then, Colombia has created other programmes that operate in a similar way to *Familias en Acción*. By the end of 2022, five national government cash transfer programmes were in place, which in 2021 covered around 70% of the population living in poverty and represented an annual cost of 1.13% of gross domestic product (GDP).

Despite their positive effects, cash transfer programmes are designed to be one component within a comprehensive public social protection policy. In and of themselves, cash transfers do not solve the structural problems that generate poverty traps, nor do they guarantee that appropriate, quality public services will be provided. Cash transfers should act as insurance to mitigate drops in the incomes of the most vulnerable households caused by unexpected shocks, or as incentives to encourage an increased accumulation of human capital. Transfers must therefore be accompanied by other public policy strategies that provide tools for income generation, and by a supply of accessible and quality social services throughout the territory.

In view of the recent growth of cash transfer programmes in Colombia and other countries, particularly in Latin America, it is important that their scope and potential impact be understood and that the relevance of their continued availability and the ways in which they should be implemented be analysed. Many questions remain to be answered regarding their scheduling, conditions, standardization, targeting, amounts, operation and fiscal sustainability. This study provides a first analysis of the five national conditional and non-conditional transfer programmes in place in Colombia as of 2022, a review of the literature evaluating them and information on their beneficiary numbers, costs and general conditions; it also offers a series of recommendations. The document refers to the programmes in place as of December 2022 and the regulations in force at that time.

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II. Description and targeting

In 2022, Colombia had 29 social programmes in place, run by 12 national agencies, intended to help improve the living conditions and incomes of the most vulnerable segments of the country's population (Sisben, n/d).² Five of those programmes focused exclusively on cash transfers, and they are the ones examined in this study: *Familias en Acción*, *Jóvenes en Acción*, *Colombia Mayor*, *Ingreso Solidario* and *Devolución del IVA*. They can be classified into two categories: conditional and non-conditional transfer programmes. *Familias en Acción* and *Jóvenes en Acción* are conditional transfer programmes, while the others involve non-conditional transfers.

1. Conditional transfers

(a) *Familias en Acción*

The *Familias en Acción* (Families in Action) programme is intended to bolster the incomes of poor families with children or adolescents through conditional cash transfers. It also aims to foster the accumulation of human capital, so payments are restricted according to the beneficiaries' ages and depend on their school attendance (in primary and secondary education) and on compliance with health checks during the early years of life.

The programme's first pilot experiments took place in 1999 as a temporary response to the economic crisis of the late 1990s, which resulted in sudden drops in the incomes of many Colombian households (Llano, 2014). Since then, the programme has become Colombia's main tool for social investment. In its first version, in 2000, the target group was 300,000 families in some 500 municipalities; that total was later expanded to 627 municipalities, or about 57% of the total number (DNP, 2000). The programme was updated in 2005, when it was expanded to cover 400,000 families (DNP, 2005). In addition to the previously targeted municipalities, this new expansion covered marginal urban areas, capitals of the new departments and specific areas defined by the national government as priority zones (DNP, 2005). Although the *Familias en Acción* programme was at first essentially rural, the 2005 expansion took it into urban areas and allowed it to reach municipalities with no banking services, with which it was able to access areas with lower levels of development.

Familias en Acción officially became a policy of the State in 2012 (Colombia, 2012a). In contrast to the initial geographic coverage, the 2012 expansion included all of the country's municipalities, a scope that has been maintained up to the most recent versions. Its coverage prioritizes, in order, dispersed rural areas, rural areas and municipal seats (Colombia, 2019a). According to the programme's most recent update, adopted in 2021, beneficiary families must belong to groups A1 to A5 and B1 to B4 as defined in the fourth version of the System for the Identification of Potential Social Programme Beneficiaries (Sisben IV) (DPS, 2021):³ in other words, households in extreme poverty (A) and the most vulnerable households within the moderate poverty group (B).

² The national social programmes are mainly administered by the Department for Social Prosperity (DPS), the Colombian Family Welfare Institute (ICBF), the Ministry of National Education and the Ministry of Housing, City and Territory. Together, these institutions are responsible for 72% of the programmes' outreach, with the Department for Social Prosperity alone accounting for one third.

³ Sisben IV classifies the population into four groups: extreme poverty (A), moderate poverty (B), vulnerable population (C) and non-poor or non-vulnerable population (D). These groups are divided, respectively, into 5, 7, 18 and 21 subcategories. Lower digits indicate a lower earning capacity and more challenging living conditions (DPS, 2019).

Table 1
Colombia: bimonthly transfers from the *Familias en Acción* programme,
average per child, by incentive type, 2022
(Dollars)

Incentive type	School grade						Monthly average ^a
	Not applicable	Preschool	Grades one to five	Grades six to eight	Grades nine and ten	Eleventh grade	
Health	44.4	22.3
Education	...	13.7	8.6	20.5	23.9	34.2	8.4

Source: Prepared by the authors, on the basis of data from the Department for Social Prosperity (DPS).

^a The figure for health is calculated as the total transfers per beneficiary in a calendar year divided by 12. The average for education is estimated in the same way, following the school year.

In the 2022 version of the *Familias en Acción* programme, cash transfers are determined as shown in table 1. Paid every two months, the amounts shown indicate the average disbursements distributed according to a differentiated regime that depends on the target group, the grade level or age of the child and the classification of the municipality of residence. Health incentives are only granted to families with children under 6 years of age. The education incentive is aimed primarily at children of school age. It is estimated that the average monthly school incentive per beneficiary is equal to 10% of the 2021 national poverty line, with the health incentive equal to 26%. Each family can have a maximum of three beneficiaries receiving the school incentive. The health incentive, in contrast, is paid per family, regardless of the number of children in the defined age range.

According to figures from the Department for Social Prosperity (DPS), 1.9 million families and 3.3 million children were enrolled in *Familias en Acción* in 2022. Displaced persons accounted for 32.8% of the total number of beneficiary children, with members of Indigenous population groups accounting for 6%.

(b) *Jóvenes en Acción*

The *Jóvenes en Acción* (Youth in Action) programme was created to encourage and strengthen human capital formation among poor and vulnerable young people and, in addition, to facilitate their incorporation into the formal labour market. This programme's cash transfers are conditional on the beneficiaries' admission to and continued attendance at a school of higher education or in the National Training Service (SENA).⁴ *Jóvenes en Acción* aims to enable young people from the *Familias en Acción* programme to make a successful transition to higher education. The programme also provides training in the strengthening of cross-cutting or socioemotional skills.

The version of *Jóvenes en Acción* in force in 2022 was launched in 2012. According to the terms of the last known version of *Jóvenes en Acción*, observed in 2022, beneficiaries must be high-school graduates⁵ without a professional degree, aged between 14 and 28 years old and classified by Sisben IV in the extreme poverty categories and the first group of vulnerability. The programme is aimed primarily at students enrolled in SENA or at a public institute of higher education.

The areas targeted by the programme are municipalities selected according to three conditions. First, the municipality must have the educational infrastructure required for higher education. Specifically, it must have facilities offered by SENA or another technical, technological or professional school recognized by the Ministry of National Education. Second, priority is given to those municipalities with

⁴ The National Training Service (SENA) is a public institution that offers free technical and technological programmes and short courses.

⁵ Defined in Colombia as a person who has completed secondary education; with the exception of some schools, the final year of secondary education school is eleventh grade.

the highest multidimensional poverty indices (MPI). Third, the areas with the highest percentages of potential beneficiaries are identified (DPS, 2020a). According to the records of the Department for Social Prosperity, in 2022 the programme was available in 493 municipalities and 525,252 young people were participating in it.

The average monthly transfer varies according to the type of educational institution the students attend. If they are enrolled at an institute of higher education, the sum of US\$ 94 is paid at the beginning of each semester. If the student remains in school over the course of the semester, an additional US\$ 94 is transferred, up to a maximum of four transfers per year. If the student obtains the minimum average needed to receive a “excellent” grade,⁶ an extra US\$ 47 is added to the semester’s final payment. For SENA students, the incentive is US\$ 94 every two months (DPS, 2020a). Students at schools of higher education receive a monthly average of US\$ 31.30 —and are also eligible for the excellence bonus— while SENA students receive a monthly average of US\$ 47.00 (see table 2). These amounts are equal, respectively, to 37% and 56% of the 2021 national monetary poverty line.

Table 2
Colombia: *Jóvenes en Acción* programme transfers for higher education
and National Training Service students, by incentive type, 2022
(Dollars)

Institution	Regular transfer	Incentive for excellence	Monthly average ^a
Higher education institution (quarterly)	94	47	31.3
National Training Service (SENA) (bimonthly)	94	---	47.0

Source: Prepared by the authors, on the basis of data from the Department for Social Prosperity (DPS).

Note: The number of transfers per year varies according to the type of institution.

^a The average is calculated as the total amount transferred per beneficiary in a calendar year divided by 12.

2. Non-conditional transfers

(a) *Colombia Mayor*

The *Colombia Mayor* (Older Colombia) programme is intended to protect older persons living in poverty or extreme poverty across the nation by means of cash transfers that, in 2022, were worth US\$ 18.80 per month.

The first step towards this programme was taken in 1993, when the foundations for the Solidarity Pension Fund were set. The programme evolved over time to become what is known today as *Colombia Mayor*, the first version of which was launched in 2003. *Colombia Mayor* has maintained practically the same requirements for potential beneficiaries since its inception. In the version of the programme examined in this study, defined in 2021, the beneficiaries were specified as Colombian nationals who had resided in the nation’s territory for the past 10 years, aged a minimum of three years below retirement age and belonging to Sisben groups A, B and C1 (Colombia, 2021).

In 2022, only 25% of Colombia’s approximately 6.8 million older persons were receiving a pension. Thus, 4.9 million people were excluded from the pension system, and the funds that the government allocated to the *Colombia Mayor* programme in that year covered only 35% of that excluded population. Since *Colombia Mayor*’s coverage fell short of the total potential beneficiaries according to the conditions described above, a process to establish priorities for its recipients was defined (Villar and others, 2020). To that end, potential beneficiaries are ranked according to their socioeconomic conditions. This procedure assigns each person a position, ranging from the most to least vulnerable. Following that order, members of the final beneficiary group are selected until the budget target is reached.

⁶ The recipients of the excellence bonus are those who achieve an average grade of above 4.

The *Colombia Mayor* programme is national in scope and therefore covers all the country's municipalities. However, the programme's coverage and transfer amounts have evolved significantly. In contrast to more recent versions, the initial programme prioritized the amount transferred per person over coverage (Villar and others, 2020). For example, between 2008 and 2012 the average monthly transfer amount was around US\$ 21.25, while in 2013 the figure was US\$ 11.75. Until 2020, the average monthly transfer per person varied by municipality and was set at the local authorities' discretion (Colombia, 2012b). This changed with the 2020 update, which defined a standardized nationwide monthly transfer of US\$ 18.80. It should be noted that in some specific cases, joint financing exists between *Colombia Mayor* programme transfers and municipal assistance. This is the case in the capital city, Bogotá, where the national transfer is supplemented with local funds, resulting in higher per-person transfers.

In 2020, the transfer schedule was changed from bimonthly to monthly. In 2022, *Colombia Mayor* benefited approximately 1.7 million older persons and the amount each received was equal to 22% of the 2021 national monetary poverty line.

(b) *Ingreso Solidario*

The *Ingreso Solidario* (Solidarity Income) programme was created in March 2020 as a result of the crisis caused by the coronavirus disease (COVID-19) pandemic, in consideration of the mandatory preventive lockdown measures implemented and the consequent drop in economic activity. The *Ingreso Solidario* programme ended with its final payment in December 2022. While it operated, the programme provided an unconditional cash transfer to those households (spending units) living in poverty, extreme poverty or vulnerability that were not receiving other transfers. The *Ingreso Solidario* programme was initially to run for three months but, because of the length of the mandatory lockdowns and the significant deterioration of economic conditions, it was extended on several occasions and funded until December 2022.

In terms of its selection criteria, two phases of the programme can be identified. In its initial stage, *Ingreso Solidario* focused on households identified in the Sisben master database as poor or vulnerable, but excluding the population receiving other cash transfer programmes, formal employees and pensioners (DPS, 2020b; Colombia, 2020). The master database was created in 2020 by the National Planning Department (DNP) from updated household information available in the Sisben databases and various administrative records. This database, which enabled cross-referencing with the beneficiaries of other cash transfer programmes, is managed by the DNP (DPS, 2020b).

A second phase began in 2022, during which fundamental changes were made to the programme: the number of beneficiaries was increased and its functioning was temporarily extended until December 2022. This extension was limited to those households classified in extreme poverty according to Sisben IV and without beneficiaries of the *Familias en Acción*, *Colombia Mayor*, *Jóvenes en Acción* or *Devolución del IVA* programmes. In addition, a new formula was defined for calculating transfers, differentiated according to the household's size and its Sisben IV classification (DPS, n/d). This programme does not select its beneficiaries on the basis of the households' geographic location, but rather according to their conditions of poverty or vulnerability.

Payments and scheduling underwent several changes after the programme's creation. In the first version, in effect between 2020 and 2021, monthly amounts of US\$ 37.60 were received. In the final version, in 2022, beneficiary households received a bimonthly amount of between US\$ 94.00 and US\$ 102.20, depending on their Sisben classification (see table 3). Under the latest version of the programme, the average monthly transfer per household was US\$ 48.60: an amount equal to around 30% of the 2021 national per capita monetary poverty line. In 2022, a total of 3.9 million households benefited from this programme.

Table 3
Colombia: bimonthly *Ingreso Solidario* programme transfers, per household,
by number of persons, 2022
(Dollars)

Classification according to the System for the Identification of Potential Social Programme Beneficiaries (Sisben)	Number of household members		Monthly average
	1	2 or more	
A	98.7	102.2	50.2
B	96.3	98.7	48.8
C ^a	94.0	94.0	47.0

Source: Prepared by the authors, on the basis of data from the Department for Social Prosperity (DPS).

^a C also refers to the amount received by households not included in the fourth version of Sisben (Sisben IV). The monthly average is calculated as the simple average of payments per household.

(c) *Devolución del IVA*

The *Devolución del IVA* (VAT Refund) programme not only seeks to alleviate the impact of sales tax (VAT) on the country's poorest households, but also to increase the equity of the tax system. The compensation method was approved in December 2019 (Colombia, 2019b) for gradual implementation over the course of 2020. However, because of the economic crisis triggered by the COVID-19 pandemic, its implementation was expedited and it was operational by March 2020. According to the latest 2022 version, the *Devolución del IVA* programme consists of a payment of US\$ 18.80 every two months, primarily benefiting the poorest households in the *Familias en Acción* and *Colombia Mayor* programmes. It functions, therefore, as a complement.

In the first version of the *Devolución del IVA* programme, beneficiaries were selected in a two-stage process. First, the beneficiary municipalities were identified based on an approximation of the MPI estimated from the 2018 National Population and Housing Census. Second, the beneficiaries were identified based on their Sisben classifications and on the households' participation in the *Familias en Acción* and *Colombia Mayor* programmes. According to the latest available version of the *Devolución del IVA* programme, potential beneficiaries are selected by the following criteria: households in extreme poverty that are beneficiaries of *Familias en Acción* or *Colombia Mayor* or not receiving any transfer, and households in moderate poverty that are beneficiaries of *Familias en Acción*.

In 2022, these transfers were received by 2 million households. The average monthly payment per household under the *Devolución del IVA* programme in that year was US\$ 9.40, equal to 10% of the 2021 national monetary poverty line.

3. Comparative analysis of transfers

Colombia's cash transfer programmes share a number of common characteristics. First, they are all intended to mitigate situations of poverty and vulnerability among the population. In operational terms, they are similar in that they use similar databases to identify and select their potential beneficiaries and in that, because of budgetary constraints, they apply prioritization strategies. In addition, they were mostly created in response to economic crises and are currently managed by the same institution, the Department for Social Prosperity (DPS).

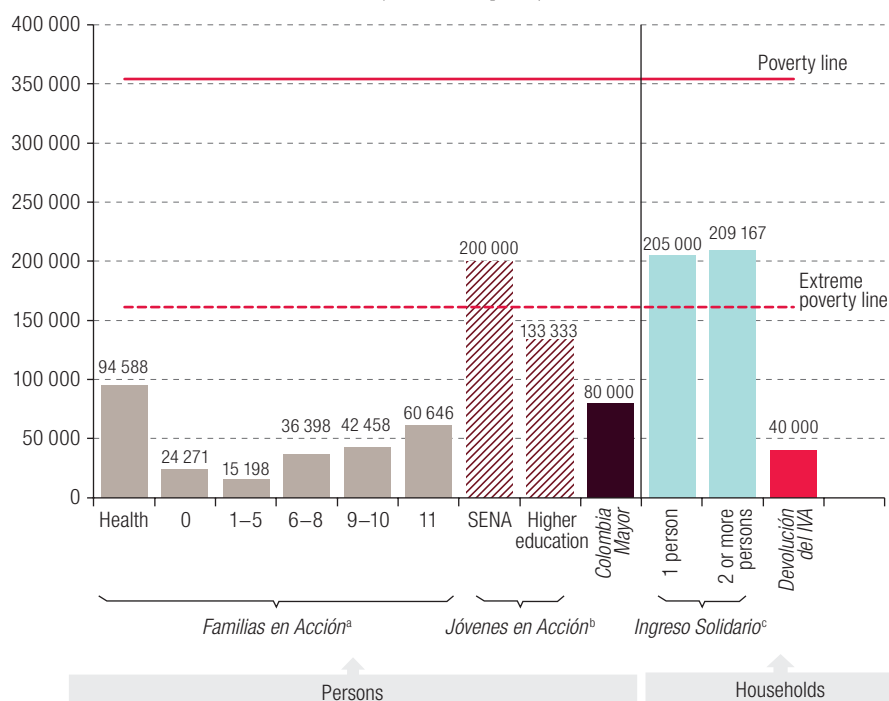
The main difference between the programmes lies in the presence or absence of conditionalities and in their beneficiary selection strategies. In programmes such as *Jóvenes en Acción* and *Familias en Acción*, financial assistance is subject to the fulfilment of certain specific conditions. In contrast, under the *Ingreso Solidario*, *Devolución del IVA* and *Colombia Mayor* programmes, there are no requirements to be met in order for transfers to be received, once the individuals or families have been identified as beneficiaries in accordance with specific targeting criteria. It should also be noted that, in contrast

to the non-conditional programmes, the conditional programmes require a registration process. In other words, an expression of interest is needed and, consequently, awareness of the programmes' existence and requirements. Another distinctive feature of the programmes is the units they identify and the types of beneficiaries they select. The *Familias en Acción* programme identifies families, but the beneficiaries are specific individuals. In turn, the identified units and beneficiaries of the *Ingreso Solidario* and *Devolución del IVA* programmes are all the household's members.⁷ Lastly, *Jóvenes en Acción* and *Colombia Mayor* use individual identification.

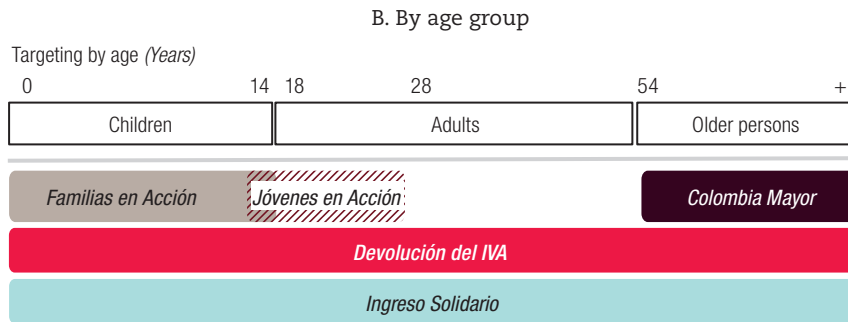
The nation's cash transfer programmes also differ in the population groups they target, and in their disbursement schedules and amounts. Because disbursements under *Familias en Acción*, *Jóvenes en Acción*, *Ingreso Solidario*, *Devolución del IVA* and *Colombia Mayor* are made with different frequencies and directed at different units (individuals, families or households), the transfer amounts cited above are not directly comparable. Figure 1 shows monthly transfer amounts per person or household. *Jóvenes en Acción* has the highest transfer amounts, while those of the *Familias en Acción* programme aimed at school-age children attending preschool through fifth grade are the lowest. Of the transfers targeting all members of a household, *Ingreso Solidario* has the highest monthly disbursements. The average monthly transfer of *Jóvenes en Acción* for SENA students is equal to 56% of the 2021 national monetary poverty line, that of *Jóvenes en Acción* for students at higher education institutions equals 38% and that of *Ingreso Solidario* equals 58.47%. Disbursements under the *Colombia Mayor* programme are equal to 22% of that poverty line, while the value drops to 11.3% in the case of *Devolución del IVA* and, on average, to 12.9% under *Familias en Acción*.

Figure 1
Colombia: average monthly programme transfers, 2022

A. By person or household, according to the classifications of the fourth version of the System for the Identification of Potential Social Programme Beneficiaries (Sisben IV)
(Colombian pesos)



⁷ A household is defined as a person or group of persons who provide for their basic needs by means of a common budget (Decree No. 1082 of 2015).



Source: Prepared by the authors, on the basis of data from the Department for Social Prosperity (DPS).

Note: Shows the most recent transfer amounts as set in 2022. The relationship between (per capita) poverty lines and (per household) monthly transfers from the *Ingreso Solidario* and *Devolución del IVA* programmes should be interpreted with caution, as they are not strictly comparable. Poverty lines are individual, while some transfers are delivered at the household level.

- ^a Bars indicate transfers subject to health and education conditions, in the latter case according to the child's current study grade between the first and the eleventh.
- ^b Bars indicate transfers to students of the National Training Service (SENA) or institutions of higher education (HE).
- ^c Bars indicate transfers directed to households with one member and with two or more members.

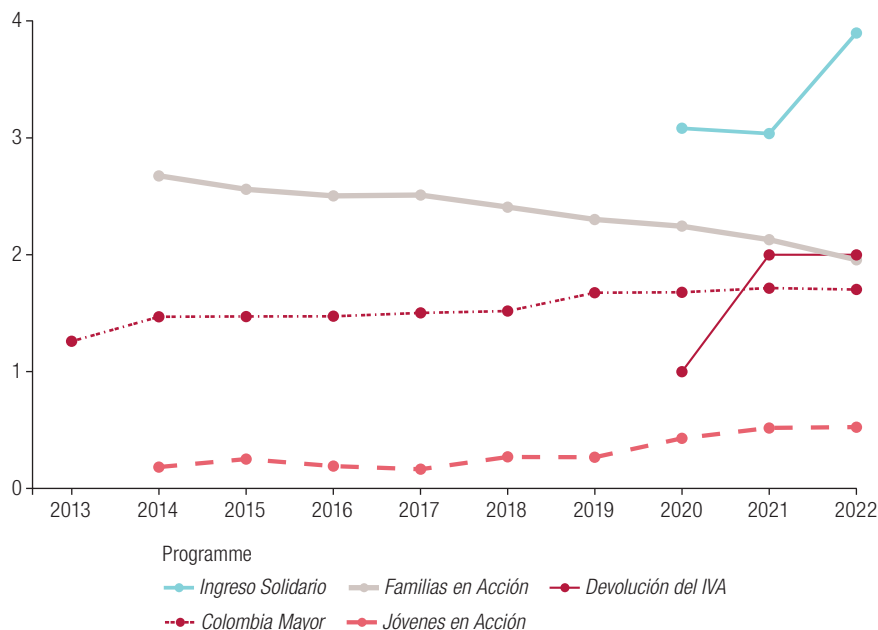
Although the different programmes have a targeting that, taken together, can cover all age groups (see figure 1), there is a clear disparity in the transfer amounts and, therefore, in the probabilities of government assistance helping beneficiaries in different age groups to escape poverty. Prior to the COVID-19 crisis, disbursements were targeted at the school-age population (under 28 years old) and older persons (at least three years younger than pension age). With the creation of *Ingreso Solidario*, transfers were made available to population groups of working age. With this, all age groups became potential beneficiaries of a national cash transfer programme.

III. Beneficiaries and costs

The disbursement amounts and beneficiaries of the *Jóvenes en Acción* and *Colombia Mayor* programmes have undergone a particularly notable expansion since 2018. Between 2014 and 2018, the average annual growth rate in the number of *Jóvenes en Acción* beneficiaries was 12.4%, compared to 40.6% between 2019 and 2021. Similarly, the number of *Colombia Mayor* beneficiaries rose by 10.3% in 2019. *Colombia Mayor* also recorded a significant increase in its beneficiary numbers between 2012 and 2013, on account of the adjustments described in the previous section (Villar and others, 2020). In contrast, the number of families benefiting from *Familias en Acción* has, since 2018, fallen at an average annual rate of 2.9% (see figure 2).

The two most recent programmes, *Devolución del IVA* and *Ingreso Solidario*, have expanded very rapidly. Not only were they launched with a high number of beneficiaries —1 million and 3 million households, respectively— but, in addition, their coverage quickly increased (see figure 2). Taken together, Colombia's 2022 cash transfers directly benefited 5.8 million families or households through the *Familias en Acción* and *Ingreso Solidario* programmes and 2.2 million people through *Jóvenes en Acción* and *Colombia Mayor*. When coverage is compared to the size of each programme's target population, it can be seen that the trends are maintained, with the exception of *Colombia Mayor*. In other words, although *Colombia Mayor* has expanded over time, its coverage of the population aged 55 and older is decreasing. It can also be seen that the programme with the highest coverage within its reference group is *Familias en Acción* (see annex 1).

Figure 2
Colombia: cash transfer beneficiaries, by programme, 2013–2022
(Millions of people)



Source: Prepared by the authors, on the basis of data from the Department for Social Prosperity (DPS) and Villar, L. and others, “El pilar no contributivo y su rol en el sistema de protección a la vejez: Colombia Mayor”, *Working Paper*, No. 78, Bogotá, Fedesarrollo, 2020.

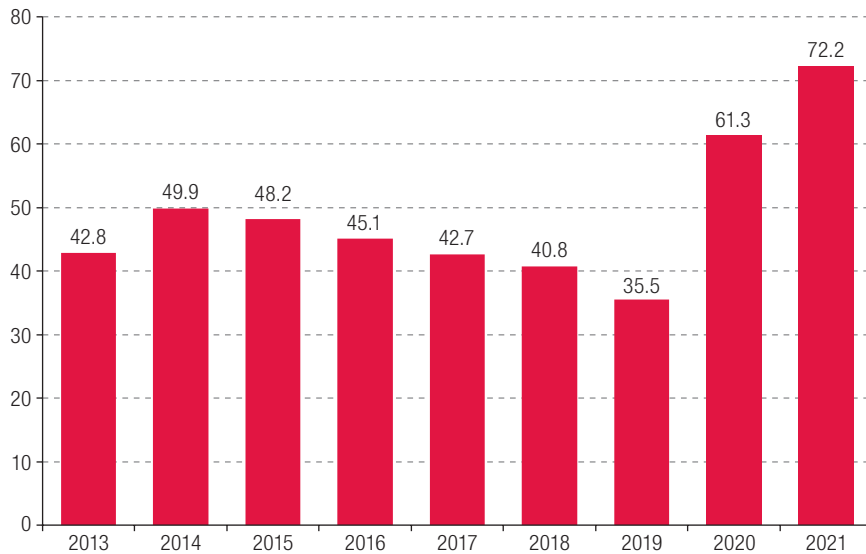
Note: The identified beneficiary for *Familias en Acción* is the household, even though the programme targets children.

The accelerated growth between 2020 and 2022 is consistent with the increase in the proportion of people facing monetary poverty who received some cash support during that period (see figure 3). Similarly, the gradual reduction in the number of families benefiting from *Familias en Acción* — Colombia’s main social investment programme until 2019— is consistent with the decrease in the proportion of poor people who received some type of assistance between 2013 and 2019. Between 2014 and 2019 alone, that proportion fell by 14 percentage points. These drops could be the result of the country’s demographic transition: the base of the population pyramid narrowed over the study period and, therefore, a lower participation in social programmes by families with school-age children —the prerequisite for participation in *Familias en Acción*— should be expected.

The creation of the new transfer programmes in 2020 and their recent expansion mean that out of every 10 people living in poverty, 6 benefited from some type of institutional assistance in 2020, rising to seven in 2021. Those results are in sharp contrast to those of 2019. Compared to that year, 3 more people out of every 10 benefited from transfers in 2021.

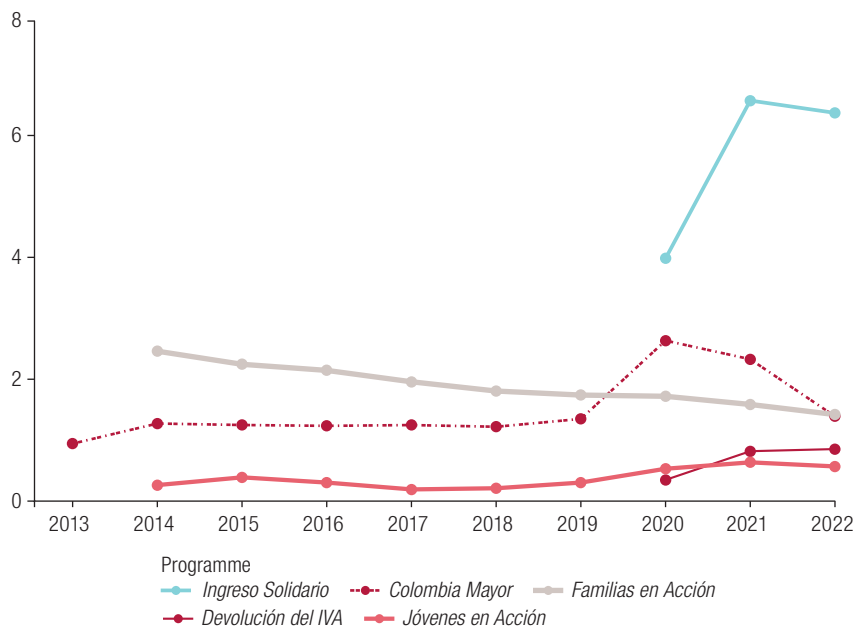
The rising numbers of beneficiaries have naturally been accompanied by an increase in the budget allocated to these social programmes (see figure 4). However, the distribution and growth of participation in each programme evolved differently. In response to the COVID-19 crisis, the *Ingreso Solidario* programme became the largest recipient of resources for cash transfers in 2021, accounting for 55% of the total. The second largest recipient was *Colombia Mayor*, ranking higher than *Familias en Acción*, which had historically accounted for the largest share of resources. The lowest levels of funding were reported by *Jóvenes en Acción* and *Devolución del IVA*.

Figure 3
Colombia: proportion of people in monetary poverty receiving some type
of institutional assistance through transfers, 2013–2021
(Percentages)



Source: Prepared by the authors on the basis of data from the Great Integrated Household Survey (GEIH) of the National Administrative Department of Statistics (DANE).

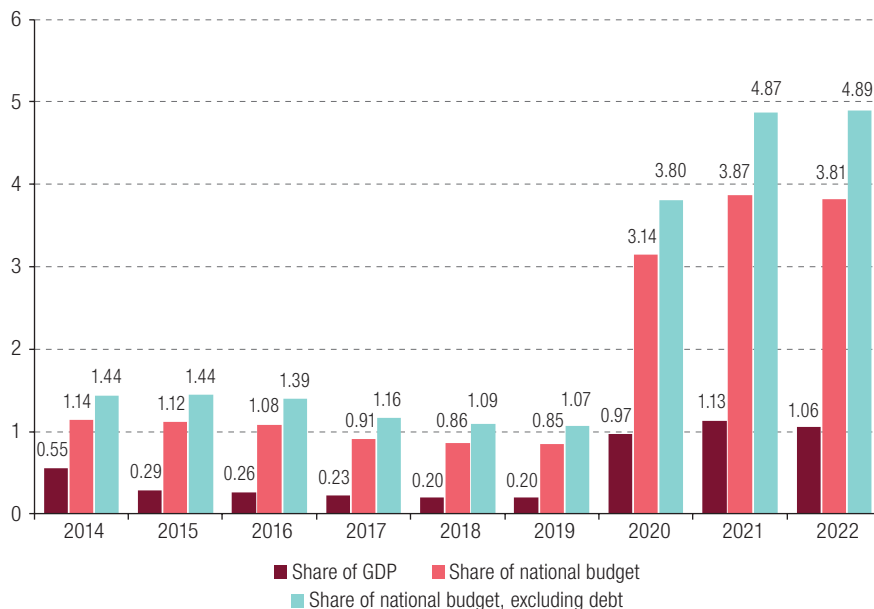
Figure 4
Colombia: budget allocations for cash transfers, by programme, 2013–2022
(Trillions of real 2018 Colombian pesos)



Source: Prepared by the authors, on the basis of data from the Department for Social Prosperity (DPS) and Villar, L. and others, “El pilar no contributivo y su rol en el sistema de protección a la vejez: Colombia Mayor”, *Working Paper*, No. 78, Bogotá, Fedesarrollo, 2020.

Between 2014 and 2019, the average annual total subsidy disbursements amounted to US\$ 822.5 million and represented, on average, 0.99% of the nation's general budget and 0.29% of GDP. That total rose to US\$ 2.162 billion in 2020 and to US\$ 2.796 billion in 2021, and the annual cost for those two years averaged 3.6% of the nation's general budget and 1.05% of GDP (see figure 5).

Figure 5
Colombia: share of total cash transfers in GDP, the nation's general budget
and the nation's general budget excluding debt, 2014–2022
(Percentages)



Source: Prepared by the authors, on the basis of data from the Department for Social Prosperity (DPS) and the National Administrative Department of Statistics (national accounts) and the Ministry of Finance.

To provide some context on the size of those amounts, comparisons with the budgets of social sector agencies and other subsidies that currently exist in Colombia are presented below. For 2022, the Unit for Victims had a total budget of US\$ 517 million (Unit for Victims, n/d). Another recipient of State assistance is the electricity subsidy, which was designed as a form of cross-subsidy to allow for minimum subsistence consumption with targeting based on the socioeconomic stratification of housing (Public Services Act (No. 142)). This consumption subsidy is received by homes in strata 1, 2 and 3, with stratum 1 receiving a higher percentage of subsidized electricity consumption and stratum 3 receiving a lower percentage. Its funding comes, in part, from a 20% surcharge on electricity rates paid by residential consumers in strata 5 and 6. However, since those funds are not sufficient to cover the full cost, the national government has transferred an annual average of between 0.3% and 0.4% of GDP between 2010 and 2019 to pay for this subsidy (Abdallah and others, 2019; Mejía, 2018). It should be noted that targeting on the basis of socioeconomic strata is seriously flawed, given the presence of a significant proportion of high-income households in strata 1, 2 and 3. In 2017, US\$ 23 million was spent every month on electricity subsidies to households that were not below the poverty line (Eslava, Révalo and Ortiz, 2021).

Another major subsidy is the one applied by the national government to pensions paid by Colpensiones, Colombia's State pension administrator. The Medium-Term Fiscal Framework (Ministry of Finance and Public Credit, 2022) estimates that between 2022 and 2033, the national government

will have to transfer, on average, 1.4% of GDP to Colpensiones to cover the agency's pension liabilities. This subsidy is concentrated among high-income individuals, since pensions worth more than four times the minimum wage are those that benefit the most.

IV. Documented lessons from the literature

Cash transfer programmes have multiple effects, as demonstrated by rigorous impact evaluations in different contexts. The literature on the effectiveness of these programmes is vast and, in recent years, has been used to adjust the design of many existing schemes. The following paragraphs describe some of the most outstanding results in Colombia documented in the literature and provide specific references to related empirical findings from across the region. It should be noted that the identified papers are only a subset of the copious literature that exists. Annex 2 provides a summary of the data and methodology used in the documents cited.

1. Impact on consumption and poverty

The effects of the *Familias en Acción* programme include an increase in food consumption (Urrutia and Robles Báez, 2018), together with a lower probability of suffering from multidimensional poverty (Cáceres, 2021). Among *Ingreso Solidario* recipients, higher spending on health and education has been observed (Gallego and others, 2021) and, in the case of *Devolución del IVA*, a higher probability of buying food (Londoño-Vélez and Querubín, 2020). All this is consistent with the effects of cash transfers on consumption observed in other Latin American countries (Fiszbein and others, 2009; Kondylis and Loeser, 2021). As regards the impact on poverty, *Familias en Acción* was found to have reduced extreme poverty (Urrutia and Robles Báez, 2018). It is estimated that between 2002 and 2013, had Colombia not had these cash transfer programmes in place, poverty would have been four percentage points higher in 2013 (Obando and Andrián, 2016), which is also consistent with observations in the rest of Latin America (Stampini and Tornarolli, 2012; Levy and Schady, 2013).

2. Impact on education

Urrutia and Robles Báez (2018) identify increases in enrolment levels, years of schooling, the probability of graduation, mathematics skills and years completed among the effects of the *Familias en Acción* programme. These results are complemented by conclusive data on lower school dropout rates (Attanasio and others, 2021). Similarly, Villa (2018) finds that the programme had positive effects on years of schooling. Other studies measuring the impact of the *Jóvenes en Acción* programme have found indications that graduation is more likely (Kugler and others, 2022) and that more students progress to tertiary education (Kugler and others, 2022; Gómez, 2017). This result with respect to tertiary education has also been seen in the case of the *Familias en Acción* programme (Attanasio and others, 2021). In turn, the *Devolución del IVA* and *Ingreso Solidario* programmes result in higher spending on education (Londoño-Vélez and Querubín, 2020) and more time devoted to study (Gallego and others, 2021), respectively.

It should be noted that although improvements in school performance and graduation probabilities are associated with the *Familias en Acción* programme without distinctions between different areas of the country (Urrutia and Robles, 2018), there are some differences in its effects between rural and urban areas. Rural areas also report improvements in the years of schooling (Urrutia and Robles Báez, 2018). Moreover, Benson (2012) identifies a positive impact on the number of schools in rural areas. However,

he also found that the student-teacher ratio remained unchanged. In contrast, evaluations of the *Familias en Acción* programme in urban areas have detected positive impacts on variables such as literacy, school attendance and dropout rates (Urrutia and Robles Báez, 2018). The positive results of the *Familias en Acción* and *Jóvenes en Acción* programmes in urban areas can be seen in access to tertiary education (Attanasio and others, 2021; Kugler and others, 2022; Gómez, 2017).

3. Health impact

Urrutia and Robles Báez (2018) find that progress in the area of health was made among children covered by the *Familias en Acción* programme: mainly in rural areas and with respect to variables such as height and malnutrition. Improvements in the health of other household members, who are not directly related to the transfer, were also observed. Those household members were less likely to be hospitalized and less likely to be in poor health (Contreras and Maitra, 2021). There was also a lower probability of food insecurity in rural areas (Urrutia and Robles Báez, 2018). Under the *Colombia Mayor* programme, lower probabilities of hospitalization and fewer reports of ill health among the elderly were found (Hessel and others, 2018), albeit only with a significant impact on men. Gallego and others (2021) show that the *Ingreso Solidario* programme increases the probability of spending on health but has no effect on food security. In the case of the *Devolución del IVA* programme, positive effects on mental health were found. In the context of the COVID-19 pandemic, it allowed for a reduction of stress-related factors among transfer recipients compared to a control group (Londoño-Vélez and Querubín, 2020). In contrast, higher levels of overweight among children covered by the *Familias en Acción* programme were identified (Urrutia and Robles Báez, 2018); this could be explained by inadequate food education, meaning that households do not necessarily buy foods that contribute to a balanced diet.

4. Employment impact

The literature examining the effects of cash transfer programmes on labour market participation in developing countries — which have highly informal labour markets, comparable to Colombia's — has not found many statistically significant negative effects of interventions of this type (Banerjee and others, 2017; Baird, McKenzie and Özler, 2018; Alzúa, Cruces and Ripani, 2013). Some possible unintended effects of cash transfers in reducing formality have been identified, particularly among women (Bergolo and Galván, 2018; Bergolo and Cruces, 2021), and even a possible disincentivization of labour participation when the amounts involved are high (Verlaet, Todeschini and Ramos, 2023). This relationship has not been proven to be true in all contexts (Gerard, Naritomi and Silva, 2021; Neves and Leite, 2014) and information for countries such as Colombia, where informality can approach a rate of 50%, is needed.

Among their positive impacts, the available data show two desirable effects of transfers of this kind. First, child labour appears to decrease in households benefiting from transfers that require children to attend school, both in Colombia and in other developing countries (Núñez and others, 2011; Behrman, Parker and Todd, 2011; Galiani and McEwan, 2013). Second, cash transfers appear to have a positive effect on women's labour participation and hours of paid work (Alzúa, Cruces and Ripani, 2013; Barham, Macours and Maluccio, 2018).

In the particular case of Colombia, the studies into the *Familias en Acción* programme are not conclusive as to its effect on the labour market because of the presence of compositional effects, given that groups who previously participated in the labour market — such as children and adolescents — are instead in school because of the conditions set for the subsidy (Fiszbein and others, 2009; Attanasio and others, 2010; Núñez and others, 2011; Attanasio, Kugler and Meghir, 2011). However, there are

no relevant statistical effects to indicate that *Familias en Acción* generates disincentives to work among its beneficiaries (Barrientos and others, 2013). In fact, Attanasio and others (2021) establish important findings on the long-term effects of *Familias en Acción* in reducing crime, increasing higher education enrolment among men and decreasing teenage pregnancy among women. These factors facilitate beneficiaries' participation in the labour market and may explain the programme's positive effects on formal male employment rates as documented by Attanasio and others (2023).

Compared to other transfer programmes, Gallego and others (2021) find no conclusive evidence that *Ingreso Solidario* generates disincentives to labour participation among its beneficiaries. The impact assessment conducted by Londoño-Vélez and Querubín (2020) on the *Devolución del IVA* programme found no positive or negative effects on beneficiaries' willingness to work. These results were corroborated by the mid-term impact assessment of the *Devolución del IVA* programme carried out by Econometría, SEI and the University of the Andes (2021), which also found these same results among older men and female-headed households. Nevertheless, that study revealed the existence of information on a reduction in the labour force participation in beneficiary households among women who were not heads of household, although this result was not robust compared to the use of other econometric tools, nor was it generalizable, given the nature of the empirical strategy applied. Pfütze and Rodríguez-Castelán (2015) show that, in the case of *Colombia Mayor*, there were signs that beneficiaries between the ages of 50 and 60 were encouraged to establish microenterprises.

It should be noted that, in its first version, *Jóvenes en Acción* was a vocational education programme for young people, as explained in the previous section. The detected effects were also very positive in terms of the beneficiaries' insertion into the formal labour market (Attanasio and others, 2017; Kugler and others, 2022).

5. Other types of impact

Not all the programmes' effects are restricted to consumption, health, education or employment. For example, Urrutia and Robles Báez (2018) and Cardona-Sosa, Medina and Núñez (2017) find that the *Familias en Acción* programme has positive effects on formal savings, access to formal credit and furniture and appliance ownership. Those results are consistent with the long-term positive impact on the consumer credit of the programme's women beneficiaries noted by Attanasio and others (2023). Similarly, Gallego and others (2021) find that *Ingreso Solidario* led to a higher probability of a bank account being opened and higher food consumption among beneficiaries. Moreover, according to Londoño-Vélez and Querubín (2020), there were indications that the *Devolución del IVA* programme improved financial health and decreased the likelihood of beneficiaries selling their belongings.

Finally, with reference to *Familias en Acción*, lower arrest and teenage pregnancy rates in urban areas were also found (Attanasio and others, 2021). Information exists to suggest that the effects of *Familias en Acción* on pregnancy rates are a result of the conditions it imposes. Cortés, Gallego and Maldonado (2016) state that only if the number of years *Familias en Acción* transfers are received is limited can it be unequivocally concluded that the programme contributes to reducing the risk of teenage pregnancy. These results, based on the case of Bogotá, also suggest transfers are more effective if their duration depends on school performance and minimum attendance, as is the case with programmes like *Familias en Acción*, such as the education subsidy.

Among other effects, it has been documented that *Familias en Acción* temporarily reduces domestic violence. Camacho and Rodríguez (2020) show that domestic violence decreases in the months when this programme's payments are made and may increase when a payment is expected and does not arrive. The mechanism that would explain this result is that *Familias en Acción* transfers ease the budget constraints of low-income households and this is associated with a reduction in domestic violence.

V. Immediate impact on income and monetary poverty

Given that subsidies are paid in cash, their immediate effect on income and, consequently, on monetary poverty can be evaluated. To analyse the effect of subsidies on household income, the following exercise artificially removes the institutional assistance component using imputations generated by the National Administrative Department of Statistics (DANE), published together with microdata from the Great Integrated Household Survey (GEIH).

It estimates that thanks to the government transfers implemented in 2020 and 2021, national poverty was 3.6 percentage points lower than it would have been without them. In other words, because of the transfers received, about 1.8 million people were not in monetary poverty in 2021. This immediate effect on monetary poverty observed between 2020 and 2021 contrasts sharply with the average calculated for the 2013–2019 period, which is estimated at 1.1 percentage points (see figure 6).

Figure 6
Colombia: monetary poverty rate with and without official assistance, 2013–2021
(Percentages of the total population)

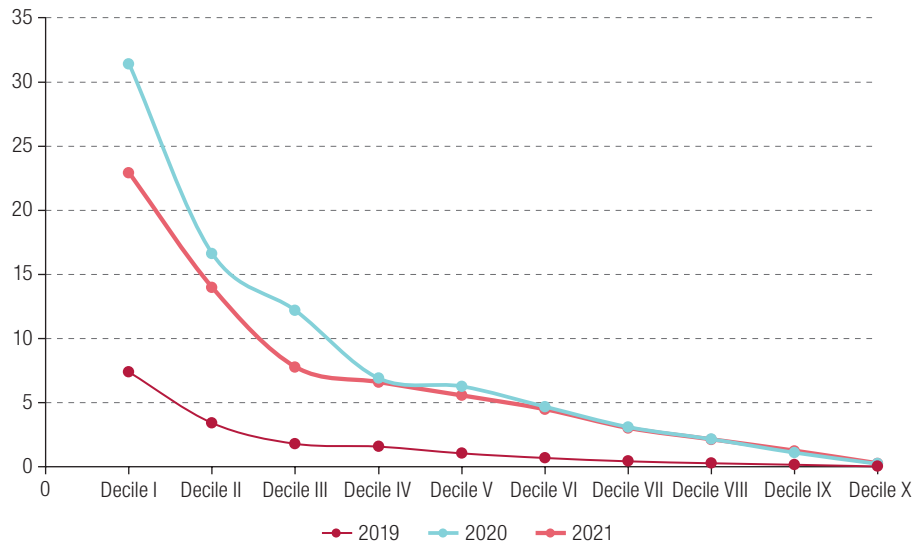


Source: Prepared by the authors on the basis of data from the Great Integrated Household Survey (GEIH) of the National Administrative Department of Statistics (DANE).

The immediate effect on monetary poverty is more noticeable in rural areas than in towns and cities. In the absence of official cash supports, an average poverty rate for urban areas 2.7 percentage points higher than that observed between 2020 and 2021 was estimated. That result rises to 6.8 percentage points in rural areas. The estimates by area type reveal that if transfers were excluded, rural monetary poverty would have risen between 2019 and 2020, a behaviour contrary to the trend actually observed.

Another notable feature of official cash transfers is their rising weight in household income as household vulnerability increases (see figure 7). In households located in the lowest deciles (those with the lowest incomes), the share of official assistance in total monthly income is much higher than that observed in higher-decile households. This feature provides partial evidence that the transfers are being targeted correctly. It also obeys the fact that, by definition, incomes are higher in the higher deciles.

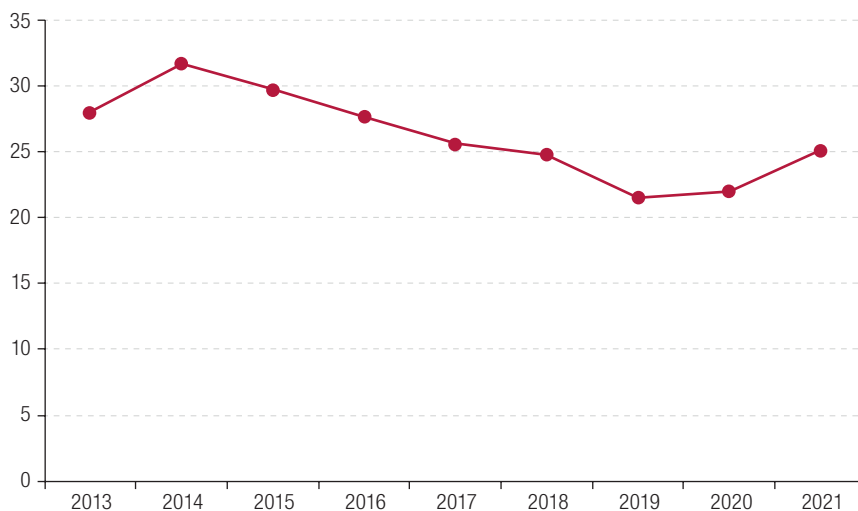
Figure 7
Colombia: share of official cash assistance in household income,
by income distribution decile, 2019–2021
(Percentages)



Source: Prepared by the authors on the basis of data from the Great Integrated Household Survey (GEIH) of the National Administrative Department of Statistics (DANE).

These results do not allow possible inclusion or exclusion errors to be ruled out in the programmes' current targeting. Although between 2013 and 2019 the targeting error followed a downward trend,⁸ from 2020 onwards there is a significant increase (see figure 8). Future studies could explore mechanisms to reduce these risks and to identify the characteristics of households with targeting errors.

Figure 8
Colombia: targeting error rate of cash transfer programmes, 2013–2021



Source: Prepared by the authors on the basis of data from the Great Integrated Household Survey (GEIH) of the National Administrative Department of Statistics (DANE).

Note: The targeting rate can be between -100 and 100, where 100 indicates perfect targeting.

⁸ According to Galasso and Ravallion (2005), the targeting error is calculated as the difference between the proportion of people living in poverty who receive subsidies and the proportion of non-poor people receiving them.

The significant increase in Colombia's social spending between 2020 and 2021 is also reflected in the change in household incomes' dependence on official assistance. Whereas in 2019 official assistance accounting for a share of between 2% and 7% of the incomes of households in the first five deciles, in 2020 the figure rose to between 6% and 31% (see figure 7). That share peaked among the first decile of households in 2020 (31%), when household incomes fell and transfers were increased on account of the pandemic.

Taken together, the estimates indicate appropriate and improved targeting. A high and growing proportion of people living in poverty benefit from official transfers, and the share or importance of those funds increases with the economic deprivation of households. Nevertheless, there is still room for improvement in targeting and in the prioritization of beneficiaries.

VI. Proposal for the design of social transfer programmes

Despite the abundant literature on public poverty reduction policies in general and on the effectiveness of cash transfers in particular, defining and implementing social protection programmes remains a complex undertaking. This paper's conclusions suggest that transfer programmes in Colombia should take account of three key elements, which could also be useful in other contexts: cohesion, conditionality and targeting. The starting point for the redesign of social protection policies must be the fact that a solid foundation of programmes in this area already exists, and that those programmes have an adequate operational infrastructure and are reporting positive results in relation to their objectives. Conditions in Colombia —a country with high levels of poverty, information challenges and budgetary constraints— leave little room for a discussion on a universal basic income.

1. Interconnections

Colombia has a range of programmes that run in parallel and, in some cases, target the same families. Gains in efficiency could be secured by unifying them into a single platform or programme. However, the conditionalities dependent on the life cycle must be maintained. Cohesion would also prevent the existence of different conditions for similar beneficiaries under different programmes, as can happen with *Familias en Acción* and *Ingreso Solidario*. This would prevent asymmetric payments being made to families with similar compositions and in the same socioeconomic situations. Transitioning from one programme to another as the age thresholds are met, in a process that begins in infancy and extends into adulthood, could allow for the incentives for children and adolescents to accumulate human capital to continue.

Integrating the transfer payments would also reduce operating and administrative costs. In some cases, households receive transfers that use different payment schedules and methods. For example, the *Devolución del IVA* programme operates as a supplement to *Familias en Acción* and *Colombia Mayor*, but follows different payment cycles.

2. Conditionality

Although the opinions in the literature do not agree on whether subsidies should be conditioned or not, the information available leads to the conclusion that imposing conditions encourages a greater accumulation of human capital. It has also been shown that the effects of non-conditional programmes tend to dwindle over the long term (Baird, McIntosh and Özler, 2011; Artuc and others, 2020). Some

of the arguments in favour of non-conditional transfers hold that the inability to meet the requirements may exclude the most vulnerable population groups, and that this would be a questionable cost of conditionality (Ladhani and Sitter, 2020; Levasseur, 2021). In designing the conditions, the available findings suggest that careful consideration be given to household composition (Heracleous, González and Winters, 2016) and to the amounts transferred (Levasseur, 2021), ensuring that they outweigh the (direct or indirect) costs of conditionality observance.

In the case of Colombia, no indications were found of the risks of non-compliance with programme conditions and, therefore, of the risk of exclusion. Studies that explore the risks of the most vulnerable segments of the population in relation to conditionalities must be conducted. For example, it would be important to assess whether children and young people belonging to the poorest families are at greater risk of dropping out of school and, consequently, of being excluded from programmes such as *Jóvenes en Acción* and *Familias en Acción*.

3. Targeting

Targeting can also be improved by adjusting the age ranges set for the current transfers. For older persons, the range defined by the *Colombia Mayor* programme could be brought into line with official pension ages. With this strategy, coverage could be expanded to include those persons of pension age who have been excluded owing to budgetary constraints. Currently, payments under *Colombia Mayor* begin three years before the official retirement age. In the age ranges defined for the *Jóvenes en Acción* programme, higher age limits could be considered for people in technical or higher education depending on their place of residence: given that young people living in less developed areas have higher rates of overage,⁹ the age ranges of young people in those areas can be expected to be higher than the national average (Otero and others, 2023).

VII. Summary and lessons learned

Cash transfers, conditional and non-conditional alike, are a key element of social policy in Colombia. In 2022, the national government's *Familias en Acción* and *Ingreso Solidario* transfer programmes had 5.8 million participating families and households, while *Jóvenes en Acción* and *Colombia Mayor* provided assistance to 2.2 million people. The beneficiaries received regular payments that, depending on the programme conditions and the family or household structure, ranged from US\$ 3.50 to US\$ 47.00 per month. In 2021, approximately 72% of the Colombian population living in poverty received at least one type of transfer.

Before the pandemic, the existing transfer programmes differed in that their target populations were at different points in the life cycle. *Familias en Acción* targets preschool and school-age children and adolescents, *Jóvenes en Acción* benefits young people of higher-education age, while *Colombia Mayor* is aimed at older persons. All the programmes focus on the poor and vulnerable population, as indicated by the different instruments used to identify beneficiaries. In addition, *Familias en Acción* and *Jóvenes en Acción* are transfer programmes that require beneficiaries to meet certain conditions in order to receive disbursements. These conditions are intended to encourage the accumulation of human capital by children and adolescents.

In 2020, on account of the COVID-19 pandemic, cash transfer coverage was significantly expanded through two new programmes: the launch of the *Devolución del IVA* programme was brought forward, and *Ingreso Solidario* —targeting households not covered by the existing programmes— was created.

⁹ Defined as the mismatch between actual age and the expected average age for a given school grade.

During its existence, between 2020 and 2022, *Ingreso Solidario* was the largest programme in terms of both its beneficiaries and its budget. The adoption of these new programmes allowed people living in poverty who were not in the age ranges set for *Familias en Acción*, *Jóvenes en Acción* or *Colombia Mayor* to receive some type of a subsidy, enabling all age groups to be potential beneficiaries.

The effectiveness of transfers in improving different aspects of the beneficiary households' lives has been extensively established in the literature. In the case of Colombia, empirical information indicates positive impacts on consumption, health, education, employment and other areas. Moreover, there is no conclusive information that receiving transfers discourages labour market participation.

Cash transfers undoubtedly have a significant fiscal cost. In 2022, they accounted for 1.13% of GDP. This does not mean, however, that the existing transfer programmes are unsustainable. In particular, it should be noted that the number of transfer beneficiaries ran high between 2020 and 2021, on account of the economic crisis caused by the COVID-19 pandemic. As the country's economy recovers, however, the number of subsidy recipients can be expected to fall, if strict targeting criteria based on the Sisben classification are maintained.

The lessons that can be drawn from two decades of cash transfer programme implementation in Colombia suggest that despite their success as support mechanisms, in mitigating declining consumption among the poorest households and as an incentive to encourage behavioural changes that allow children and young people to accumulate human capital, it would be useful to review the current status of the programmes as a whole, in light of their rapid growth since 2020.

Discussions about the possibility of introducing a universal basic income in the country are futile, given the current fiscal deficit, which is above the limits recommended by the Autonomous Fiscal Regulations Committee (CARF, 2022). This article discusses the usefulness of unifying the social transfer programmes into a single platform, with clear criteria for targeting and conditionalities according to the life cycle and households' socioeconomic conditions. A model with unified criteria could be considered, which would allow for a single transfer programme targeting children in primary and secondary education, young people in tertiary education and un pensioned older persons. Additionally, consideration could be given to a hybrid model that integrates the current conditionalities with non-conditional transfers targeting households with children and single-person households of pension age that are without social security, living in extreme poverty and unable to comply with the current requirements.

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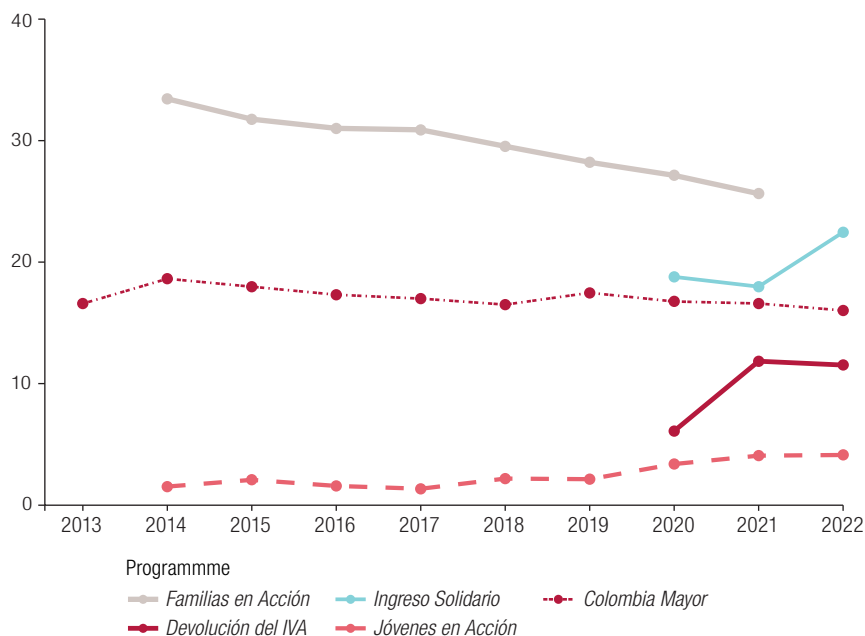
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Annex A1

Figure A1.1
Colombia: proportion of beneficiaries in relation to their reference group,
by programme, 2013–2022
(Percentages)



Source: Prepared by the authors.

Note: In all cases, the reference groups are taken from Colombia's census-based population and household projections; the exception is the *Familias en Acción* programme, where the number of households with children was estimated on the basis of the Great Integrated Household Survey (GEIH). The reference group for the *Ingreso Solidario* and *Devolución del IVA* programmes is the total number of households; for the *Colombia Mayor* programme, it is the total number of people aged over 54; and for *Jóvenes en Acción*, it is the number of young people aged between 14 and 28. The beneficiary identifier for *Familias en Acción* is the household, even though it targets children.

Annex A2

Table A2.1

Colombia: summary of data and methodologies used in social programme impact assessments

Reference ^a	Data source	Data type	Methodology
Attanasio and others (2010)	Random survey based on <i>Familias en Acción</i>	Administrative records and surveys	Difference in differences
Attanasio and others (2017)	Survey based on <i>Jóvenes en Acción</i> and Integrated Contribution Settlement Form (PILA)	Administrative records and surveys	Difference in differences
Attanasio and others (2021)	Administrative information from <i>Familias en Acción</i> and Sisben	Administrative records	Regression discontinuity
Attanasio and others (2023)	Administrative information	Administrative records	Regression discontinuity
Attanasio, Kugler and Meghir (2011)	Random survey based on <i>Jóvenes en Acción</i>	Administrative records and surveys	Difference in differences
Barrientos and others (2013)	Sisben and other administrative records	Administrative records	Regression discontinuity
Benson (2012)	Censuses	Population censuses	Matched difference in differences
Cáceres (2021)	Sisben and the National Quality of Life Survey	Administrative records and surveys	Regression discontinuity and correspondence based on propensity score
Camacho and Rodríguez (2020)	Administrative information from <i>Familias en Acción</i> and the National Institute of Forensic Medicine and Science	Administrative records	Event study
Cardona-Sosa, Medina and Núñez (2017)	Survey based on <i>Familias en Acción</i> , Sisben and Financial Superintendency of Colombia (SFC)	Administrative records	Regression discontinuity
Contreras and Maitra (2021)	Administrative information from <i>Familias en Acción</i>	Administrative records	Difference in differences
Cortés, Gallego and Maldonado (2016)	Behaviour survey and attitudes about sexuality among school-aged children and adolescents (Bogotá)	Surveys	Difference in differences
Econometría/Sistemas Especializados de Información (SEI)/University of the Andes (2021)	Survey by experiment and administrative records	Administrative records and surveys	Regression discontinuity
Gallego and others (2021)	Telephone survey	Surveys	Difference in differences
Gómez (2017)	Databases of the Colombian Education Evaluation Institute (ICFES), the Higher Education Dropout Prevention System (SPADIES) and the National Training Service (SENA)	Administrative records	Regression discontinuity
Kugler and others (2022)	Survey by experiment and database of the Colombian Institute for the Promotion of Higher Education (ICFES)	Administrative records and surveys	Difference in differences
Londoño-Vélez and Querubín (2020)	Survey by experiment and Sisben	Administrative records and surveys	Difference in differences
Núñez and others (2011)	Administrative information from <i>Familias en Acción</i>	Administrative records	Matched difference in differences
Obando and Andrián (2016)	Great Integrated Household Survey (GEIH) and National Quality of Life Survey	Surveys	Decomposition analysis
Pfütze and Rodríguez-Castelán (2015)	National Quality of Life Survey	Surveys	Regression discontinuity
Urrutia and Robles Báez (2018)	<i>Familias en Acción</i> survey	Surveys	Difference in differences and regression discontinuity
Villa (2018)	Administrative information from <i>Familias en Acción</i>	Administrative records	Difference in differences

Source: Prepared by the authors, on the basis of the cited publications.

^a For complete information on the references cited, see the bibliography.

The expected effects of climate change on the current account of Colombia

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Abstract

This study examines the expected effects of climate change on the current account of Colombia. We present a literature review that explains how the associated risks affect the balance of payments. We then project the current account balance until 2050 in different climate scenarios to establish whether the impact of these risks could affect the country's current account over the long term. Our results indicate that, compared with a scenario in which current climate policies are maintained, achieving net zero emissions by 2050 could widen the current account deficit by the equivalent of 4.6% of GDP. Under a scenario in which the transition is delayed, the cost would be equivalent to 2.6% of GDP. This finding can be attributed to a permanent drop in oil prices and an expansion of public debt, resulting from a decline in global demand for fossil fuels and additional spending to meet environmental targets.

Keywords

Climate change, economic aspects, risk, national accounts, balance of payments, economic conditions, Colombia

JEL classification

F32, Q51, Q54

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I. Introduction

Relative to pre-industrial levels, global temperature has increased markedly (by 1.1 °C) over the last few decades, a trend that will continue through the twenty-first century as a result of greenhouse gas emissions, the main cause of climate change (Bárcena and others, 2020). In the most encouraging scenario, where decisive action is taken to curb their production, average temperatures will increase by 2 °C by the end of the century, while increases of between 3.5 °C and 4 °C are projected if current climate policies are maintained (IPCC, 2021; Acevedo and others, 2017). Therefore, regardless of future climate scenarios, the effects of climate change will be compounded by more frequent, intense and long-lasting climate disasters, such as hurricanes, droughts and floods (NGFS, 2021; Knutson, Landsea and Emanuel, 2010).

This is a matter of significant concern, as the costs associated with such events are substantial. Although uncertainty remains high with regard to the scope of losses, the literature suggests that an average global temperature rise of 2.5 °C will produce losses equivalent to 1.4% of gross domestic product (GDP), and that depending on the implementation of climate change mitigation measures, losses could reach the equivalent of 4 percentage points (Tol, 2018).

Although this impact could initially be considered moderate, losses rise to the equivalent of 2% of GDP with a temperature rise of 3 °C and reach 8.1% of GDP with a rise of 6 °C (Nordhaus and Moffat, 2017). The effects on economic activity are also persistent. According to Dell, Jones and Olken (2012), a 1 °C increase in temperature would reduce the long-term economic growth rate by 1.6 percentage points.

In an effort to offset the macroeconomic impacts of climate change, numerous containment initiatives (1,302 between 1998 and 2017) have been taken around the world, most aimed at limiting fossil fuel consumption and production (Batten, Sowerbutts and Tanaka, 2020; Gaulin and Le Billon, 2020; IEA, 2019; Krogstrup and Oman, 2019; World Bank, 2019; Batten, 2018). McGlade and Ekins (2015) calculate that, to limit temperature rise to 2 °C by 2050, one third of oil reserves, half of gas reserves, and 80% of coal reserves should not be extracted or exploited. Although such measures are pro-environment and avoid the costs associated with natural disasters, they pose serious risks to developing countries (Jakob and Steckel, 2014), in particular for economies heavily dependent on mining and energy revenues. The transition towards a low-carbon economy implies the adoption of new energy sources and market schemes that will inevitably affect the demand for these types of products, curtailing income in these countries (Bernal-Ramírez and Ocampo, 2020).

In Colombia, where exports of mining and energy products accounted for 37% of public revenue and the related sectors absorbed 42% of foreign direct investment between 2000 and 2020, a fall in oil prices triggered by a contraction in global fossil fuel demand could produce external imbalances that alter domestic macroeconomic factors (González, Hamann and Rodríguez, 2015). In the absence of alternatives to offset the expected reduction in oil revenues as governments enact climate change mitigation policies, in particular in the advanced economies, the current account deficit of certain countries could widen significantly and sovereign borrowing costs could surge, weakening their external position as an unintended consequence of achieving universal climate goals.

In this study, we show that in scenarios with greater implementation of climate change mitigation measures, the current account deficit in Colombia would grow by the equivalent of between 2.6% and 4.6% of GDP, compared with growth in the current climate policy scenario. This deterioration would stem from a permanent drop in oil prices and an expansion of public debt, resulting from weaker global fossil fuel demand and additional spending to meet environmental targets.

The remainder of this study is organized as follows: section II describes the risks associated with climate change and the climate scenarios considered in the study. Section III is a literature review explaining how these risks can affect the balance of payments of countries whose income is heavily dependent

on mining and energy. Section IV describes the variables, data and econometric approach used to project the current account balance until 2050. Section V contains projections for the current account balance between 2021 and 2050 in the different climate scenarios and analyses the effects of climate change risks on the long-term external position of Colombia. Section VI contains concluding remarks.

II. Risks and scenarios associated with climate change

To analyse how the impact of the risks associated with climate change can affect the long-term current account in Colombia, we employ the climate scenarios of the Central Banks and Supervisors Network for Greening the Financial System (NGFS). These scenarios serve as an analytical framework that facilitates the identification of macroeconomic and financial risks in the coming decades on the basis of assumptions that differ in scope of climate policies and technological advances (NGFS, 2021). The NGFS climate risk scenarios include physical and transition risks. Physical risks include the economic losses generated by climate shocks (such as hurricanes, floods and droughts), which can amount to 25% of GDP. Transition risks represent the cost of adjustments arising from changes to environmental policy and regulations and from technological advances and shifts in consumer preferences, which can reach 9% of GDP (NGFS, 2021).

The trajectories in the various NGFS climate scenarios are determined by these risks. In particular, the establishment of strong climate policies reduces physical risks, since the timely implementation of containment measures limits the impact of future climate shocks and the resulting economic losses. However, achieving the related environmental goals generally involves the use of economic mechanisms (taxes, tradable permits and subsidies) that affect certain economic activities and boost spending, increasing the influence of transition risks.

These trade-offs are reflected in the different NGFS climate scenarios, three of which are considered in this study: current policies, a delayed transition, and net zero by 2050. In the current policy scenario, it is assumed that existing climate policies are maintained for decades, with no further efforts aimed at strengthening climate change mitigation. In this scenario, the global temperature would exceed 3 °C (relative to pre-industrial levels) by 2080, leading to significant physical impacts. Likewise, technology that enables carbon to be removed from the atmosphere would advance slowly, limiting the capacity to contain climate disasters and their impacts.

Unlike the previous scenario, the delayed-transition and net-zero-by-2050 scenarios impose climate goals. The first assumes that global temperature rise remains below 2 °C (relative to pre-industrial levels) between now and 2050; the second assumes that net zero emissions levels are achieved by 2050, and sets the limit for global temperature rise at 1.5 °C (relative to pre-industrial levels) for the same time horizon. Climate targets are mainly achieved through market mechanisms (such as environmental taxes or tradable permit systems) that internalize the social cost of carbon emissions by raising the price of energy, which curbs fossil fuel demand (NGFS, 2021; Bauer and others, 2016).¹

The main distinction between these scenarios lies in the timing of the enactment of measures aimed at meeting emissions targets and that of the availability of carbon removal technologies. The net-zero-by-2050 scenario involves the immediate introduction of climate policies that accelerate the transition towards renewable energy sources. In the delayed-transition scenario, current climate policies are maintained until 2030, after which stringent measures are implemented, and greater technological capacity to remove carbon dioxide from the atmosphere is projected. Under the scenario in which

¹ Annex A1 shows the shadow carbon price path between 2020 and 2050 based on the different climate scenarios considered in this study. A higher carbon price reflects a more stringent climate policy (NGFS, 2021).

current policies are maintained, coal and oil each continue to account for more than 25% of total energy consumption. In the delayed-transition scenario, these shares are fixed to match the trend of the current policy scenario until 2030 and rapidly decrease thereafter, with coal consumption almost null and oil accounting for 19% of total energy consumption by 2050. The net-zero-by-2050 scenario projects a similar, albeit more gradual, decline in demand for fossil fuels (NGFS, 2021).

In each scenario, the path for public debt is determined by the following factors: (i) losses produced by climate disasters, which affect economic activity; (ii) the cost of reconstruction and adaptation to climate change; and (iii) spending related to the implementation of climate change mitigation policies (Bernal-Ramírez and others, 2022). These factors vary across the scenarios and in their impact on central government indebtedness. For example, in the net-zero-by-2050 scenario, countries make a comprehensive commitment to mitigate climate change such that public spending on this component is higher than in the other scenarios. Similarly, global demand for mining and energy products falls more sharply, resulting in comparatively lower government revenues in oil-exporting countries. However, in this case, economic growth is higher because fewer and less intense climate disasters mean less economic loss and disruption, forestalling reconstruction costs. Conversely, in a scenario in which current climate policies are maintained, public spending would be lower since there would be no strengthening of policy in this area. Furthermore, oil revenues would be higher since the global demand for mining and energy products would remain robust. However, in this case, a drop in economic growth is anticipated, as a result of sectoral losses produced by natural disasters as well as increases in public spending for reconstruction and adaptation to climate change.

III. Literature review of the effects of risks associated with climate change on the balance of payments

According to the literature, the main climate change risks that can affect a country's balance of payments include the following: (i) deterioration of transport infrastructure, (ii) negative shocks to agricultural productivity, (iii) a fall in the price of mining and energy products, and (iv) an increase in the cost of sovereign borrowing. The first two are physical risks, while the other two constitute transition risks.

With respect to the first risk, the expected increase in the frequency and intensity of climate disasters would adversely affect infrastructure critical for international trade, such as ports and roads (IPCC, 2014; Schweikert and others, 2014; UNEP/WTO, 2009). In this regard, Calderón and others (2014) estimate that, by 2040, the effects of climate change would reduce the operating capacity of the transport sector in Colombia by 2.3%. This would aggravate logistical deficiencies that affect the country's competitiveness on international markets and significantly limit commercial activity (Arvis and others, 2016; Dennis and Shepherd, 2011; García García, Montes Uribe and Giraldo Salazar, 2019; Ramírez-Giraldo and others, 2021).

With regard to the second risk, the increasing impacts of climate disasters will trigger economic losses that reduce agricultural productivity. According to Zhai and Zhuang (2009), by 2080, global agricultural production will have fallen by 7.4% as a result of the effects of climate change, affecting developing countries to a greater extent. Masters, Baker and Flood (2010) estimate that this would represent a 20% reduction in low- and middle-income countries. Gallic and Vermandel (2020) calculate that climate fluctuations account for 35% of the variation in New Zealand's agricultural production. Likewise, Álvarez-Espinosa and others (2014) estimate that annual agricultural production in Colombia would decrease by between 1.9% and 2.8%, which in turn would cut this sector's exports by approximately 6.3%.

The price of mining and energy products would also fall owing to the establishment of policies and regulations aimed at containing the effects of climate change (Arndt and others, 2019). These policies would progressively weaken global fossil fuel demand, curtailing public revenue in economies highly dependent on exports of these types of goods (Bernal-Ramírez and Ocampo, 2020; NGFS, 2019; Carbone and Rivers, 2017; Burnete and Choomta, 2015; Böhringer, Fischer and Rosendahl, 2010). In this area, Mattoo and others (2012) estimate that, in response to a 17% decline in global carbon emissions, the value of energy exports in low- and middle-income countries would drop by 8.2% compared to a scenario in which current climate policies were maintained. In South Africa, the value of coal exports would fall by 65% by 2035 in response to a 50% contraction in foreign demand, costing the equivalent of one third of GDP (Huxham, Anwar and Nelson, 2019). Meanwhile, Makarov, Chen and Paltsev (2020) project that, if the climate targets of the Paris Agreement (UNFCCC, 2016) are met by 2030, the decline in the value of Russian fossil fuel exports would dampen the country's economic growth by half a percentage point. In Colombia, the transition to renewable energy sources would cut the demand for coal by 68% by 2030 and limit exports (Oei and Mendelevitch, 2019). Furthermore, Álvarez-Espinoza and others (2017) calculate that the enactment of the policies that would allow Colombia to meet its commitments under the Paris Agreement would reduce the value of Colombian exports by between 8% and 9% by 2040.

The expected decline in economic growth and overall revenue would erode investor confidence and intensify uncertainty, increasing sovereign risk (Cevik and Jalles, 2020). Countries highly vulnerable to climate change would face a rise of 1.2% in sovereign borrowing costs, on average (Beirne, Renzhi and Volz, 2021; Kling and others, 2018). Furthermore, the intensity of climate shocks, particularly in agricultural or tropical countries, could trigger sovereign defaults or restrict sovereign borrowing capacity (Mallucci, 2020; Sturzenegger and Zettelmeyer, 2007; Van Dijk and others, 2000; IMF, 1999).

1. Effects of the 2014–2015 oil price shock on Colombia's balance of payments

Over the past decade, conditions characterized by favourable terms of trade resulting from positive oil price shocks produced surpluses that bolstered economic growth and narrowed trade deficits in various economic sectors in Colombia (López and others, 2013; Toro and others, 2015). However, this deepened the country's reliance on oil revenues and intensified its vulnerability to external shocks that hinder economic growth (Garavito-Acosta and others, 2020). On average, between 2000 and 2020, the value of mining and energy product exports was equivalent to 6% of GDP, 37% of public revenue (more than 50% during the oil price boom at the beginning of the 2010s) and 42% of foreign direct investment. It is therefore no surprise that the negative oil price shock in 2014 and 2015 widened the current account deficit by the equivalent of 7% of GDP. During this period, foreign direct investment flows in the oil sector fell by 35% and the emerging markets bond index (EMBI) risk premium for Colombia rose by 121 basis points (Francis and Restrepo-Ángel, 2018; Toro and others, 2015).

IV. An estimation of the current account

This section provides projections of Colombia's current account balance in different climate scenarios to establish whether the impacts of the risks associated with climate change would affect the country's current account over the long term. First, the current account is estimated between 1997 and 2020 to obtain the long-term relationships between this variable and some of its main determinants. Next, a linear projection of the current account between 2021 and 2050 is made, using the results of the

estimation combined with the expected trajectories for the determinants in the scenarios considered in this study. Lastly, deviations in the current account balance with respect to a scenario of unchanged current policies are calculated, to analyse how the implementation of climate change mitigation measures could affect the country's long-term current account deficit.

The projections of this study do not factor in any government responses or exchange-rate movements that would offset a potential expansion of the current account deficit, such as public spending cuts or real depreciation.² Likewise, there is no measurement of physical or transition risks, or of their contribution to the differences in the current account across scenarios. However, despite these limitations, the model captures 87% of the variation observed in the current account balance in recent decades.

1. Determinants of the current account

The selection of current account determinants was based on a literature review of studies that included empirical exercises for estimating the current account. We found that the factors that affect the behaviour of this variable are the dependent population, public debt, per capita GDP, the oil price, the foreign interest rate, and life expectancy (see table 1). The set of variables included in the estimations was determined by the availability of prospective data, since there are no projections (particularly in different climate scenarios) for some of the factors that normally affect the current account trend, such as net external assets, financial depth, terms of trade and value of oil exports. The data are annual, and the analysis refers to 1997–2020.³

Table 1
Determinants of current account balance

Variable	Description	Source	Expected effect
Dependent population	Population aged over 65 as a proportion of the total workforce	National Administrative Department of Statistics	Negative
Public debt	Balance of total central government debt as a percentage of GDP	Ministry of Finance and Public Debt	Negative
Per capita GDP	Per capita GDP	Bank of the Republic of Colombia	Negative
Oil price	West Texas Intermediate oil price	United States Energy Information Administration	Positive
Foreign interest rate	Federal funds rate	United States Federal Reserve	Positive
Life expectancy	Life expectancy at birth	National Administrative Department of Statistics	Positive

Source: Prepared by the authors.

Note: Although demographic variables do not vary across scenarios, they were included among the determinants of the current account balance because of their importance in explaining the variation in this variable over the period of analysis.

The expected effect of each determinant may differ across studies, and ultimately depends on context-specific factors, such as country, analysis period, frequency of data, number of observations, measurement units and estimation technique. However, the overarching effect of the determinants indicated in this study can be described as follows: an increase in the dependent population reduces national savings, as retirees use their savings, thereby reducing the value of net external assets, which in turn produces a current account deficit (Khan, Nsouli and Wong, 2002; Lane and Milesi-Ferretti, 2002;

² The inclusion of endogenous variables in the estimations would require a general equilibrium model in which the Colombian economy adjusts to the shocks considered in this study. However, the general equilibrium models employed in the NGFS climate scenarios are not applicable to Colombia.

³ Annex A2 summarizes the literature reviewed to identify the determinants of the current account balance.

Ojeda-Joya and Torres, 2012). The effect of public debt is similar, albeit channelled through increases in public spending. This is offset by increases in life expectancy, a factor that favours national savings (Backus, Cooley and Henriksen, 2014). The effect of per capita GDP increases is negative, as higher growth is associated with strengthening domestic demand, which translates into higher imports. Rises in oil prices improve terms of trade, increasing the value of exports. Lastly, a higher foreign interest rate drives capital outflows from emerging economies (such as Colombia) and tightens external financing conditions, producing real depreciation that enhances the country's competitiveness and boosts exports, improving the current account balance.

2. Estimation method

We estimated the long-term correlation between the current account balance and indicated determinants through an autoregressive vector model employing the fully modified least squares method. This method, proposed by Phillips and Hansen (1990), mitigates endogeneity caused by simultaneous causality deriving from a cointegration relationship between non-stationary regressors. Moreover, anticipating that some determinants contain a unit root and assuming the existence of a cointegration vector, we apply the extension proposed by Phillips (1995). This enables the addition of series with a unit root in the estimations without compromising statistical inference, since the estimators resulting from this approach exhibit a mixed normal (normal) asymptotic distribution for non-stationary (stationary) series.⁴

To verify the existence of a unit root in the series of determinants of the current account balance, as well as a possible cointegration relationship between them, we applied the augmented Dickey-Fuller and Engle-Granger tests; the results are shown in tables 2 and 3.^{5 6} According to these tests, the foreign interest rate is stationary, the oil price has a unit root, and the other variables contain two unit roots. Therefore, the variables with two unit roots must be differentiated before being included in the estimations, such that the change in these variables represents a growth rate, except in the case of life expectancy (see table 2). Series containing a unit root show a strong trend component during the period of the study. Population dependency and life expectancy are estimated to have increased steadily over the past few decades, highlighting changes in demographic patterns, such as population ageing and improvements in quality of life. Central government debt as a percentage of GDP reached 59% in 2020, following rates of roughly 13% in the mid-1990s, an increase that highlights institutional changes which had a significant impact on public expenditure. The results of the Engle-Granger test indicate that there is indeed a cointegration relationship between the variables of the system, validating the estimation of the current account balance by means of fully modified least squares (see table 3). To corroborate the results of the Engle-Granger cointegration test, the augmented Dickey-Fuller test was performed for residuals resulting from the estimation of the current account balance and its determinants, with the results showing stationary behaviour, thus indicating that, indeed, the series displays a long-term cointegration relationship.

⁴ When this problem arises, ordinary least square estimators exhibit a non-Gaussian, biased and asymmetric asymptotic distribution, thus invalidating the results of the estimations (Wang and Wu, 2012).

⁵ To corroborate the findings of the augmented Dickey-Fuller test, we performed a Phillips-Perron unit root test, whose results confirmed the need to differentiate the dependent population, per capita GDP, public debt and life expectancy variables before performing estimations using fully modified least squares (see annex A3).

⁶ The results of the augmented Dickey-Fuller and Engle-Granger tests are robust to the information criterion used to detect the unit root and cointegration.

Table 2
Augmented Dickey-Fuller test

Variable	Series in levels	First difference	Second difference	Result
Dependent population	-4.405	-2.164	1.681**	I(2)
Log per capita GDP	-1.381	-1.041	-4.352***	I(2)
Public debt	0.793	-0.792	-5.769***	I(2)
Foreign interest rate	-4.027**	-	-	I(0)
Oil price	-1.195	-4.974***	-	I(1)
Life expectancy	-2.287	-0.536	-4.839***	I(2)

Source: Prepared by the authors.

Note: The null hypothesis of the augmented Dickey-Fuller test states that the series analysed contains a unit root. The test was performed using the Schwarz information criterion. *, ** and *** indicate rejection of the null hypothesis at 90%, 95% and 99% confidence levels, respectively.

Table 3
Engle-Granger Test

	Value	p-value
Engle-Granger statistic	-7.780	0.018

Source: Prepared by the authors.

Note: Dependent variable: current account balance between 1997 and 2020. Null hypothesis: there is no cointegration relationship between the variables of the system. The estimation equation includes public debt, dependent population, log per capita GDP, life expectancy, oil price and foreign interest rate. Specification: test without lags using Schwarz's information criterion.

The results of the estimation of the long-term relationship between the current account balance and its determinants are found in table 4. All variables proposed for this exercise, except the foreign interest rate, are statistically significant and exhibit the expected sign. The determinants with the biggest impact on the current account trend are the growth rate of the dependent population and per capita GDP.

Table 4
Estimation of long-term relationship between current account balance and its determinants, 1997–2020

Determinants	Coefficients	Standard error	p-value
Public debt	-0.042	-1.680	0.093
Dependent population	-18.997	-19.07	0.000
Per capita GDP	-25.429	-8.950	0.000
Life expectancy	3.073	5.660	0.000
Foreign interest rate	0.030	0.950	0.342
Oil price	0.471	2.760	0.006
Constant	-0.558	-0.780	0.435
R-squared	0.875		
Adjusted R-squared	0.825		
Standard error	0.738		
Long-term standard error	0.218		

Source: Prepared by the authors.

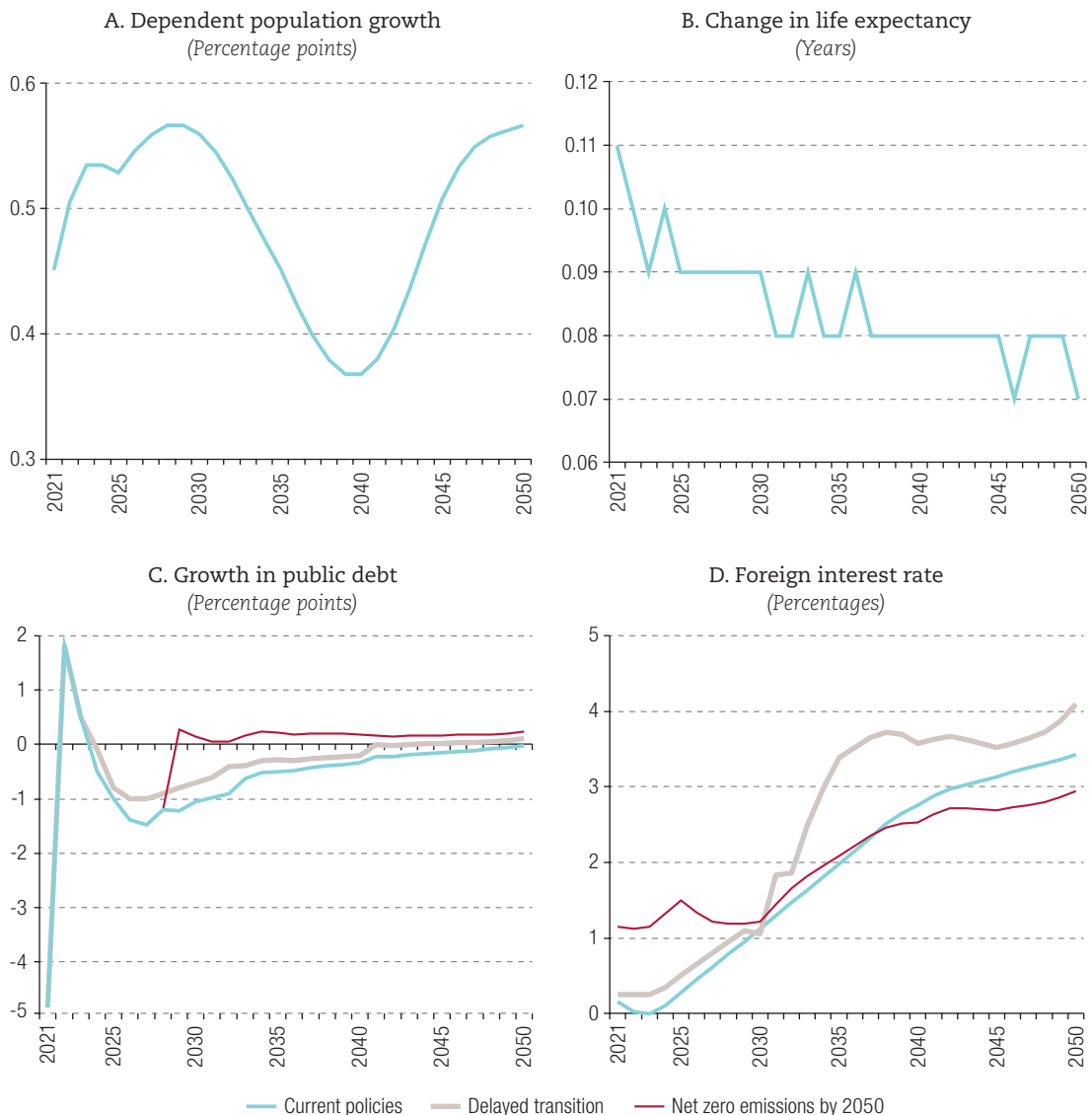
Note: Dependent variable: current account balance as a percentage of GDP. The series that refer to the dependent population, life expectancy, public debt and the logarithm of per capita GDP contain two unit roots, which requires their differentiation before entering estimations.

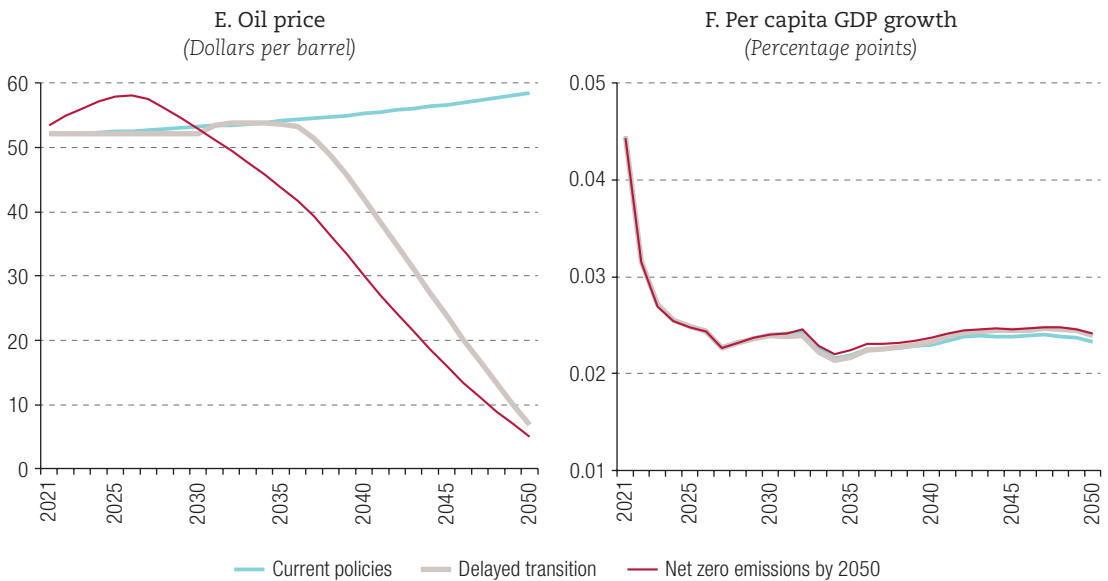
V. Projection of the current account balance

To project the current account balance, we use the long-term relationship between this variable and its determinants in conjunction with their expected trajectories in different climate scenarios (see figure 1). The paths for public debt and per capita GDP are based on the projections presented in Bernal-Ramírez and others (2022). If current climate policies are maintained, public spending on climate change mitigation and adaptation is constant and accounts for 19.6% of annual GDP. Oil revenues initially contribute 0.6% of GDP, which then falls by 0.2 percentage points by 2050 because of an energy transition that eliminates this source of tax revenues. In a delayed-transition scenario, government spending on climate change would increase by 0.4 percentage points of GDP and oil revenues would decrease by 0.4 percentage points if net zero emissions were reached by 2050; spending in this area would increase by 0.6 percentage points of GDP, while oil revenues would disappear from the end of the current decade.

Figure 1

Determinants of current account balance in different climate scenarios, 2021–2050





Source: Prepared by the authors on the basis of information from the Central Banks and Supervisors Network for Greening the Financial System (NGFS) and the National Administrative Department of Statistics.

Note: The series that refer to the dependent population, life expectancy, public debt and the GDP logarithm require differentiation before the estimations are entered. This figure therefore presents growth rates or changes for these variables. The figure shows changes to the current account balance across the different climate scenarios considered in this study, in percentage points of GDP, using the current policy scenario as a baseline. Negative values indicate a wider current account deficit compared with the baseline scenario.

The projections of Bernal-Ramírez and others (2022) show that, under current climate policies, GDP would decline by 8% by 2100. The expected losses in the scenarios in which climate change mitigation measures are implemented would be equivalent to between 2% and 3% of GDP. In keeping with the above, economic growth rates would be higher in the scenarios of delayed transition and net zero by 2050, which highlights the potential for physical risks to dampen economic activity.

The trends for the oil price and the foreign interest rate are derived from the projections shown in NGFS (2021) for the REMIND-MAGPIE model.⁷ In particular, the oil price trend reflects the climate policy differences in the different scenarios. If current policies continue, this variable will maintain an upward trajectory, which is to be expected considering the absence of tangible efforts aimed at containing climate change. However, in the other scenarios, the trajectories reflect the introduction of measures aimed at supporting the achievement of climate goals. In the net-zero-by-2050 scenario, the oil price would immediately rise owing to the imposition of carbon taxes. However, a transition to renewable energy sources would trigger a permanent decrease from the end of the current decade.

In the models used by NGFS, monetary policy is adjusted to contain inflation and depends to a significant extent on energy price trends. In the net-zero-by-2050 scenario, the Federal Reserve monetary policy rate would be raised to counter the positive shock to the oil price. The same response is seen in the delayed-transition scenario, albeit with some lag. Under the current policies, this variable continues trending upward, keeping pace with the oil price.

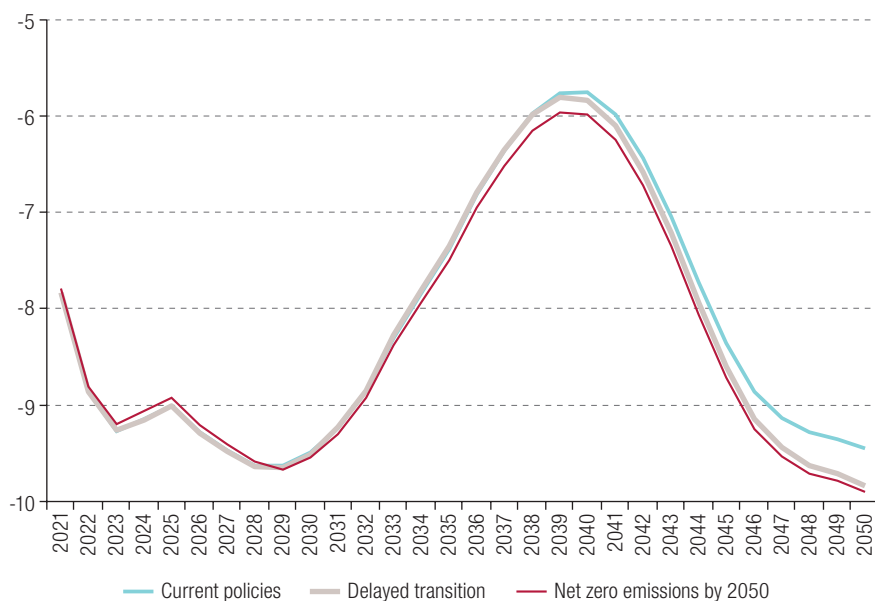
⁷ Owing to the elevated uncertainty inherent to scenario analysis, three socioeconomic models are used to generate possible trajectories for the variables of interest under the NGFS framework: the Global Change Assessment Model (GCAM), MESSAGEix-GLOBIOM and REMIND-MAGPIE. The paths for macroeconomic variables are obtained by combining information from these models with a global macroeconomic model (NiGEM) that incorporates trade and capital markets. The MESSAGEix-GLOBIOM and REMIND-MAGPIE models favour macroeconomic analysis because they allow for endogenous changes in macroeconomic variables (for example, prices, consumption and GDP). However, only the results associated with REMIND-MAGPIE are shown, since it models endogenous technological changes and has higher-frequency data, thus favouring scenario analysis (NGFS, 2021).

The dependent population and life expectancy data are obtained from the demographic projections of the National Administrative Department of Statistics and remain the same in all scenarios; they also capture demographic trend projections in Colombia over the coming decades. According to Parra and others (2020), a steady decline in fertility would lead to population ageing, increasing the proportion of retirees who depend on transfers for their subsistence compared with the proportion of the population able to put away savings. Likewise, it is projected that life expectancy will continue to rise steadily, highlighting the advances in quality of life.

1. Results

Figure 2 shows the expected path of the current account balance between 2021 and 2050 in the climate scenarios described in section II. In the short term, the current deficit widens, which can be explained by three factors: (i) an increase in the dependency ratio; (ii) central government debt from the implementation of programmes to cushion the economic impacts of the coronavirus disease (COVID-19) pandemic; and (iii) per capita GDP growth as economic activity normalizes following the negative shock caused by the pandemic.

Figure 2
Projection of current account balance in different climate scenarios, 2021–2050
(Percentages of GDP)



Source: Prepared by the authors.

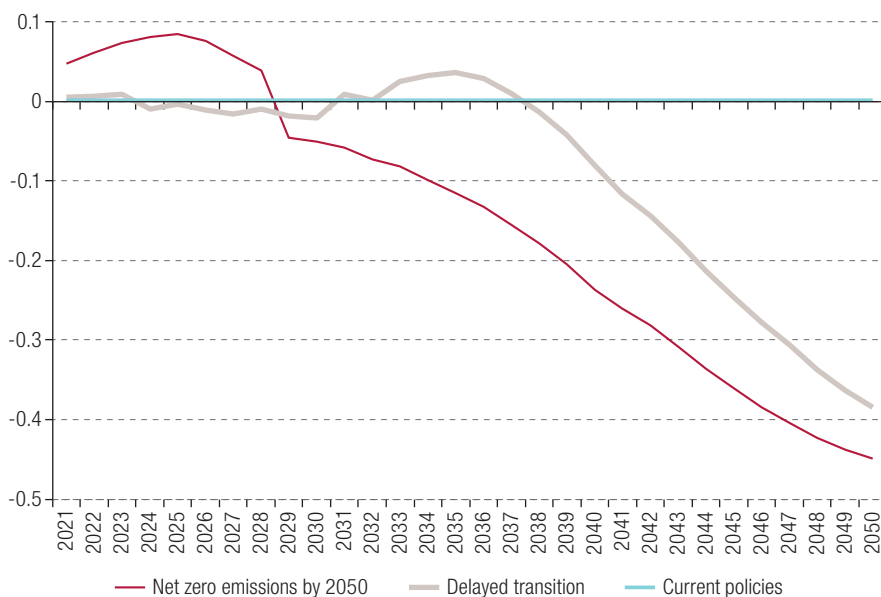
Over the long term, the path of the current account balance will be determined mainly by the growth rate of the dependent population and by oil prices. Specifically, a decrease in the dependency ratio is expected at the beginning of the next decade, resulting in the current deficit reaching a nadir by 2040. However, new demographic changes would reverse the downward trend in this variable, widening the current deficit further. This is consistent with Parra and others (2020), in which demographic projections show gradual population ageing owing to a decrease in the fertility rate from 2030 onward. This would cause a decrease in the proportion of the working-age population (persons aged 18–65), which explains the expected increase in the dependency ratio. Under scenarios in which the impact of transition risks is high, a wider current account deficit driven by a greater dependency ratio would be exacerbated by a permanent decrease in the oil price, which would further worsen the external position.

The other determinant whose effect and magnitude are statistically relevant is per capita GDP. It would vary so little in the future that its contribution to the fluctuations of the current account balance would be limited. Likewise, although public debt is one statistically relevant factor that is expected to change significantly in the coming decades, the magnitude of its effect is comparatively small and its impact on the expected trajectory of the current account balance is moderate.

2. Effects of risks associated with climate change on the long-term current account in Colombia

Figure 3 shows the deviations in the current account balance for the different climate scenarios considered in this study, using a scenario assuming continuity of current climate policies as the baseline. Positive (negative) values indicate a current account surplus (deficit) compared with the baseline scenario. The results of this calculation suggest that the long-term current account deficit would be larger in scenarios in which a robust climate policy was adopted. This deterioration would result from a contraction in external revenues and increments in public debt owing to negative oil price shocks.

Figure 3
Deviations in current account balance in different climate scenarios, 2021–2050
(Percentage points)



Source: Prepared by the authors.

In particular, in the net-zero-by-2050 scenario, there would be a transitory increase in oil price, which would improve the terms of trade and balance in the short term compared with other scenarios where current climate policies are maintained until 2030 or later. This momentum, however, would be weakened by an eventual transition to renewable energy sources and the subsequent permanent decline in the oil price, leading to a gradual expansion of the current deficit. In addition, in the net-zero-by-2050 scenario, long-term public debt would be higher owing to an increase in public spending aimed at mitigating climate change to meet the climate goals of the scenario, which would worsen the deterioration of the country's external position (Bernal-Ramírez and others, 2022).⁸

⁸ In the current policy scenario, oil prices remain relatively high and even increase further.

An analogous situation is expected in a scenario of delayed transition, although in this case the expected deterioration of the current account would occur towards the end of the 2030s. The initial transitory increase in the oil price would be smaller than in the previous case, owing to a less stringent climate policy, reflected in lower carbon taxes (see annex A1). For this reason, the long-term decline in the final oil price would be less steep, curbing the expected deterioration of the current account balance. In this scenario, public finances would also benefit from comparatively lower public debt owing to a reduction in public spending on climate change.

VI. Concluding remarks

The external sector in Colombia is highly vulnerable to risks associated with climate change. Projections for the current account balance in different climate scenarios indicate that the orderly achievement of net zero emissions by 2050 could widen the current deficit in Colombia beginning in the second half of the current decade, compared with a scenario in which current climate policies are maintained. Specifically, we found that the cumulative net cost for the current account balance associated with meeting the climate targets of the net-zero-by-2050 scenario would rise to the equivalent of 4.6% of GDP. This increase is mediated by a permanent decrease in oil price and an increase in public debt. In the event of a delayed transition, this cost would reach 2.6% of GDP.

Regardless of how the transition to a low-carbon economy unfolds, our results show that the implementation of climate change mitigation policies would worsen the country's external position in the long term. These results also emphasize the potential of transition risks to compromise economic activity, since the negative effect on the current account balance would arise despite fewer and less intense physical risks, producing a 6% decline in GDP by 2100 if current climate policies are maintained. According to the results reported in Bernal-Ramírez and others (2022), continuity of current climate policies would lead to a loss equivalent to 7.8% of GDP by 2100. This loss would be 2.0% in a scenario of net zero emissions by 2050.

Other factors that could affect the long-term current account were not included in the projection owing to information constraints. According to Paltsev (2012), negative shocks to agricultural productivity would lead to increases in food prices, which could improve the terms of trade between countries with export potential in this sector, such as Colombia. Conversely, the expected deterioration in transport infrastructure, coupled with an increase in external borrowing costs in response to the contraction in oil revenues, could deepen the long-term current deficit. Ultimately, the effect depends on the magnitude of the impacts associated with physical and transition risks, which exert opposite effects on the current account balance and are highly unpredictable.

Lastly, it is important to consider that the transition risks analysed in this study stem from changes in external factors that Colombia, as a small and open economy, has little control over, such as the oil price (Perilla, 2010). Considering that climate scenarios involving the energy transition are increasingly likely to be realized and that this transition plays an important role in the variations of the long-term current account, it is imperative that the country establish alternatives that can replace oil revenues (Garavito-Acosta and others, 2020). This would diminish the vulnerability stemming from such a shock, mitigating the anticipated impact on external revenues.

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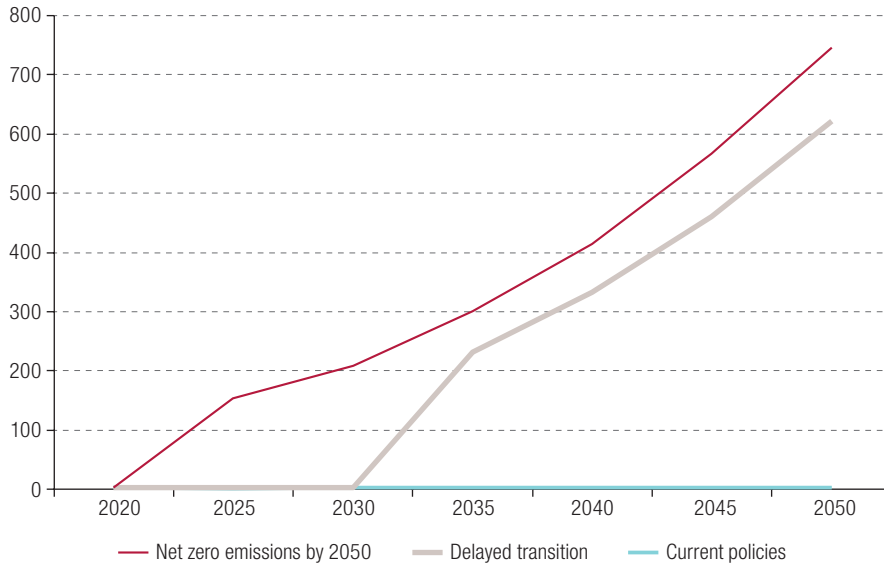
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Annex A1

Figure A1.1
Shadow carbon price path, by climate scenario, 2020–2050
(Dollars per ton of CO₂)

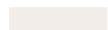



Source: Prepared by the authors on the basis of information from the Central Banks and Supervisors Network for Greening the Financial System (NGFS).

Annex A2

Table A2.1
Literature review of current account determinants

Author(s)	Year	Country	Frequency	Time period	Dependent population	Public debt	Per capita GDP	Oil price	Foreign interest rate	Life expectancy
Arteaga, Luna and Ojeda-Joya	2011	Colombia	Quarterly	First quarter 1994–Fourth quarter 2010	✓					
Backus, Cooley and Henriksen	2014	3 AE; 1 EE	Annual	1980–2013						✓
Cheung, Furceri and Rusticelli	2013	22 AE; 72 EE	Annual	1973–2008	✓					
Chinn and Prasad	2003	18 AE; 71 EE	Annual	1971–1995	✓					
Das	2016	27 AE; 79 EE	Annual	1980–2011						
Faruqee and Debelle	1996	21 AE	Annual	1971–1993	✓					
Lane and Milesi-Ferretti	2002	39 EE	Annual	1970–1998		✓	✓			
Lee and others	2008	22 AE; 32 EE	Annual	1973–2004	✓					
Moral-Benito and Viani	2017	Spain	Annual	1980–2015	✓	✓		✓		
Ojeda-Joya	2019	Colombia	Annual	1986–2017				✓	✓	
Phillips and others	2013	49	Annual	1986–2010	✓					
Sadiku and others	2015	North Macedonia	Quarterly	First quarter 1998–Fourth quarter 2013						

 Negative and significant effect
 Positive and significant effect

Source: Prepared by the authors.

Note: AE denotes advanced economies; EE denotes emerging market economies. Although this table does not include an exhaustive list of the determinants used in the listed studies, it indicates whether the determinants used in this exercise were considered in those studies.

Annex A3

Table A3.1
Phillips-Perron unit root test

Variable	Series in levels	First difference	Second difference	Result
Dependent population	1.518	-2.652	-5.674***	I(2)
Per capita GDP	-1.858	-0.066	-6.405***	I(2)
Public debt	0.496	-1.924	-5.766***	I(2)
Foreign interest rate	-1.892*	-	-	I(0)
Oil price	-1.669	-4.661***	-	I(1)
Life expectancy	-2.906	-1.507	-4.163***	I(2)

Source: Prepared by the authors.

Note: The null hypothesis of the Phillips-Perron test states that the series analysed contains a unit root. *, **, *** indicate rejection of the null hypothesis at 90%, 95% and 99% confidence levels, respectively.

Foreign capital and national development in the debate between Celso Furtado and Maria da Conceição Tavares (1964–1982)

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Abstract

The aim of this article is to analyse foreign capital and national development in the debate between Celso Furtado and Maria da Conceição Tavares between 1964 and 1982. To this end, it investigates how Furtado's analytical radicalization, following the 1964 coup d'état in Brazil, enabled him to make a pioneering interpretation of the transnationalization of capital in Latin America and the Caribbean, despite Tavares' criticism of his stagnationist thesis. Moreover, although Tavares was considered to have won the debate with Furtado, this study reveals how her approach failed to define the limits of peripheral industrialization when capital in the region was under foreign control.

Keywords

Economic development, capital, foreign investments, capital controls, Furtado, Celso, economists, thinking, economic history, Brazil, Latin America

JEL classification

B31, B25, F63

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I. Introduction

Frustration with the import-substitution-industrialization process in the 1960s was compounded by the political infeasibility of reforms to overcome underdevelopment. This led a new generation of thinkers influenced by the classical structuralism of the Economic Commission for Latin America and the Caribbean (ECLAC) inaugurated by Prebisch (2000), or critics thereof, to rethink the relationship between foreign capital and national development in Latin America and the Caribbean. These thinkers, most of them exiled in Chile because of the dictatorships prevailing in their respective countries, proposed new ways of interpreting the Latin American reality. This gave rise to dependency theories (for example, Frank, 1966; Cardoso and Faletto, 1975; Sunkel, 1971; Marini, 2005), and to neo-structuralist approaches to development styles, based on Keynesian, Kaleckian and neo-Schumpeterian theories (for example Pinto, 2000 and Fajnzylber, 1976).¹

In this context, Maria da Conceição Tavares, with co-author José Serra (1983), critiqued Celso Furtado's stagnationist model, as described in *Subdesenvolvimento e Estagnação na América Latina* (1966). In 1970, at the height of the “economic miracle” (1968–1973), Tavares and Serra (1983) argued, in *Além da estagnação: uma discussão sobre o estilo de desenvolvimento recente do Brasil*, that Furtado's error in interpreting the crisis of the 1960s was based on the use of neoclassical economic theory, which made unrealistic assumptions about perfect competition and used categories (such as the capital-output ratio and the effective profit rate) that did not explain the dynamic nature of the Brazilian economy. Although she considered Furtado one of her great teachers, Tavares sought new theoretical bases in this critique, having, like him, relied on classical structuralism until then.²

Reinforced in her later work (Tavares, 1998, 1986a and 1986b), the critical interpretation of Furtado (Tavares and Serra, 1983) was inspired by Kalecki's cycle and oligopoly theories (for example, Kalecki, 1987; Steindl, 1983). From a historical standpoint, this “second Tavares” approach pointed to a new periodization of Brazilian development, which was viewed as a horizon for other peripheral countries. Although tardy, capitalism had likely reached a stage of maturity in countries such as Mexico and Brazil, guaranteeing them the “self-determination of capital” (Tavares, 1986a; Mello, 1975). In this process, foreign capital, particularly transnational firms, was indispensable. However, Tavares defended the primacy of domestic determinants, not only from the political perspective (Cardoso and Faletto, 1975) but also from the economic standpoint. She stressed that domestic markets could be internationalized through state planning to overcome structural heterogeneity (Pinto, 2000).³ The “second Tavares” would envisage foreign capital as an inducer of autonomous investment which, in conjunction with government spending, would bring about industrial endogenization. Thus, its political control over peripheral economies —an analytical element dear to Furtado and other authors— is subsumed in a theoretical Kaleckian matrix abstraction. In this neo-structuralism, Tavares, along with other thinkers, helped found the “Campinas School”.⁴

¹ On the context and bifurcation of structuralist thinking built around ECLAC in the 1960s, see Sampaio Jr. (1997), Faletto (1998) and Silva (2017).

² In a letter sent to Furtado in 1971 (which is included in the volume of Celso Furtado's correspondence compiled recently by Rosa Freira D'Aguiar), Tavares wrote: they say that to become a real adult, a woman has to “kill” the mother. For a poor apprentice intellectual, trying to “kill” the master seems to be a condition for advancement. There are two intellectual “fathers” whom I have tried in vain to “kill” in recent years: you and Aníbal Pinto. [...] All of this “semi-Freudian” chatter is merely intended, in an embarrassed way, to make you aware of the challenge you represent for me and how much all of us (your disciples) owe you in this great struggle to understand this wretched country of ours (D'Aguiar, 2021). As she mentioned in an interview (Robillotti, 2016), her criticisms of Furtado were much stronger than those directed at Aníbal Pinto, since she actually considered the latter her main teacher; and her theoretical advances were very close to the structural heterogeneity approach that Pinto (2000) was developing in the same period, as will be seen later in this article. She also pointed out that Furtado's influence was more generic, and she declared herself a supporter of the historical-structural method.

³ For a critique of this type of defence of the government function in Brazilian dependent monopoly capitalism, see Sampaio Jr. (1997), Franca and Campos (2022) and Rodrigues (2023).

⁴ On Tavares' relationship with the intellectual project of the Campinas School, see Bastos (2021).

Following the critique by Tavares and Serra (1983), the heterodox tradition started to frame Furtado within this system and to consider his economic theory inferior.⁵ However, by separating the economic analysis from the political (Coutinho, 2015 and 2019), this consensus omitted key dimensions of the debate and incurred in a form of economism.⁶ In contrast, another group of authors interpret Furtado's work more broadly from this period onwards, based on the economic formation of Latin America and the Caribbean, the transnationalization of capital, the distinction between growth and development⁷ and the development of his own dependency theory (Sampaio Jr., 1997; Hadler, 2009; Campos and Rodrigues, 2014; Bianconi and Minda, 2014; Jurgenfeld, 2018; Jurgenfeld and Rodrigues, 2021; Silva, 2021; Manzatto and Saes, 2021; Vieira, 2021). Drawing on this literature, this article proposes to divide Furtado's work into two stages.

Before the dictatorship, the "first Furtado" hoped for a bourgeois-democratic revolution capable of giving birth to a national economic system, as had been proposed by Hamilton (1934) and List (1983). Furtado (1962) believed that Brazilian industry had already reached a stage of maturity that provided the mainly technological means to leverage State intervention for the purposes of national development.⁸ In reality, this belief was based on the classical structuralism of ECLAC, which criticized the English international division of labour guided by foreign trade, rather than on the post-war American hegemony driven by the expansion of transnational corporations (Carvalho, 2020). After 1964, Furtado departed from this belief. From *Subdesenvolvimento e Estagnação na América Latina* onwards, the impact that the 1964 coup d'état in Brazil had on him (personally affected by exile) became explicit; and he radicalized his position on peripheral industrial internationalization, a phase defined here as the "second Furtado". In a pioneering way, by revealing not only the economic but also the political and cultural effects of the transnationalization of capital in Latin America and the Caribbean, a Furtadian dependency theory became consolidated.

This article addresses a dimension that is generally underestimated in the debate between Furtado and Tavares, namely the role of foreign capital in national development. The methodology adopted is that of the history of economic thought, with changes in the authors' interpretation being evaluated according to the structural transformation of the centre-periphery system itself, with reflections on the Brazilian case between 1964 and 1982. Following this brief introduction, the next two sections of this article describe the interpretations of foreign capital made by Furtado and Tavares; and the final section contrasts them and offers some conclusions.

II. Foreign capital according to Celso Furtado

1. Second half of the 1960s

Prior to the civil-military coup in Brazil, Furtado had participated actively in the Brazilian Government: as coordinator of the joint National Economic Development Bank (BNDE)/ECLAC group in Getúlio Vargas' second administration (1951–1954), as Superintendent for the Development of the Northeast (SUDENE) in

⁵ Even the in-depth studies on Celso Furtado ultimately reproduced the idea of a "neoclassical Furtado" until his theoretical reorganization in the 1970s (Mallorquín, 2005).

⁶ Coutinho (2019) argues that the criticisms made by Tavares and Serra (1983), which he considers one of the factors mainly responsible for the negative image associated with the 1966 paper, are confined to just a segment of the argument contained in the different versions of the stagnationist model. While Coutinho points out that the difficulties of Furtado's model in interpreting the crisis of the 1960s owe more to the attempt to integrate the use of the multiplier with the accelerator, along Harrod-Domar lines, he also stresses the need to interpret *Subdesenvolvimento e Estagnação na América Latina* broadly, even highlighting foreign capital: few commentators realized this broad and integrated nature of the work.

⁷ As Furtado himself said in a letter replying to Tavares: today I see the problem somewhat differently: it is less a tendency towards stagnation than a perpetuation of underdevelopment (D'Aguiar, 2021).

⁸ On the means and ends of development, see Furtado (1966, 1972, 1972, 1982 and 2001), Campos (2014) and Paula (2015).

Juscelino Kubitschek's government (1956–1961); and as Special Planning Minister in that of João Goulart government (1961–1963), in which he formulated the Triennial Plan. However, following the coup, he found himself isolated from his country's centres of decision-making, and he went into exile in Chile. There he participated in a seminar of the Latin American and Caribbean Institute for Economic and Social Planning (ILPES) and encouraged a critical debate on the main ECLAC theses, along with authors who would go on to develop dependency theories (Furtado, 1991), including that of Sunkel (1971), which had the greatest influence on his own work.

In the United States, where he spent a year at Yale University, Furtado became close to Stephen Hymer (1960 and 1983), considered the founder of the literature on the determinants of foreign direct investment (FDI),⁹ who made him aware of a central element of his post-1964 analysis: the transnational corporation.¹⁰ This influence can already be seen in *Subdesenvolvimento e Estagnação na América Latina* (1966), *Um Projeto para o Brasil* (1969) and in *A Hegemonia dos Estados Unidos e o Subdesenvolvimento da América Latina* (1973).¹¹

During this period, Furtado interpreted the dispute between the United States and the former Union of Soviet Socialist Republics (USSR), over areas of influence, as an external obstacle to the development of the periphery. For Third World countries, the definition of such areas was to be understood as a system of political and economic domination, since the assimilation of technical progress and economic policies aimed at overcoming underdevelopment could be made subservient to the interests of these superpowers. The Cuban Revolution in 1959, in conjunction with Fidel Castro's adoption of socialism and assistance from the former USSR, triggered an alert in the United States; and the 1962 missile crisis revived the Monroe doctrine through coups d'état in Latin America in response to the nuclear emergency. For Furtado (1966) it was clear that, in addition to political and military control, foreign financial aid was the United States' main economic tool of domination. Foreign capital and, specifically, the investments of large United States firms, played a fundamental role in underpinning the capitalist order in the region, eliminating any more radical nationalist impetus.¹²

To conceptualize large United States firms, Furtado (1966, 1969 and 1973) was inspired by the antitrust and institutionalist literature (for example Galbraith, 1967). His concern was that, as they expanded internationally, large firms imposed the American mass culture, based on the modernization of consumption patterns (*the American way of life*) and the use of non-renewable raw materials, which damaged the environment and discouraged labour-saving technical progress. It started to be defined as a system of decisions of multinational scope, the coherence of which stems from value criteria founded on the domestic reality of the American economy (Furtado, 1969). In other words, foreign capital in its United States FDI modality, beyond the control of that country's antitrust legislation but with the political-military backing of the United States, would tend to become a superpower in any Latin American country; and, as a result, the centres of decision-making represented by the current national governments would increasingly be relegated to a secondary role (Furtado, 1966).

⁹ This literature, based on the seminal work of Hymer (1960) that was very much in vogue in the 1960s and 1970s, sought to explain transnational corporations, which had expanded in an unprecedented way in the post-war period. For a summary of these authors, see Michalet (1983).

¹⁰ At first, both in the 1960s and in the early 1970s, Furtado followed Hymer's (1960) original formulation and preferred the terms "large firm" and "multinational firm", because the difference between "national" and "international" tends to be secondary, whereas the relative size of the firm is of fundamental importance (Furtado, 1974, p. 32, note 16). He considered that firm size imposes internationalization; in other words there is a relationship between the monopolistic or oligopolistic nature of firms and FDI (Furtado, 1974, p. 32, note 17). However, as will be seen in the next section, he then proceeded to question this initial conception and whether such activities could continue to be called "international" (Furtado, 1974, p. 50). He argued that, once the category "national economic system" (1974, p. 51) ceased to be relevant, it was no longer possible to speak of international relations. Later, Furtado (1976) preferred the term "transnational" to refer to the relations between countries in the phase of large corporation pre-eminence: here he was following the evolution of Hymer's (1983) thinking, which sought to emphasize national governments' loss of control over the activities of large corporations, resulting from the transnationalization of capital.

¹¹ The latter volume is actually a collection of articles written in the second half of the 1960s.

¹² Drawing on his autobiographical accounts (Furtado, 1989 and 1991), Furtado's new critical view of cold-war power relations —and their effects on Latin America and the Caribbean— can be seen as a self-criticism of the author's belief in the neutrality and multilateralism of United States hegemony in the region.

Among the multiplicity of factors that drove different national decisions, transnational corporations were inappropriate for Latin American development because they resulted in: (i) a reduction in available saving, by encouraging new consumption patterns through the “demonstration effect”; (ii) a structural external deficit through the remittance of profits and dividends abroad, seeking to realize them in dollars (the “transfer problem”, as discussed in the literature on the determinants of FDI); (iii) a reconcentration of economic activities in certain sectors or regions to the detriment of others, despite the need for national integration; (iv) a separation of research funding for technological innovation from the productive process; (v) a tendency towards stagnation in countries with small domestic markets and insufficient economies of scale and labour to introduce the capital-intensive technology of the new sectors (such as in Chile and Argentina); or towards forced income concentration in countries with larger domestic markets (such as Brazil), to adapt the profile of demand to the new structure of supply, which generated social tensions; and (vi) structural unemployment, which reflected the assimilation of modern technical progress by foreign firms to satisfy a discontinuous, concentrated pattern of demand, facilitated by a surplus supply of labour (Furtado, 1962, 1966, 1969, 1973 and 2009).

Consequently, the issue of development comes to focus less on the importance of industry and more on its control and on who dominates it. In Latin America and the Caribbean, the import-substitution-industrialization process, driven by transnational corporations, would thus reassert the region’s peripheral status, because this type of industrialization is simply an adaptation to a new form of external dependency (Furtado, 1969). Far from the instrumentalization that Furtado (1962) imagined possible in the Kubitschek government, or the attempt at vertical regulation in the Goulart administration, foreign capital came to be seen as a type of domination implicit in the expansion of large-country firms that install themselves in economically weak countries (Furtado, 1969). Despite being industrialized, Latin American countries continued to depend on political and economic interests established in external centres of decision-making. For Furtado, since the objective was to expand external openness without causing drastic changes in social structures, these foreign interests converged with the domestic interests of ancient elites, which reproduced secular power structures and thereby perpetuated a “technique for freezing the social *status quo*”. This basically explains the repressive nature of state action in the form of civil-military coups.

Thus, the analysis of foreign capital made by the “second Furtado” was integrated into the analysis of stagnation and was actually inseparable from it. Irrespective of the economic theory used, Furtado made a complex analysis of the perpetuation of social inequalities and the lack of political autonomy in decisions that were central to national interests, even with the advance of industrialization. In addressing the significance of the expansion of large United States firms in Latin America and the Caribbean, and their relationship to coups d’état, Furtado also made a pioneering contribution to new interpretations of the transformations of global capitalism.

2. The 1970s

As a professor at Sorbonne University, in the 1970s Furtado deepened his thinking on foreign capital and consolidated his dependency theory, in *Teoria e Política do Desenvolvimento Econômico* of 1971,¹³ *Análise do ‘Modelo’ Brasileiro*, of 1972, *O Mito do Desenvolvimento Econômico*, of 1974, “Prefácio” a *Nova Economia Política*, of 1976, and *Criatividade e Dependência na Civilização Industrial*, of 1978.

¹³ Chapter 18 of the fourth edition of *Teoria e Política do Desenvolvimento Econômico* (Furtado, 1971a), which was published previously as an article titled “External dependence and economic theory” (Furtado, 1971b).

During this period, he started to characterize FDI as an intermediate phase of an evolutionary process of capital transnationalization. Influenced by Hymer (1983) and by Gerschenkron's (2015) periodization, his new understanding revealed the dismantling of "national economic systems", in which Latin American industrialization was an integral part of the process, the fruit of a third phase in the evolution of industrial capitalism (Furtado, 1974). In the 1970s, when analysing the economic policy of the Brazilian dictatorship, Furtado argued that the deepening of productive internationalization did not generate stagnation but would lead, even with growth, to models of industrialized underdevelopment (Furtado, 1972) or to dependent forms of capitalism (Furtado, 1974, 1976 and 1978).

Transnational corporations would have strategies for expansion in domestic markets which, following internationalization, would profoundly alter the capitalist economies' pattern of integration and, consequently, of the centre-periphery system. Whereas, until World War II, the main economic relationship between economies was foreign trade, in the post-war period, capital flows, led by FDI, would likely be the dynamic factor in the balance of payments, as trade flows became progressively transformed into the domestic operations of large firms (Furtado, 1974).

Initially, the production associated with a given capital was organized in several nations simultaneously, with technological and financial control being separate from the industry's physical production. Then, the actual production process within the industry ceased to be confined to a single national accumulation space, giving rise to what are known today as "global value chains". From the financial standpoint, the emergence of the euromarket was the crowning achievement of this process, since it enabled large firms to break free from many of the constraints created by national monetary and financial systems (Furtado, 1974). The author's idea of "post-national capitalism" to some extent foreshadowed, in the 1970s, phenomena that became predominant in capitalism from the 1980s onwards (Furtado, 1976).¹⁴

In the new context, crises also started to originate from an instability that tends to manifest itself through changes in the terms of trade or international transfer of net assets (Furtado, 1976). This makes it difficult to reconcile domestic and external equilibrium in the framework of a full employment policy (*idem*), which underlies both the 1971 collapse of the Bretton Woods agreements and the 1973 oil crisis. Furtado considered that macroeconomic adjustment would henceforth be implemented through a deliberate policy of unemployment, implemented through contractionary fiscal and monetary policies, to absorb, cushion and offset the propagation of external instability.

The transnationalization of capital had even more dramatic consequences for the countries of the periphery. According to Furtado (1972), the institutional reforms introduced by the Brazilian dictatorship in its Programme of Economic Action for Government (PAEG), in 1964–1967, consolidated the industrial model that had been established in the Kubitschek period. This was implemented through anti-democratic and deliberate policies of income concentration, thereby forming a new type of association, the "Brazilian model", which gave rise to the expansionary phase of the "economic miracle". In the case of the balance of payments, instead of more restrictive measures regulating the operations of transnational corporations, profit remittance abroad was liberalized, and transnational corporations and national banks were institutionally connected to the eurodollar market which was expanding in this period.¹⁵ To make the adverse effects of profit remittances viable, an attempt was made to use the accumulation potential of transnational corporations to encourage them to export. Also defended by the neo-structuralists (Fajnzylber, 1969), this strategy was criticized by Furtado (1974), who advocated development oriented towards the domestic market. In his view, the obstacle to an

¹⁴ When analysing —alongside other authors, such as Michalet (1983) and Hymer (1983)— the transition from multi-divisional Fordist factories (Hymer, 1960) to "network firms" (Chesnais, 1996), it would be no exaggeration to say that Furtado (1976) foreshadowed the globalization process or the "globalization of capital" (Chesnais, 1996). On the transnationalization of capital in Furtado, see Hadler (2009), Campos and Rodrigues (2014) and Bianconi and Minda (2014).

¹⁵ Through amendments to Act No. 4131/1962 in 1964, the adoption of Instruction No. 289 of the Office of the Superintendent of Money and Credit in 1965 and Central Bank Resolution No. 63 in 1967. On the Brazilian regulatory framework for foreign capital in the period, see Campos (2009) and Carvalho (2020).

export strategy was the fact that the geographical horizon of the transnational firms was pre-defined, and manufacturing exports effectively entailed exporting cheap labour, which in fact does not contribute to development.¹⁶

Measures to adjust the structure of demand and financing of the operations of transnational corporations in the domestic market were more complex than those traditionally used to stimulate effective demand. According to Furtado (1972), in Latin American countries there was no feedback loop between productivity and wages, unlike in the centre where this had been created socially through union struggle and fiscal policies that underwrote the demand of large firms.¹⁷ With their repression of trade unions, the dictatorships ruled out this possibility. Moreover, in the “Brazilian model”, the process of wealth and income concentration that already existed in the country was dynamically and continuously retargeted to benefit a broader social group (upper-middle class), in addition to the elite, thereby expanding the market for durable consumer goods. Accordingly, his approach already went far beyond the stagnationist thesis.

3. Threshold of the 1980s

Until then, Furtado had analysed transnationalization from a technological, productive and commercial perspective, but not a financial one. With the foreign debt crisis and the struggle for re-democratization in the early 1980s, the “second Furtado”, in *A Nova Dependência: dívida externa e monetarismo* (Furtado, 1982), focused his research into foreign capital on the loan capital modality. Here the internationalization of monetary and financial circuits via the expansion of offshore markets also revealed a process of financial transnationalization, resulting in a new dependency (Furtado, 1982).

Following the PAEG reforms, the foreign loans that entered the Brazilian economy from 1967 onwards exceeded by far what was needed for imports and external services, generating an increase in reserves that put pressure on the monetary base. In response, the Government engaged in open-market operations to sterilize the surplus liquidity, thus increasing Brazil’s domestic debt by issuing indexed government bonds with guaranteed profitability at no risk to creditors — the subsidiaries of transnational corporations, and foreign and domestic banks.¹⁸ These securities paid much higher interest than the rate on government bonds issued by the central countries, and well above the cost of eurocurrency deposits. The debt service thus created, both externally and domestically, turned the whole process into a vicious circle. This speculative triangulation between external and domestic debt became known in Brazil at the time as the “financial wheel”.¹⁹

Despite the 1973 oil crisis and recession in the central countries in 1973–1974, which slowed down the expansion of transnational companies, the recycling of petrodollars from 1974 onwards created the conditions to try to implement the ambitious Second National Development Plan of the Geisel Government (1974–1979) and to maintain the borrowing process until 1982, through deposits obtained from State-owned enterprises.²⁰ Brazilian economic policy started to react increasingly to capital flows, which made it ever more difficult to manage interest rates autonomously, while the exchange rate experienced large-scale devaluations. Thus, at the outbreak of the crisis caused by United States

¹⁶ In the early 1970s, Furtado came to believe that this would be possible, given the pressure from peripheral countries on multilateral organizations (Furtado, 1972); but he changed his mind as early as 1974 (Furtado, 1974).

¹⁷ On the social structure that makes it possible to link productivity and wages in the central countries, see Furtado (1964).

¹⁸ For details of the financial reform of the Brazilian dictatorship and the characteristics of the government bonds created on that occasion, see Carvalho (2020).

¹⁹ The financial wheel was demonstrated empirically by Pereira (1974) and Cruz (1984) and discussed analytically by Tavares (1998). However, unlike Furtado (1982) these authors saw excessive external debt and the domestic recycling of government bonds as merely the result of institutional deviations or economic policy errors, rather than the effect of the “new dependency”.

²⁰ See Rodrigues (2023).

interest rate hikes broke out in 1979, the situation of vulnerability and lack of macroeconomic autonomy was already established. The subordination of domestic centres of decision-making was fully revealed in the adjustment to the debt crisis in the 1980s, under the tutelage of the International Monetary Fund (IMF), when the Latin American economies were forced to make a net transfer of real resources abroad on such a large scale that it was the death-knell of developmentalism.²¹

According to Furtado (1982), this crisis stemmed from the loss of control over macroeconomic policy, not its consequence, which led to the subordinate integration of Latin American economies in the new global pattern of accumulation that continues to this day. In the mid-1970s he could still envisage solutions for societal control of transnationalization. However, the outcome of these events, which involved the imposition of monetarism to guide economic policy (which Furtado viewed as the ideological expression of financial transnationalization), revealed a real civilizational dead end for a part of humanity.²²

III. Foreign capital according to Maria da Conceição Tavares

1. Second half of the 1960s

After working as assistant to Aníbal Pinto and having him guide her research at the ECLAC office in Rio de Janeiro, Maria da Conceição Tavares succeeded him as head of the ECLAC office of BNDE in his place following the 1964 coup d'état. While facing political persecution, including eviction of the ECLAC office of BNDE, which was later transferred to Brasília through the Institute of Applied Economic Research (IPEA) and ILPES, Tavares began to mature her thinking and endow her structuralism with its own characteristics.²³

At that time, in *Notas sobre o Problema do Financiamento* of 1967, that is, before her critique of Furtado (1966), her reflection on foreign capital related to the financing of the Brazilian economy and also expressed concern about a potential stalling of the industrialization process. Along the same lines as *Auge e declínio do processo de substituição de importações no Brasil*, published in 1963, she analysed foreign capital in heavy industrialization. By internalizing new industrial sectors, such as metal and machinery manufacture, FDI facilitated the transition from the old import-substitution model to one of self-sustained growth. In this new model, the decisive variable would be the quantity and composition of government investments. since only the public sector, with its relative weight in the economy, had the capacity to exert an autonomous demand that could counter the negative trends arising from the exhaustion of external momentum (Tavares, 1983a).

This emphasis on public investment to move to a new development model without the need for major structural reforms — which already diverged from Furtado — was influenced by the economist Ignácio Rangel (Tavares, 1983b; Robilloti, 2016), who embraced Marx, Keynes and Schumpeter in his theoretical framework.²⁴ Rangel (2005) positioned himself as the third way in the debate on the Triennial Plan, by arguing that the inflation of the 1960s was driven by costs, rather than by demand (as monetarists would have it), or by food supply shortages (as structuralists claimed). Similarly, the growth slowdown was seen as the result of a crisis of realization or underconsumption, mitigated by inflation.

²¹ A process that Furtado (1992) later called “the interrupted construction”.

²² On this topic in Furtado, see Campos (2014).

²³ For details of Tavares' evolution, see Melo and Costa (2019).

²⁴ On Rangel's contribution to Brazilian economic thought prior to the 1964 coup d'état, see Bielschowsky (2000).

With an already mature industrial structure, the Brazilian economy was entering a new era, with no supply-side constraints, in which the State should focus on exploiting installed industrial capacity, by stimulating effective demand through public investment. In addition to harnessing fiscal policy for this purpose, the government should consolidate a national financial system, to fulfil the historical role of financial capital described by Rudolf Hilferding. This would enable surplus resources to be transferred between sectors, and thus make the productive system more homogeneous and reduce dependency on new FDI or supplier credit. In other words, the organization of the capital market and vigorous financial capital associated with industrial capital emerges as a key problem (Rangel, 2005).

Like Rangel (2005), Tavares (1983b) argued that the transition to a new development model necessarily had to involve the reorganization of the national financial system. The stagflation of the 1960s in Brazil stemmed from the difficulty faced by transnational corporations, especially in the consumer durables sector, to maintain a satisfactory profit rate given the country's level of potential effective demand. In the first half of the 1960s, a policy of “forced” consumption by transnational corporations led them to use all increases in income and additional loans, at rising interest rates, to fuel the current financing mechanism (Tavares, 1983b). The problem with foreign capital was not the capital itself, but the institutional inadequacy of the Brazilian financial market to make proper use of it. Like Rangel (2005), Tavares was also optimistic, believing that a genuine capital market seemed to be forming through a partnership between the conventional banking system, which had started to set up its own financial companies, and the large foreign-owned companies (Tavares, 1983b). Although they were still formed under the structuralist paradigm and remained ambiguous, these thoughts were already diverging from Furtado.

2. The 1970s

In 1968, Tavares moved to the ECLAC office in Chile and also started to teach at the First Graduate School of Latin American Economic Studies (Escolatina) of the University of Chile. It was thus in the agitated Chilean intellectual climate that she wrote *Além da Estagnação* with José Serra in 1970 (Tavares and Serra, 1983), thereby inaugurating the “second Tavares”. After working as a volunteer advisor in the Ministry of Economy of Salvador Allende's government, she travelled to Mexico in late 1973 as a visiting professor at the National Autonomous University of Mexico and worked at the ECLAC office in Mexico City. Upon her return to Brazil, she taught at the State University of Campinas (UNICAMP) and the Federal University of Rio de Janeiro (UFRJ) and published her theses: *Acumulação de Capital e Industrialização no Brasil*, in 1974, and *Ciclo e Crise*, in 1978, both seminal works of the Campinas School (Melo and Costa, 2019).

By self-critiquing the structuralist formation, the “second Tavares” refined her understanding of foreign capital. Drawing on Cardoso and Faletto (1975) and on Pinto (2000), Tavares and Serra (1983) claimed that the national government could define the type of objective relationship that prevails between the country and foreign capital in strategic sectors, as well as modalities of national behaviour in the decision-making process (Tavares and Serra, 1983). Countries such as Brazil and Mexico were able to establish a “developmentalist tripod” between foreign capital, the State and national private capital, with an unprecedented degree of solidarity that generated a new type of integration in international capitalism. This new dependency's flexible adaptation to the system allowed these countries, anchored in an integrated core of intersectoral expansion, to grow on the basis of their domestic markets, which were larger in absolute terms than those of the other countries of Latin America and the Caribbean (Tavares and Serra, 1983).

In her 1974 thesis— as in “O Capitalismo Tardio: contribuição à revisão crítica da formação e do desenvolvimento da economia brasileira” (Mello, 1975) (another work that helped define the thinking of the Campinas School)— Tavares argued that partnering with transnational corporations was essential

for Brazil's development. Drawing also on Gerschenkron (2015), she claimed that, in the first half of the twentieth century, Latin American and Caribbean capitalisms encountered even greater obstacles than those faced by economies such as the United States and Germany, which were backward compared to England but where industrialization had already consolidated. The new level of demand for capital mobilization confined the industrialization of Latin American countries to sectors that were not very dynamic (the “wage-earner consumption department – DIII”), instead of more advanced sectors such as capital goods (the “production goods department – DI”) and consumer durables (the “capitalist consumption department – DII”), already developed by the other capitalisms.²⁵ As the Latin American countries were in a late (rather than backward) stage of industrialization, they needed to install the new dynamic sectors with the help of transnational corporations, in order to internalize all departments of industry, and thus guarantee the self-determination of capital (Tavares, 1986a; Mello, 1975).²⁶

Nonetheless, Tavares emphasized the capacity of the Brazilian State and other countries that had recently secured the self-determination of capital to instrumentalize transnational corporations: her central analytical hypothesis continued to be that trade and foreign capital flows do not exogenously determine the course of accumulation (Tavares, 1986a). She also considered that it would be ironic if some peripheral countries, such as those mentioned, were to face the unexpected problem of reacquainting or redefining themselves as national economies, merely because they represented the international frontier of capitalist expansion (Tavares, 1986a). Tavares thus made economic dependency a relative matter (and not just political as in Cardoso and Faletto (1975)), since, domestically, foreign capital became DI or DII in abstract form alongside national capitals. The question of external control of foreign capital —so dear to the Furtadian formulation— was thus subsumed internally in the formal logic of capital self-determination. By predefining the domestic systems of spending and financing to underpin future effective demand, the Government was strategically placed to influence the profitability of the different capital blocs and thus manipulate foreign capital for capitalist development.

Having established the primacy of the national government over foreign capital, the economic policy of the dictatorship would be judged by its successes and failures in instrumentalizing foreign capital and managing the cyclical fluctuations of capitalism, which are common to the central and peripheral economies alike (Tavares, 1986a). However, despite inheriting a mature industrial structure with organic links between transnational corporations and the domestic capital blocs of the Kubitschek period, the Brazilian dictatorship adopted an economic policy that failed to develop the macroeconomic instruments appropriately (Tavares, 1998 and 1986a).

With respect to the balance of payments, Tavares, who was also an advocate of inward-looking development like Furtado, criticized the creation of an export incentive for transnational corporations on the same grounds. However, unlike Furtado, the problem of the transfer or remittance of profits was circumscribed to course of the business cycle, since, except in periods of crisis, new FDI would outweigh remittances plus imports, given the new interest in the Brazilian market displayed by transnational corporations. These would accumulate the surpluses generated domestically in the peripheral markets, under wide-ranging modalities of appropriation and allocation of resources, and not necessarily for the purpose of exporting them (Tavares, 1986a).

²⁵ In the Kaleckian three-department system used by the author. See Kalecki (1987).

²⁶ Tavares defines “self-determination of capital” as follows: I think that the concept of capitalist productive forces relates to a type of development of the productive forces, the nature and pace of which are determined by a specific capital accumulation process. In other words, this concept only has *raison d'être* if it is defined on the basis of a specifically capitalist accumulation dynamic, which goes far beyond the increase in surplus per worker resulting from the introduction of technical progress. From this point of view, we view the constitution of capitalist productive forces as the process of creating the material foundations of capitalism —that is, as the constitution of a productive goods department with capacity to enable the self-determination of capital, thereby freeing accumulation from any barrier caused by the fragility of the technical structure of the capital (Mello, 1975).

In terms of domestic growth, the Brazilian economy was able to recover from the cyclical crisis of the 1960s using traditional instruments of accumulation (Tavares and Serra, 1983), such as wage compression, the creation of basic social capital in infrastructure, and expansion of the consumer durables market thanks to the reconcentration of income. It was also possible to increase financing for consumer durables through the reorganization of the financial system, and the supply of working capital to transnational companies through transfers between the parent company and the subsidiary, based on the relaxation of laws on foreign capital. However, in a new study on the Brazilian financial system of the early 1970s Tavares (1983c) argued that the financial accumulation measures developed under PAEG, which were intended to consolidate national financial capital, became asymmetric and fuelled speculation, thus preventing long-term financing for industry. Investment banks became intermediaries in relations between the parent company and the subsidiaries of transnational corporations; and monetary correction pushed up interest rates and boosted securities trading in the financial market. In addition, the market value of company shares diverged from their real rate of return. Thus, more pessimistic than before, Tavares recognized that the interaction between financial and industrial capital that would enable something like an integrated process of accumulation in the capitalist pole of the economy did not yet seem to be occurring in Brazil (Tavares, 1983c).

At the end of the decade, Tavares (1998) detected a new problem in the financial system, resulting from institutional deviations also committed in PAEG. In addition to raising the interest rate, as she had already noted at the start of the decade, inflation-linked government bonds were performing two of the functions of money — store of value and unit of account— thus replacing the cruzeiro which, hostage to inflation, was functioning only as a means of payment. This happened because, in addition to the monetary correction that transformed the indexed government bonds into first-tier financial assets with zero risk, the institution of the repo agreement made it possible for prefixed government bonds to be transformed into money that was endogenous to the financial system, especially in the very short-term (overnight) secondary market. This financial currency, which fulfilled all of the traditional functions of money, was accessible only to privileged agents in a restricted market that had speculative characteristics.

Thus, concern about the inflow of speculative capital and its association with the national financial system became paramount in her analysis.²⁷ In addition to exchange rate policy, Tavares (1998) noted that monetary policy was forcing an increasing spread between domestic and foreign interest rates, with the aim of attracting loans to refinance the previously accumulated foreign debt, even if this meant an increase in international reserves. In her opinion, this type of connection between external and domestic debt, the financial wheel, created a dangerous mechanism of speculation based on the specific characteristic of Brazilian money. Mediated by monetary and exchange-rate policies, this speculative circuit facilitated FDI, by giving transnational corporations a new channel for transferring resources abroad, in addition to the transfer pricing and profit remittance mechanisms.

In short, during the 1970s, the “second Tavares” took a path that was diametrically opposed to that of the “second Furtado”. In her view, by ensuring the self-determination of capital in partnership with the State and national capital, foreign capital had made a national economic system viable. Without much thought about the political and cultural consequences of foreign capital, since it remained within the confines of economic theory, macroeconomic instability and the reconcentration of income did not stem from a deleterious form of international integration in the new phase of capitalism. Instead they reflected the inability of the dictatorship to evaluate the instruments of economic policy and domestic financial capital adequately.

²⁷ Until this 1978 study, she had not paid much attention to private foreign debt, which was considered healthier even than borrowing from IMF (Tavares, 1983c). In her 1974 thesis, Tavares expressed concern about the inflow of foreign currency loans from the euromarket, considering it excessive, given the policy of mini-devaluations which, by overvaluing the cruzeiro, fuelled the foreign debt of transnational corporations and the inflow of speculative capital (Tavares, 1986a).

3. Threshold of the 1980s

In the 1980s, Tavares became one of the main economic advisors of the Brazilian Democratic Movement (MDB) and helped found the graduate programme in international political economy at UFRJ (Melo and Costa, 2019).²⁸ It was only from that decade on, that she started to critique the transnationalization of capitalism, although restricting this to the financial sphere. In the article “O Capital Financeiro e a Empresa Multinacional”, written in 1980 with Belluzzo, another of the founders of the Campinas School, Tavares stressed that national governments lost control of the macroeconomic prices because of the speculative activities of transnational financial capital. The transnationalization of financial capital no longer respected any stable monetary standard; and this neutered the controls exercised by central banks, including those of hard currency countries, which were forced periodically to bail out the weaker currencies (Tavares and Belluzzo, 2009). Moreover, each country’s domestic macroeconomic prices became linked to interest rates on the interbank eurocurrency market.

Although Tavares admitted in 1980 that transnationalization meant that their private issuance power outweighed that of national governments (Tavares and Belluzzo, 2009), she sought to differentiate herself from Furtado (1974, 1976 and 1978). The impossibility of operating a stabilizing monetary policy was explained by the periodic destabilization of the purchasing power of the national currency, or of its parity with other currencies, caused by speculation in a floating exchange rate environment, and not by the supposed lack of authority of national governments (Tavares and Belluzzo, 2009). The point was that the internationalization of domestic markets and financial transnationalization imposed a *de facto* reform of the international monetary and financial order, compounded by uncertainty surrounding the global coordination of capital flows as United States hegemony waned. Thus, Tavares saw the global transnationalization of the system and the crisis of United States national hegemony as two sides of the same coin (Tavares and Teixeira, 1982).

In the 1985 essay titled *A retomada da hegemonia norte-americana*, she analysed the emergence of a new international monetary system: starting from the 1979 interest-rate crisis and applying robust “dollar diplomacy”, the United States managed to regain both its hegemony and control over the transnationalized banks. The way in which the United States restructured the financial power of its monetary authority, the Federal Reserve, radically changed the terms of capital accumulation and, consequently, the way in which other countries could conduct their economic policy. This new mode of conducting international economic relations, under the dollar standard based on the financial power of the Federal Reserve, left no more room for the other countries to implement an autonomous monetary policy (Tavares, 1985). In 1983, at the presentation of Hobson’s *A Evolução do Capitalismo Moderno*, Tavares saw the economy and international politics as separate entities, with their own dynamics, thus denying the Marxist tradition of interpretation of imperialism.²⁹ Conversely, the resumption of United States hegemony demanded a certain imperialist policy (Tavares, 1985), since the financial extroversion of capitalism led Washington to a turning point in its foreign economic policy, which reversed the causality of the relationship between the State and foreign capital in countries with peripheral currencies.

²⁸ The Brazilian Democratic Movement is a political party that was created in 1967 to oppose the dictatorship.

²⁹ Although Hobson was one of the authors who most influenced her understanding of monopoly capitalism, along with the Marxists influenced by him, such as Hilferding, Lenin and Bukharin, Tavares considered that he confused the evolution of modern capitalism with economic policy adventures abroad, which in the last 80 years have been commonly associated with “imperialism”. Comparing Hilferding with Hobson, and expressing a preference for the latter, she said that Hilferding was thinking of a superior and transformed form of capitalism from which imperialism would emerge as the aggressive foreign policy of large-scale financial capital. But for Hobson, the supremacy of United States large-scale capital does not derive from the way in which the financial class is foreign-dominated. Instead it reflects the characteristics of its domestic domination and, above all, the expansionary potential of large-scale capital, which cannot be contained within a country’s national borders, given the tendency to over-accumulation, however large its market may be (Tavares, 1983d).

Nonetheless, Tavares (1985) did not rework her interpretation of the economic policy of the Brazilian dictatorship as expressed in her 1978 thesis. The key determinants of the instability of the Brazilian dictatorship remained merely institutional deviations and economic policy errors (Tavares and Assis, 1985), and not the problems of transnationalization or imperialism. Several years earlier, she had already reaffirmed the endogenous and complementary nature of foreign capital in Brazilian industrialization, in *Problemas de industrialización avanzada en capitalismo tardíos y periféricos* (Tavares, 1986b). She also played down the problem of external strangulation of the productive domain on the eve of the debt crisis, because the dynamic control of international capital did not allow industrialization to be blocked by foreign strangulation at such an early stage. The only constraints on the supply of capital in the parent-subsidiary relationship are those arising from the absence (or insufficiency) of prospects for profit, in order to continue expansion.

IV. Furtado versus Tavares, concluding remarks

Why did these two authors respond differently to the 1960s crisis in Latin America and the Caribbean? Firstly, Furtado applied a long-term methodology and analysed the Latin American reality with an interdisciplinary approach, in the context of national development. According to the “first Furtado”, industry, foreign capital and capitalism as a whole could contribute to national capacity building. However, after the 1964 coup d’état in Brazil, he distanced himself from this assumption. By radicalizing the centre-periphery approach, the dependency theory of the “second Furtado” viewed the issue of progressing industrialization in a scenario of transnationalization of capital —unlike the context of backward industrialization in Germany and Japan, for example. Thus the formation of a national economic system became more problematic. The very conceptualization of stagnation was transformed into the idea of a crisis of national capacity building or “interrupted construction”. According to Furtado, no matter how heterodox the analytical tools imported from the central countries were, they failed to identify the absence of a structural nexus between foreign capital and the national economic space, which led to a loss of control by the Latin American countries, not only economically, but also politically and culturally.

In contrast, Tavares’ critique of Furtado interpreted the internationalization of the most important domestic markets in Latin America and the Caribbean as the interdepartmental internalization of industry, in keeping with the Kaleckian system. Although externally dependent, this endogenization-driven industrial dynamism, which had been enabled by foreign capital complementary to State expenditures, guaranteed a certain margin of economic policy autonomy domestically. Tavares thus wanted to show that typically capitalist productive forces had potential for progress even under conditions of dependency: peripheral industrialization was tardy relative to that of countries that had overcome their backwardness relative to English capitalism. Moreover, owing to the greater need for concentration and centralization of capital in the new context, it was necessary to proceed with technological and financial support from transnational corporations, since the partnership with foreign capital did not entail structural, but cyclical difficulties. The specific features of the more advanced, semi- or newly industrialized peripheral countries would become less salient. The economic policy instruments to be used increasingly resembled those used in the central countries. In Tavares’ opinion, the most radical dependency theories reproduced an ideological vision of foreign capital and did not use the heterodox economic theory that was best suited to understanding the dynamism of the system.

In the short term, Tavares’ theory captured the cyclical dynamics of heavy industrial capital in Brazil (from its establishment in the Kubitschek government, to the crisis and its maturation in the dictatorship, thereby showing that it was not stagnant). However, in the long term it proved insufficient to account for the process of Latin American external dependency, which became even more dramatic as financial transnationalization advanced. Although this dependency contained contradictions that had

become entrenched over the centuries, it also expressed the new global transformations. The Furtadian interpretation proved better for understanding the dead ends of this dependent industrialization, in terms of problems derived from the colonial period, from the external control of foreign capital, and from the transmutations of global capitalism — some of which had already penetrated the country well before the 1980s. Furtado noted the blockage of nation building in the face of the structural crisis that transnationalization injected early on into the Brazilian economy and which still persists and generates stagnation to this day.

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Challenges and strategic opportunities for Brazil's participation in global value chains

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Abstract

The objective of this study is to measure the effects of global value chain participation on the total factor productivity of the Brazilian economy, using heterogeneous dynamic panel models and methods suitable for diagnosing short-run and long-run effects. The study has two innovative features: it estimates the impact of global value chains on Brazil's sectoral total factor productivity by disaggregating the indicators of simple and complex value chain participation developed by Wang and others (2017), and it uses a novel methodology to analyse the relationship between participation in global value chains and sectoral total factor productivity in Brazil. In the long run, this participation appears to generate productivity gains whatever indicator is considered, with the largest long-run effects arising when activities are carried out in complex chains. Positive effects are found in 15 of the 31 sectors analysed.

Keywords

Economic development, economic integration, international trade, productivity, competitiveness, value, economic models, Brazil

JEL classification

O40, F00, F14

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I. Introduction

Integration into global value chains can be a way to achieve higher productivity gains that, in turn, influence the way a country participates in these chains, generating a dynamic process of long-term growth. A report by OECD/WTO/UNCTAD (2013) points out that, in the long run, global value chains can create opportunities for industrial upgrading through the diffusion of technology and increased domestic value added in trade. According to recent studies, participation in global value chains can lead to productivity gains and indirect technological diffusion in participating countries, allowing them to increase their economic growth (Baldwin and Yan, 2014; OECD/WTO/UNCTAD, 2013; IMF, 2015).

There have been instances of South and South-East Asian countries initially integrating into global production in low-technology sectors with strong demand for low-skilled labour and then successfully consolidating in advanced-technology sectors as they moved up global value chains (Callegari, Melo and Carvalho, 2018). However, these benefits are not automatic. Developing countries can become trapped in low value added activities, as seems to be the case with Brazil. Integration into global value chains is not an automatic process, as factors such as geography, market size, institutional quality, workforce skills and economic policies influence participation in these chains.

Callegari, Melo and Carvalho (2018) observe that Brazil presents a unique form of participation in global value chains, characterized by: (i) an industrial sector that is strongly focused on the domestic market and driven by high levels of foreign direct investment and imported medium-high technology goods and (ii) rising commodity exports. According to the authors, this form of participation in global value chains is a trap that compromises competitive development, since it does nothing to increase momentum in industry and the service sector.

The challenge, then, is to work out how to capitalize on any benefits from integration into global value chains and to develop strategies for migrating to more complex stages of the production process organized in these chains. Pathikonda and Farole (2017) stress the importance of setting realistic goals for increased participation in global value chains. There is a sectoral “ladder” that is not identical in all countries and that has specific requirements. The challenge for policymaking in countries like Brazil is to identify the most viable strategies and sectors for increasing participation in these chains.

Accordingly, it is crucial to investigate the potential productivity gains from integration into global value chains and to identify key sectors in which these gains could be increased, prioritizing strategic investments for integration into chains. The purpose of this study is thus to analyse the effects of Brazil’s global value chain participation on its productivity and to determine which sectors have the greatest potential to increase this productivity. In Brazil’s case, there is a dearth of empirical studies investigating the impact of global value chain participation on total factor productivity, especially in relation to sectoral participation.

This analysis aims to measure the effects of participation in global value chains using the participation indicators developed by Wang and others (2017), who disaggregate them into simple and complex chains. A sectoral analysis is conducted to identify key sectors for Brazil to increase its participation in globally segmented production chains. Brazil is involved in less complex activities in global value chains, and the hypothesis is that moving towards complex global chains can be a way to boost its productivity and thence its long-term economic growth.

We use heterogeneous dynamic panel models for this study, applying methods that allow short-run and long-run effects to be diagnosed. One advantage of these methods is that they do not require an assumption that variables need to be integrated in the same order to demonstrate the existence of a long-term relationship between two or more variables. This study is the first to use such an empirical approach to analyse the impact of global value chains on total factor productivity, at least in the case

of the Brazilian economy, to the authors' knowledge. It is therefore innovative in at least three areas: (i) estimation of the impact of global value chains on total factor productivity, in aggregate and sectoral terms, for the Brazilian economy; (ii) empirical analysis using indicators of participation in simple global value chains and complex global value chains; and (iii) use of heterogeneous dynamic panel models to identify key sectors that would yield higher productivity gains.

The main results suggest that participation in simple global value chains has no effect on long-run total factor productivity and that the coefficients, if statistically significant, have a negative sign. Therefore, the results indicate that participation in simple global value chains is not an attractive strategy for stimulating the productivity of the Brazilian economy. Meanwhile, most sectors participating in complex global value chains do contribute to higher total factor productivity in the long run. The sectors with the largest productivity gains are: food, beverages and tobacco; water, air and inland transport; sale, maintenance and repair of motor vehicles and motorcycles and retail sale of fuel; and the rubber and plastics industry. The results also indicate that there is no clear relationship between the complexity and technological sophistication of the sectors involved in global value chains and productivity gains in the Brazilian case, since a number of the sectors with the largest gains are of low technological sophistication and complexity.

The sectors achieving particularly high productivity gains by virtue of inclusion in global value chains and also accounting for a substantial sectoral share of value added in the Brazilian economy (2% or over) are: mining; food, beverages and tobacco; sale, maintenance and repair of motor vehicles and motorcycles and retail sale of fuel; and inland transport. These segments are thus strategic for public policies aimed at increasing Brazil's participation in global value chains to stimulate productivity growth. With the exception of mining, however, these sectors' share of total value added declined between 2000 and 2014, which may be one of the reasons for the low productivity growth in the Brazilian economy.

The present article is divided into five sections, apart from this introduction and final considerations. The next section presents an analysis of participation in global value chains, describing Brazil's involvement in these chains and explaining the methodological aspects entailed in the indicators used to measure this. The third section presents an analysis of the relationship between participation in global value chains and productivity. The fourth section describes the methodology and database used in the study. The fifth section presents and discusses the results. The sixth and final section concludes.

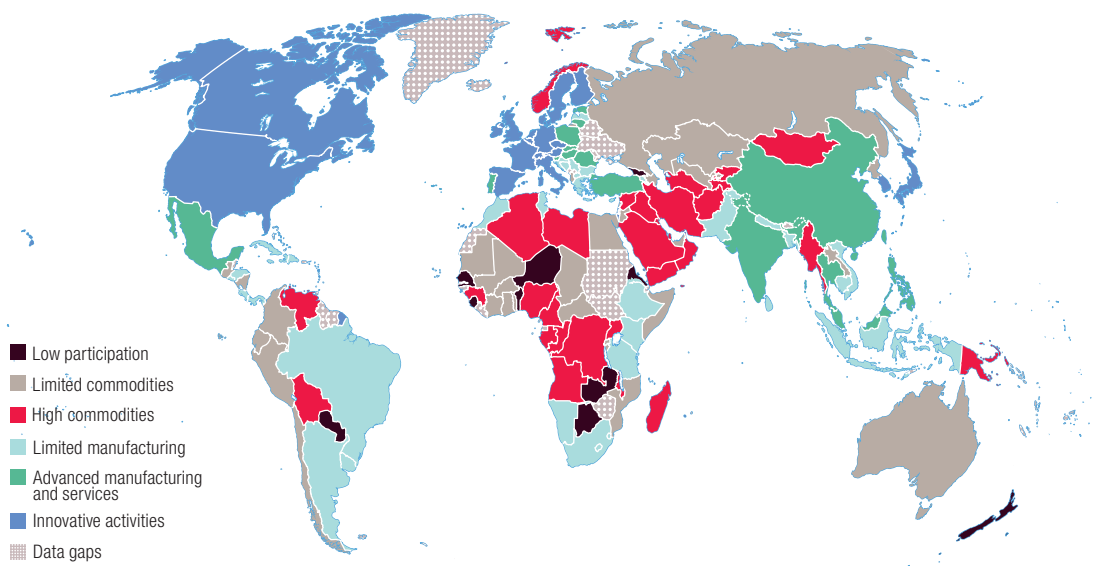
II. Participation in global value chains

1. Brazilian participation

According to a survey for *World Development Report 2020* (World Bank, 2019), and as shown in map 1, many countries in North America, Western Europe and East Asia participate in complex global value chains, producing manufactured goods and services, as well as innovative activities. Meanwhile, many countries in Africa, Latin America and Central Asia, among them Brazil, still supply commodities for processing elsewhere.

Callegari, Melo and Carvalho (2018) note that Brazil's participation in global value chains is characterized by low use of imported inputs to produce exported goods (backward linkages). Its imports of technological goods are mainly for domestic consumption, whereas in countries with high backward participation in global value chains, imports are mainly used to add value to exports. Considering forward participation criteria, i.e. the participation of domestic inputs in other countries' exports, Brazil's performance is similar to that of other developing countries, but with a heavy concentration in the production and export of low value added commodities.

Map 1
Countries' participation in global value chains, 2015



Source: World Bank, *World Development Report 2020. Trading for Development in the Age of Global Value Chains*, Washington, D.C., 2019.

Brazil's integration into global value chains centres on supplying inputs and raw materials to firms in other countries so that they can add value to their products, with a modest performance when it comes to exporting products with higher value added. Even in sectors where it has comparative advantages, such as agribusiness, the country has struggled to migrate to more advanced stages of the value chain (Sturgeon and others, 2014). Hollweg and Rocha (2018) show that Brazil's performance in global value chains differs substantially across sectors. The authors stress that Brazil is most competitive in agribusiness (excluding primary agriculture), wood and paper, basic metals and the automotive industry, while also performing relatively well in the chemical sector.

Likewise as part of a sectoral analysis, Ferraz, Gutierre and Cabral (2015) highlight a substantial increase between 1995 and 2011 in imported intermediate goods as a share of final goods produced in the country, especially in high-technology sectors. However, they stress that the use of imported intermediate goods in domestic production is still low compared to other countries and that the Brazilian economy exhibits an increase in the production and export of low-technology intermediate goods. In addition, Brazil has been losing competitiveness in the production of more sophisticated goods, such as transport equipment, chemicals and electrical and optical equipment (Ferraz, Gutierre and Cabral, 2015).

Araújo, Perobelli and Faria (2021), considering the period between 1990 and 2015, show that Brazilian production fragmented internationally, consequently increasing its participation in global value chains, especially at the regional level. The results of this study indicate that Brazil's share in the total value added of world exports increased from 0.98% in 1990 to 1.38% in 2015. The authors note that, although the Brazilian economy occupies a prominent position in South America, its participation in global production chains remains modest.

According to the newsletter of the Institute for Industrial Development Studies (IEDI, 2022), an analysis of more recent indicators based on Organisation for Economic Co-operation and Development (OECD) data shows that Brazil's integration into world trade was greater in 2018 than in 2011 or 2015.

Information in the OECD Trade in Value Added (TiVA) database indicates an increase in re-exports of imported intermediate goods as a share of total imported intermediate goods. The indicator increased

from 16.0% in 2011 to 19.5% in 2015 and 23.1% in 2018. Imported value added increased from 10.1% to 12.9% of total gross exports in the same years, holding steady at 12.9% in 2018. Imported value added increased from 14.5% of gross manufacturing exports to 17.2% and then to 17.9%, respectively.

Domestic value added in other countries' exports relative to Brazil's total gross exports fell from 25.2% in 2011 to 20.5% in 2015, before rising back slightly to 22% in 2018. Lastly, domestic value added in other countries' exports relative to Brazil's gross exports of manufactured goods also declined between 2011 and 2015, from 19.9% to 15.4%, before increasing to 17.1%, in 2018.

Despite the progress on some indicators, Brazil's profile is still that of a country which is relatively unintegrated into global value chains. This is partly due to problems of external competitiveness and the lack of a sound international trade integration policy, as well as to the large size of its domestic market and an export basket heavily weighted towards commodities. In addition, the higher share of imported value added in Brazilian exports may be related to technological dependence and loss of competitiveness, or indeed to a greater inflow of imported inputs and components not matched by increased production in domestic supply chains (IEDI, 2022).

2. Methodological aspects

Global value chains led to the emergence of borderless production systems in which goods and services began to accrue value added in different countries and sectors. Some studies have attempted to capture these relationships by developing indicators. In a pioneering paper, Hummels, Ishii and Yi (2001) introduced a measure of vertical specialization by calculating the share of imports contained in exports where backward linkages in global value chains were concerned. However, this measure has problems of double counting. Thus, Koopman and others (2010) proposed measures to calculate participation in global value chains based on the share of foreign value added in domestic gross exports (backward) and the share of domestic value added in foreign gross exports (forward). However, these also present problems of double counting, especially where sectoral indicators are concerned (Yanikkaya and Altun, 2020).

To correct the problem, Wang and others (2017) proposed a structure for disaggregating production activities consistent with the System of National Accounts standard. The authors suggest two ways of disaggregating production activities, one from the producer's perspective (based on forward industrial linkages) and the other from the buyer's (based on backward industrial linkages). They set out from this breakdown to present indices of participation in global value chains that are more appropriate than the measures previously available in the literature, disaggregating the value added of each relationship by sector or country with reference to its destination, as depicted in equation (1):

$$Va' = \hat{V}BY = \underbrace{\hat{V}LY^D}_{(1)V_D} + \underbrace{\hat{V}LY^F}_{(2)V_RT} + \underbrace{\hat{V}LA^F LY^D}_{(3a)V_GVC_S} + \underbrace{\hat{V}LA^F (BY-LY^D)}_{(3b)V_GVC_C} \quad (1)$$

The first term in equation (1), V_D , represents value added produced domestically without the involvement of international trade. The second term, V_RT , is the sum of a country or sector's value added used in all downstream sectors and is related to traditional trade, i.e. products are manufactured in a given country and cross its border just once for final consumption.

Term (3a) indicates the measure of activity in simple global value chains. Taking two countries (A and B), V_GVC_S is the domestic value added embodied in the intermediate goods exports of a sector in country A used by country B in domestic production for domestic consumption. Exports cross borders for production just once. Thus, there are no indirect exports via third countries and no re-exports or re-imports of the origin countries' value added. This activity is considered to take place in simple global value chains. As an example, we can take exports from Brazil (country A) to China (country B) of steel that is then used to fabricate houses on Chinese soil.

Term (3b) denotes value added that crosses borders more than once, i.e. when intermediate goods produced in country A are exported to country B and used in turn to produce intermediate or final goods in country B for export to other countries. This is considered to be complex global value chain activity.

Wang and others (2017) break down final goods production in each sector or country by the origin of the value added, as shown in equation (2):

$$Y' = VB\hat{Y} = \underbrace{VL\hat{Y}^D}_{(1)Y_D} + \underbrace{VL\hat{Y}^F}_{(2)Y_RT} + \underbrace{VLA^F L\hat{Y}^D}_{(3a)Y_GVC_S} + \underbrace{VLA^F (B\hat{Y} - L\hat{Y}^D)}_{(3b)Y_GVC_C} \quad (2)$$

The first term in equation (2), Y_D , represents the value absorbed by domestic final demand without the intervention of international trade. The second term, Y_RT , represents a given country's imports for final consumption, i.e. is related to traditional trade.

Term (3a), Y_GVC_S , is the foreign value added in a sector in country B that is imported by country A to be used in the production of domestically consumed goods and services, these being considered simple global value chain activities. As an example, we can take exports of manure and fertilizer from China (country B) to Brazil (country A), where they are then used in the production of soybeans consumed on Brazilian soil. In this hypothetical example, the entire production chain for manure and fertilizer exported to Brazil is located in China.

Term (3b) in equation (2), Y_GVC_C , represents products exported by country B for the production of final goods for export in country A. This would be the case with exports from Brazil (country A) to China of soybeans grown using manure and fertilizer from China itself (country B) or from other countries (country C, for example). This sector would then form part of a complex global value chain in all the countries involved.

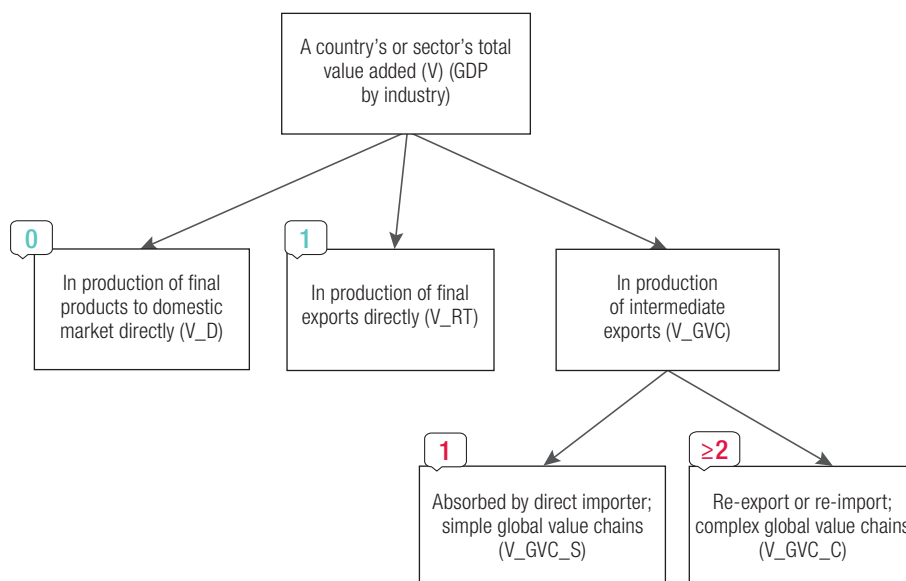
The breakdown described above is summarized in diagrams 1.A and 1.B: diagram 1.A illustrates the decomposition of GDP by industry on the basis of forward linkages, and diagram 1.B illustrates the decomposition of final goods production on the basis of backward linkages.

Diagram 1

Decomposition of production and value added by sector

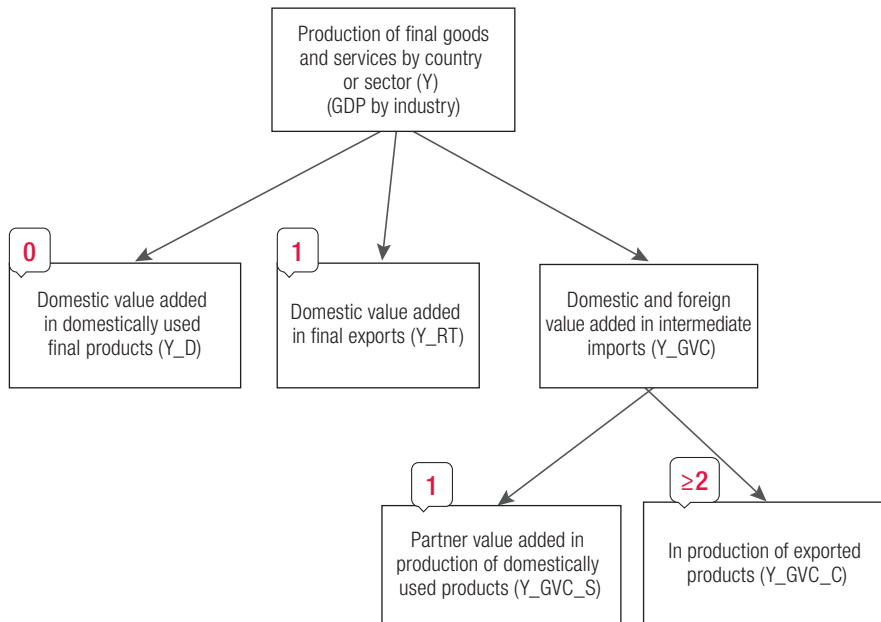
A. Breakdown of GDP by industry

Which types of production and trade are global value chain activities?



B. Decomposition of final goods production by country or sector

Which part of final goods production and trade belongs to global value chains?



Source: Z. Wang and others, *Measures of Participation in Global Value Chains and Global Business Cycles*, No. w23222, National Bureau of Economic Research (NBER), 2017.

The decomposition presented by the authors thus includes the four ways in which it is possible for a country to participate in global production networks:

- (i) By exporting intermediate goods to country B to produce goods or services for final consumption (in country B), crossing borders between countries only once.
- (ii) By exporting intermediate goods to country B for production that will be exported to other countries, crossing borders between countries more than once.
- (iii) By importing intermediate goods from other countries for domestic production of goods that will be exported, crossing borders between countries at least twice.
- (iv) By importing intermediate goods from other countries for domestic production of goods that will be consumed domestically, crossing borders between countries only once.

According to Wang and others (2017), the measures of participation in global value chains proposed by Hummels, Ishii and Yi (2001), called VS and VS1 and expressed as percentages of the value of gross exports, only consider the channels of participation represented by (ii) and (iii). Hummels, Ishii and Yi originally called the measure for imports directly and indirectly embodied in a country's exports the VS index. The VS1 measure is for the domestic content of a given country present in the exports of third countries. By excluding items (i) and (iv), these measures omit many of the activities involved in internationally fragmented production.

Another limitation of conventional VS1 measures is that, because they use gross exports as the denominator, the shares calculated from them may be overestimates in the case of sectors with few direct exports. Lastly, conventional measures cannot distinguish between participation in simple global value chain activities and complex global value chain activities.

Accordingly, the authors construct and define two indices of participation in global value chains at the sectoral level:

$$GVCpt_forward = \frac{V_GVC}{Va'} = \frac{V_GVC_S}{Va'} + \frac{V_GVC_C}{Va'} \quad (3)$$

$$GVCpt_backward = \frac{Y_GVC}{Y'} = \frac{Y_GVC_S}{Y'} + \frac{Y_GVC_C}{Y'} \quad (4)$$

These measures differ from the conventional VS measure (as a percentage of gross exports) in two respects: first, they are based on a net concept and, second, they go by production rather than trade. Consequently, the indices presented by the authors take into account both forward and backward industrial linkages, allowing a country's participation in global value chains to be described more accurately.

III. Participation in global value chains and productivity: empirical aspects

According to different theoretical studies, countries can benefit from participation in global value chains through various channels, such as productivity effects generated by trade in intermediate inputs, learning by interaction, access to new markets and movement up the value chain so that they position themselves in higher value added production activities (Yanikkaya and Altun, 2020).

Empirical studies are still in their infancy when it comes to analysis of the impact of country and sector participation in global value chains on output and productivity growth (using indicators of participation in these chains). The available empirical literature focuses mainly on cross-country analysis and generally finds that participation in global value chains has positive effects on output and productivity growth. Sectorally, studies are limited (Yanikkaya and Altun, 2020).

These empirical studies include, for example, Kummritz (2015), who concludes from a sample of 20 industries in 50 countries for the years 1995, 2000, 2005 and 2008 that participation in global value chains has a positive impact on domestic value added only for middle- and high-income countries. Kordalska, Wolszczak-Derlacz and Parteka (2016) provide estimates on 20 sectors (13 classified as manufacturing and 7 as service sectors) in 40 countries and find positive effects from backward participation, especially in the case of manufacturing industries. Constantinescu, Mattoo and Ruta (2019) analyse the relationship between participation in global value chains and labour productivity in a sample of 13 sectors in 40 countries over 15 years. They conclude that participation in global value chains, especially backward linkages, has a positive impact on labour productivity.

However, as highlighted by Wang and others (2017), none of the existing studies disaggregates trade into simple and complex global value chain activities. Applying the methodology they developed, as described in the previous section, the authors assess the impact of participation in global value chains, employing their new participation rates for simple and complex value chain activities. They use data from the World Input-Output Database (WIOD) for 44 countries and 56 industries over the period from 2000 to 2014, dividing this into four subperiods: rapid growth (2002–2008), global financial crisis (2009), post-crisis recovery (2010 and 2011) and growth slowdown (2012–2014).

For both the full sample and the manufacturing subsample, they find a positive association between participation in global value chains and economic growth, with complex chains having a larger and more significant impact than simple chains. Wang and others (2017) find no clear link between the share of value added in traditional trade and economic growth, and the results indicate that most purely domestic production activities have a negative association with economic growth. The authors divide the sample into two subsamples by countries' income level and find a stronger association between participation in global value chains and economic performance in advanced economies.

Yanikkaya and Altun (2020) investigate the impact of participation in global value chains on value added and total factor productivity growth, in sectoral terms, over two periods: 1995–2011 and 2005–2015. In addition to traditional participation indices, the authors use sectoral indices of participation in OECD global value chains that are based on final demand. Using the generalized method of moments (GMM) for their estimates, the authors find that, for the full sample, sectors with greater participation in global value chains experienced considerably higher output and total factor productivity growth, especially over the period 1995–2011. In separate estimates for manufacturing and services, both sectors benefited in output and productivity terms from higher participation in global value chains between 1995 and 2011. However, only manufacturing experienced higher productivity growth in the period 2005–2015.

Given that the indicators developed by Wang and others (2017) are more appropriate than traditional measures and also permit division into simple and complex chains, the goal of the present study is to estimate the effects of these indicators on total factor productivity in the different sectors of the Brazilian economy.

IV. Methodology and database

1. Heterogeneous dynamic panel models

Let us begin by assuming a simple specification of an autoregressive distributed lag (ARDL) model (p, q_1, \dots, q_k) for certain periods, $t = 1, 2, \dots, T$, and for the cross-sectional units (sectors), $i = 1, 2, \dots, N$:

$$y_{it} = \sum_{j=1}^p \lambda_{ij} y_{i,t-j} + \sum_{j=0}^q \delta'_{ij} X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (5)$$

where X_i is a $(k \times 1)$ vector of explanatory variables for the group i ; μ_i represents fixed effects; λ_{ij} are scalars for the lags of the dependent variables; and δ_{ij} are $(k \times 1)$ vectors of coefficients. For simplicity of presentation, equal T and p are used across sectors and equal q between sectors and regressors.

If the variables in (5) are, e.g. I (1) and are cointegrated, then the error term is a process I (0) for all i . A major feature of cointegrated variables is their responsiveness to any deviation from the long-run equilibrium, implying an error correction model (ECM) in which the short-run dynamics of the variables in the system are influenced by deviation from the long-run equilibrium.

Using equation (5), the long-run and short-run coefficients can be obtained by estimating the model in error-corrected form (ARDL-ECM):

$$\Delta y_{it} = \phi_i (y_{i,t-1} - \theta'_i X_{it}) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \delta_{ij}^* \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (6)$$

where $\phi_i = -\left(1 - \sum_{j=1}^p \lambda_{ij}\right)$ is an error correction term for group i . It is to be expected that ϕ_i will be different from zero. Otherwise, there would be nothing to indicate the existence of the long-run relationship. This parameter is expected to be negative on the assumption that the variables return to the long-run equilibrium. Of particular importance is the vector θ'_i , which contains parameters of the long-run relationship between the variables, namely

$$\theta_i = \sum_{j=0}^q \frac{\delta_{ij}}{(1 - \sum_k \lambda_{ik})}; \lambda_{ij}^* = -\sum_{m=j+1}^p \lambda_{im}, \quad j = 1, 2, \dots, p-1$$

$$\delta_{ij}^* = -\sum_{m=j+1}^q \delta_{im}, \quad j = 1, 2, \dots, q-1$$

In studies using the heterogeneous dynamic panel method, different approaches may be followed to estimate equation (6). At one extreme is fixed effects (FE) estimation, where only the intercepts can differ between the cross-sectional units. If the slope coefficients are not identical, however, the FE approach produces biased and inconsistent results.

Alternatively, the specifications could be estimated separately for each cross-sectional unit. In this case, a simple arithmetic mean of the coefficients could be calculated. This is the mean group (MG) estimator in heterogeneous dynamic panels proposed by Pesaran and Smith (1995), where the intercepts, the short- and long-run coefficients and the error variance may differ between sample units. Pesaran and Smith (1995) show that the MG method produces consistent estimates of the average long-run coefficients. If the coefficients are homogeneous, however, these estimates will be inefficient.

Since the parameters of (6) are non-linear, Pesaran, Shin and Smith (1999) developed a maximum likelihood method to estimate them. To use the authors' term, the estimators of the long-run and error correction parameters, estimated by maximum likelihood, are pooled mean group (PMG) estimators in heterogeneous dynamic panels. This method allows the coefficients, intercepts and error variance to vary between cross-sectional units in the short run, like the MG estimator, but requires their coefficients to be identical in the long run. With the PMG method, the long-run equilibrium relationships between variables tend to be similar across the cross-sectional units. This method is particularly appropriate for sectoral analyses, considering that different sectors of a given economy are subject to the same exchange-rate policies, inflation movements and business cycles.

Moreover, this method does not require the variables to be integrated in the same order to test for the existence of a long-run relationship (Pesaran, Shin and Smith, 2001). The model is therefore applicable even if the variables are only I(0) (stationary), only I(1) (non-stationary) or a combination of the two.

What is proposed is to estimate equations using measures of participation in global value chains as explanatory variables for Brazil's sectoral total factor productivity. Accordingly, different specifications are estimated considering the general indicator of participation in global value chains presented above and its breakdown into simple and complex chain activities, as presented in the equations below:

$$\text{Model 1: } \ln TFP_{it} = \ln(GVCP_{it}) \quad (7)$$

$$\text{Model 2: } \ln TFP_{it} = \ln(GVC_{S_{it}}) \quad (8)$$

$$\text{Model 3: } \ln TFP_{it} = \ln(GVC_{C_{it}}) \quad (9)$$

where $i = 1, \dots, 31$ represents the sectors of the Brazilian economy² and $t = 2000, \dots, 2014$. Each indicator of participation in global value chains in each of the three equations above is the sum of the backward and forward participations presented by Wang and others (2017).

Setting out from the methodology described and using disaggregated indicators, it is possible to determine the short- and long-term effects of participation in global value chains, indicating which sectors contribute most to productivity growth in Brazil, depending on the type of global chain in which they are embedded.

² The 2013 and 2016 versions of the sectors in the WIOD database are presented in table A1.2 of the annex.

2. Data source

For the econometric estimations, we used the data for the global value chain sectoral participation indicators proposed by Wang and others (2017) available in the UIBE GGVC Database of global value chain indicators developed by the team at the Global Value Chains Research Centre of the University of International Business and Economics (UIBE). This database provides information on the decomposition of value added and final goods production by country and sector, and on gross trade at the bilateral sectoral level. Indicators of global value chain participation based on Wang and others (2017) were generated from these decompositions.

To calculate total factor productivity, data from the socioeconomic accounts of the World Input-Output Database (WIOD) were used (GGDC, 2013 and 2016).³ This database contains information on capital stock and employment variables and is available in two versions, 2013 and 2016. Given the unavailability of ready-calculated sectoral productivity data, sectoral total factor productivity in Brazil was calculated using the following equation,⁴ with data measured in monetary values deflated by the 2014 harmonized consumer price index (IPCA).

$$TFP_{it} = \frac{VA_{it}}{\left(K_{it}^{\frac{CAP_{it}}{VA_{it}}}\right) * \left(EMP_{it}^{\frac{LAB_{it}}{VA_{it}}}\right)} \quad (10)$$

where $i = 1, \dots, 31$ sectors, $t = 2000, \dots, 2014$, VA is gross value added at 2014 prices, CAP is capital compensation at 2014 prices, LAB is total labour compensation at 2014 prices, K is the real capital stock and EMP is the number of people employed, measured in thousands.

V. Results

1. Cointegration and unit root panel tests

Table 1 presents the results of the unit root tests for panel data. For the series corresponding to the indicators of participation in global value chains ($\ln GVC_{Pt}$), participation in complex chains ($\ln GVC_C$) and participation in simple chains ($\ln GVC_S$), the results of all tests indicate that the series are stationary. The series $\ln(TFP)$ was found by most tests to be non-stationary.

Since there are different results for the stationarity of the series and for the order of integration, the intention is to investigate the existence of a long-run relationship between the variables. Table 2 presents the results of the Pedroni panel cointegration tests. The combinations of variables are investigated as specified in equations (7), (8) and (9).

In most cases, the null hypothesis of no cointegration can be rejected at a statistical significance level of 1%. The tests therefore indicate the existence of a long-run equilibrium relationship between the different indicators of participation in global value chains and total factor productivity. Once the conditions of differences in the order of integration of the variables and the existence of cointegration have been verified, in addition to the heterogeneity of the sample containing different sectors, it is observed that the application of the FE, MG and PMG methods is viable.

³ The variables available in the WIOD databases (GGDC, 2013 and 2016) can be found in table A1.1 of the annex.

⁴ The variables are represented using the notation of the WIOD database (GGDC, 2016) (see table A1.1 of the annex).

Table 1
Unit root tests

Variable	Test	Result	Probability	Stationarity
ln(<i>TFP</i>)	Levin, Lin and Chu	-3.130	0.001***	Stationary
	Breitung (t-statistic)	0.616	0.731	Non-stationary
	Im, Pesaran and Shin (W statistic)	-1.047	0.148	Non-stationary
	Fisher based on augmented Dickey-Fuller (ADF) tests (χ^2)	71.743	0.186	Non-stationary
	Fisher based on Phillips-Perron tests (χ^2)	98.744	0.002***	Stationary
ln(<i>GVCpt</i>)	Levin, Lin and Chu	-4.484	0.000***	Stationary
	Breitung (t-statistic)	-2.593	0.005***	Stationary
	Im, Pesaran and Shin (W statistic)	-1.666	0.048**	Stationary
	Fisher based on ADF tests (χ^2)	81.260	0.051*	Stationary
	Fisher based on Phillips-Perron tests (χ^2)	140.014	0.000***	Stationary
ln(<i>GVC_S</i>)	Levin, Lin y Chu	-4.895	0.000***	Stationary
	Breitung (t-statistic)	-1.599	0.055*	Stationary
	Im, Pesaran and Shin (W statistic)	-1.334	0.091*	Stationary
	Fisher based on ADF tests (χ^2)	78.210	0.080*	Stationary
	Fisher based on Phillips-Perron tests (χ^2)	122.571	0.000***	Stationary
ln(<i>GVC_C</i>)	Levin, Lin and Chu	-4.746	0.000***	Stationary
	Breitung (t-statistic)	-4.964	0.000***	Stationary
	Im, Pesaran and Shin (W statistic)	-2.859	0.002***	Stationary
	Fisher based on ADF tests (χ^2)	94.568	0.005***	Stationary
	Fisher based on Phillips-Perron tests (χ^2)	171.106	0.000***	Stationary

Source: Prepared by the authors.

Note: All tests include intercepts (fixed effects) and individual trends. Fisher's test probabilities are calculated using an asymptotic χ^2 distribution. The remaining tests assume asymptotic normality. (***), (**) and (*) reject the null hypothesis at statistical significance levels of 1%, 5% and 10%, respectively.

Table 2
Pedroni cointegration tests

Variables	Within-dimension			Between-dimension		
	Statistic	<i>p</i> -value		Statistic	<i>p</i> -value	
ln(<i>TFP</i>) - ln(<i>GVCpt</i>)	V	-1.066	0.857	Rho	2.998	0.999
	Rho	0.156	0.562	PP	-3.563	0.000***
	PP	-4.779	0.000***	ADF	-3.871	0.000***
	ADF	-5.440	0.000***			
ln(<i>TFP</i>) - ln(<i>GVC_S</i>)	V	-0.963	0.832	Rho	2.813	0.998
	Rho	0.052	0.521	PP	-3.174	0.001***
	PP	-4.916	0.000***	ADF	-2.945	0.002***
	ADF	-5.343	0.000***			
ln(<i>TFP</i>) - ln(<i>GVC_C</i>)	V	-1.475	0.930	Rho	3.249	0.999
	Rho	0.425	0.665	PP	-2.436	0.007***
	PP	-4.368	0.000***	ADF	-1.378	0.084**
	ADF	-2.724	0.003***			

Source: Prepared by the authors.

Note: PP: Phillips-Perron; ADF: augmented Dickey-Fuller (*) and (***) reject the null hypothesis of no cointegration at a statistical significance level of 10% and 1%, respectively.

2. The relationship between total factor productivity and global value chains: estimations using heterogeneous dynamic panel models

Table 3 shows the short-run and long-run effects of participation in global value chains on total factor productivity, considering the panel with aggregate variables. To control for the effects of the 2008 crisis and the contraction of world trade, a dummy variable was included for the post-crisis period. The results presented in the first two columns were estimated using the MG and PMG methods. We use the Hausman test to check for the restriction of equality between the long-run coefficients, whereas in the MG method this restriction is not imposed. If long-run relationships are heterogeneous, PMG estimates are inconsistent; if equality is not rejected, the PMG method is more efficient. Table 4 shows that the PMG method is more efficient in all comparisons, as the null hypothesis of the Hausman test for equality of long-run coefficients is not rejected. The specifications were also estimated by the FE method, using the Hausman test to determine whether it was more appropriate than the MG method.

Table 3
Results of heterogeneous dynamic panel models

Short-term coefficients	Equation (1)			Equation (2)			Equation (3)		
	PMG	MG	FE	PMG	MG	FE	PMG	MG	FE
$\ln(GVCPt)$	-0.414*** (0.019)	2.688 (3.319)	-0.131 (0.125)	-	-	-	-	-	-
$\ln(GVC_S)$	-	-	-	0.494*** (0.021)	84.254 (84.701)	-0.032 (0.129)	-	-	-
$\ln(GVC_C)$	-	-	-	-	-	-	0.260*** (0.032)	0.225 (1.281)	-0.165* (0.098)
Long-term coefficients									
$\ln(GVCPt)$	0.281* (0.170)	0.425*** (0.164)	0.098 (0.092)	-	-	-	-	-	-
$\ln(GVC_S)$	-	-	-	0.344*** (0.116)	0.152 (0.122)	0.024 (0.097)	-	-	-
$\ln(GVC_C)$	-	-	-	-	-	-	0.444*** (0.097)	0.351*** (0.095)	0.123* (0.073)
Crisis dummy	0.206*** (0.042)	0.206*** (0.042)	0.102*** (0.024)	0.179*** (0.032)	0.179*** (0.032)	0.104*** (0.022)	0.221*** (0.046)	0.221*** (0.046)	0.105*** (0.027)
Constant	0.136 (0.417)	0.136 (0.417)	0.187 (0.196)	0.759** (0.294)	0.759** (0.294)	0.349** (0.147)	0.710*** (0.247)	0.710*** (0.247)	0.303*** (0.093)
Error correction	0.347*** (0.063)	0.347*** (0.063)	0.752*** (0.043)	0.387*** (0.063)	0.387*** (0.063)	0.759*** (0.044)	0.358*** (0.066)	0.358*** (0.066)	0.744** (0.038)
Number of observations	465	465	465	465	465	465	465	465	465

Source: Prepared by the authors.

Note: PMG: pooled mean group estimator; MG: mean group estimator; FE: fixed effects estimator. *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 4
Hausman test (*p*-value)

Models without human capital			
Model1	PMG-MG	0.350	PMG
	MG_DFE	0.958	DFE
Model2	PMG-MG	0.323	PMG
	MG_DFE	0.948	DFE
Model3	PMG-MG	0.978	PMG
	MG_DFE	0.986	DFE

Source: Prepared by the authors.

Note: PMG: pooled mean group estimator; MG: mean group estimator; DFE: dynamic fixed effects estimator. The null hypothesis of the Hausman test is long-run equality of coefficients.

The results obtained show short-term effects that are statistically significant only in the case of the PMG method, with the indicators exhibiting positive effects in simple and complex chains. When the overall participation indicator is considered, however, the effect is negative. In the long run, participation in global value chains seems to generate an increase in productivity whichever indicator is considered by the PMG method. Furthermore, according to the results of equation (3) estimated by PMG, the greatest long-term effects arise when productive integration occurs through complex global value chains. This result is consistent with those obtained in Wang and others (2017) for participation in global value chains and its effects on economic performance across countries.

As regards the magnitude of the effects, we find from the PMG method that, in the long run, a 1% increase in participation in global value chains increases total factor productivity by 0.28%, while the impact of participation in simple chains is an increase of 0.34%, and participation in complex chains increases total factor productivity by 0.44%.

Positive and significant coefficients for the dummy variable indicate an increase in participation in global value chains during the post-crisis period, with the largest effects observed for participation in complex chains. As for the error correction term,⁵ all specifications indicate the existence of a cointegrating relationship.

To complement the analysis, long-run elasticities of participation in global value chains are estimated for each sector of the Brazilian economy in the sample. Since the PMG method proved to be more efficient than the MG method in results with aggregated data and, moreover, is suitable for sectoral studies, the estimates by sector were carried out using this method. The results presented in table 5 indicate varying effects, which may be related to the differing performance of Brazilian sectors in global value chains, as highlighted by Hollweg and Rocha (2018).

Table 5
Brazil: sectoral elasticities of participation in global value chains (GVCs),
long-run coefficients calculated by the pooled mean group method

Sector	Variable and error correction term	Long-run coefficients	Variable and error correction term	Long-run coefficients	Variable and error correction term	Long-run coefficients
Agriculture, hunting, forestry and fishing	<i>Error correction</i>	0.918***	<i>Error correction</i>	0.925***	<i>Error correction</i>	0.892***
	ln(part GVCs)	-0.415	ln(part simple GVCs)	-1.842*	ln(part complex GVCs)	0.315
Mining and quarrying	<i>Error correction</i>	0.814***	<i>Error correction</i>	0.850***	<i>Error correction</i>	0.777***
	ln(part GVCs)	0.213	ln(part simple GVCs)	-0.495	ln(part complex GVCs)	0.484**
Food, beverages and tobacco	<i>Error correction</i>	0.952***	<i>Error correction</i>	0.943***	<i>Error correction</i>	1.009***
	ln(part GVCs)	0.974**	ln(part simple GVCs)	-0.520	ln(part complex GVCs)	1.750***
Textiles and textile products	<i>Error correction</i>	0.808***	<i>Error correction</i>	0.627***	<i>Error correction</i>	0.768***
	ln(part GVCs)	1.409	ln(part simple GVCs)	0.674	ln(part complex GVCs)	0.403
Wood and products of wood and cork	<i>Error correction</i>	0.565***	<i>Error correction</i>	0.527***	<i>Error correction</i>	0.628***
	ln(part GVCs)	-1.315	ln(part simple GVCs)	-2.187**	ln(part complex GVCs)	-0.023
Pulp, paper, printing and publishing	<i>Error correction</i>	-0.077	<i>Error correction</i>	-0.053	<i>Error correction</i>	-0.143
	ln(part GVCs)	-0.588	ln(part simple GVCs)	-0.318	ln(part complex GVCs)	-0.784
Chemicals and chemical products	<i>Error correction</i>	0.290	<i>Error correction</i>	0.250	<i>Error correction</i>	0.297
	ln(part GVCs)	0.598	ln(part simple GVCs)	0.557	ln(part complex GVCs)	0.288
Rubber and plastics	<i>Error correction</i>	0.524**	<i>Error correction</i>	0.576**	<i>Error correction</i>	0.545***
	ln(part GVCs)	0.908*	ln(part simple GVCs)	0.033	ln(part complex GVCs)	1.203***
Other non-metallic minerals	<i>Error correction</i>	0.961***	<i>Error correction</i>	0.910***	<i>Error correction</i>	1.005***
	ln(part GVCs)	0.881**	ln(part simple GVCs)	-0.077	ln(part complex GVCs)	0.797**
Basic metals and fabricated metal products	<i>Error correction</i>	0.562**	<i>Error correction</i>	0.568**	<i>Error correction</i>	0.550**
	ln(part GVCs)	-0.012	ln(part simple GVCs)	-0.678	ln(part complex GVCs)	0.188
Electrical and optical equipment	<i>Error correction</i>	0.294	<i>Error correction</i>	0.275	<i>Error correction</i>	0.195
	ln(part GVCs)	0.093	ln(part simple GVCs)	-0.094	ln(part complex GVCs)	0.044

⁵ These terms allow analysis of the stability of the long-term relationship and the speed of adjustment of short-term deviations.

Sector	Variable and error correction term	Long-run coefficients	Variable and error correction term	Long-run coefficients	Variable and error correction term	Long-run coefficients
Machinery not elsewhere classified	<i>Error correction</i>	1.067***	<i>Error correction</i>	1.147***	<i>Error correction</i>	1.014***
	In(part GVCs)	-0.078	In(part simple GVCs)	-1.522***	In(part complex GVCs)	0.706*
Transport equipment	<i>Error correction</i>	0.782***	<i>Error correction</i>	0.779***	<i>Error correction</i>	0.839***
	In(part GVCs)	1.435***	In(part simple GVCs)	0.315	In(part complex GVCs)	0.925*
Manufacturing not elsewhere classified; recycling	<i>Error correction</i>	0.874***	<i>Error correction</i>	0.680***	<i>Error correction</i>	0.787***
	In(part GVCs)	0.054	In(part simple GVCs)	0.374	In(part complex GVCs)	0.145
Electricity, gas and water supply	<i>Error correction</i>	0.585***	<i>Error correction</i>	0.574***	<i>Error correction</i>	0.606***
	In(part GVCs)	0.618*	In(part simple GVCs)	-0.049	In(part complex GVCs)	0.702*
Construction	<i>Error correction</i>	1.035***	<i>Error correction</i>	0.994***	<i>Error correction</i>	0.962***
	In(part GVCs)	-0.725	In(part simple GVCs)	-1.937**	In(part complex GVCs)	0.414
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	<i>Error correction</i>	0.784***	<i>Error correction</i>	0.808***	<i>Error correction</i>	0.714***
	In(part GVCs)	1.079**	In(part simple GVCs)	0.080	In(part complex GVCs)	1.258***
Wholesale trade and commission trade, except of motor vehicles and motorcycles	<i>Error correction</i>	0.614***	<i>Error correction</i>	0.636***	<i>Error correction</i>	0.614***
	In(part GVCs)	0.838***	In(part simple GVCs)	0.044	In(part complex GVCs)	0.977***
Retail trade, except of motor vehicles and motorcycles; repair of household goods	<i>Error correction</i>	0.357	<i>Error correction</i>	0.357	<i>Error correction</i>	0.410*
	In(part GVCs)	1.034**	In(part simple GVCs)	0.641	In(part complex GVCs)	0.943***
Inland transport	<i>Error correction</i>	0.743***	<i>Error correction</i>	0.759***	<i>Error correction</i>	0.748***
	In(part GVCs)	1.101***	In(part simple GVCs)	0.063	In(part complex GVCs)	1.280***
Water transport	<i>Error correction</i>	0.671***	<i>Error correction</i>	0.974***	<i>Error correction</i>	0.797***
	In(part GVCs)	2.722**	In(part simple GVCs)	-1.681	In(part complex GVCs)	1.388***
Air transport	<i>Error correction</i>	0.937***	<i>Error correction</i>	1.046***	<i>Error correction</i>	0.735***
	In(part GVCs)	-0.046	In(part simple GVCs)	-2.676*	In(part complex GVCs)	1.385*
Other supporting and auxiliary transport activities; activities of travel agencies	<i>Error correction</i>	0.710***	<i>Error correction</i>	0.678***	<i>Error correction</i>	0.784***
	In(part GVCs)	0.936***	In(part simple GVCs)	0.180	In(part complex GVCs)	1.036***
Hotels and restaurants	<i>Error correction</i>	0.977***	<i>Error correction</i>	0.979***	<i>Error correction</i>	0.963***
	In(part GVCs)	0.510	In(part simple GVCs)	-0.700	In(part complex GVCs)	0.889**
Financial intermediation	<i>Error correction</i>	0.503**	<i>Error correction</i>	0.513**	<i>Error correction</i>	0.494**
	In(part GVCs)	0.309*	In(part simple GVCs)	-0.324	In(part complex GVCs)	0.517**
Real estate activities	<i>Error correction</i>	0.155	<i>Error correction</i>	0.142	<i>Error correction</i>	0.216
	In(part GVCs)	0.241**	In(part simple GVCs)	0.067	In(part complex GVCs)	0.317*
Renting of machinery and equipment and other business activities	<i>Error correction</i>	1.010***	<i>Error correction</i>	0.905***	<i>Error correction</i>	0.965***
	In(part GVCs)	-0.072	In(part simple GVCs)	-1.129	In(part complex GVCs)	0.609**
Public administration and defence; compulsory social security	<i>Error correction</i>	0.613***	<i>Error correction</i>	0.609***	<i>Error correction</i>	0.714***
	In(part GVCs)	1.052**	In(part simple GVCs)	0.338	In(part complex GVCs)	1.007***
Education	<i>Error correction</i>	1.011***	<i>Error correction</i>	0.991***	<i>Error correction</i>	1.078***
	In(part GVCs)	0.821***	In(part simple GVCs)	-0.329	In(part complex GVCs)	0.994***
Health and social work	<i>Error correction</i>	0.072	<i>Error correction</i>	0.074	<i>Error correction</i>	0.093
	In(part GVCs)	0.530	In(part simple GVCs)	0.183	In(part complex GVCs)	0.799
Other community, social and personal services	<i>Error correction</i>	0.340	<i>Error correction</i>	0.369	<i>Error correction</i>	0.348
	In(part GVCs)	-0.435	In(part simple GVCs)	-0.855***	In(part complex GVCs)	-0.230

Source: Prepared by the authors, on the basis of global input-output matrices.

Note: Sectoral data are based on global input-output matrices and underlying data covering 43 countries, plus a model for the rest of the world spanning the period 2000–2014. Sectors are classified according to the International Standard Industrial Classification of All Economic Activities (ISIC Rev. 4). The matrices follow the 2008 version of the System of National Accounts. *** significant at 1%; ** significant at 5%; * significant at 10%.

Overall, positive effects on total factor productivity from participation in global value chains were found in 15 of the 31 sectors in the sample. In all of them, elasticities were positive when participation in complex chains was considered, and most had magnitudes very close to or above 1%. The sectors showing the highest long-term productivity gains as a result of participation in complex chains were: food, beverages and tobacco (1.7%); water transport (1.39%); air transport (1.39%); inland transport (1.28%); sale, maintenance and repair of motor vehicles and motorbikes and retail sale of

fuel (1.26%); and the rubber and plastics industry (1.2%). In most Brazilian sectors, a total of 20, an increase in participation in complex global value chain activities contributes to a long-term increase in total factor productivity.

Some sectors are notable for showing positive effects with both general and complex measures of participation in global value chains: food, beverages and tobacco; water and inland transport; sale, maintenance and repair of motor vehicles and motorbikes and retail sale of fuel; the rubber and plastics industry; the transport equipment industry; other supporting and auxiliary transport activities and activities of travel agencies; public administration and defence and compulsory social security; retail trade, except of motor vehicles and motorbikes, and repair of household goods; wholesale trade and commission trade, except of motor vehicles and motorbikes; education; mining and quarrying of other non-metallic minerals; and electricity, gas and water supply. Other segments show positive but smaller effects with both measures of participation in global value chains.

The results on productivity from the integration of the above segments into global value chains show that there is no clear relationship between the complexity and technological sophistication of the activities involved and appropriation of the spillovers from participation in chains, since a number of the sectors with the highest elasticities are of low complexity and technological sophistication. Perhaps Brazil's productive specialization process itself generates this type of relationship, an aspect that it will be important to explore in future studies.

Table A1.1 of the annex shows sectoral participation in the value added of the Brazilian economy, the aim being to ascertain whether the sectors with the highest total factor productivity elasticities are those with the largest shares of value added in the Brazilian economy. Mining; food, beverages and tobacco; sale, maintenance and repair of motor vehicles and motorbikes and retail sale of fuel; and inland transport are some examples of segments which have proven to be strategic for participation in global value chains and whose share in the economy's total value added is close to or higher than 2%. However, the total value added share of most of these sectors declined between 2000 and 2014, the exception being mining.

Participation in simple global value chains showed no effect on long-run total factor productivity, and where there was statistical significance, the coefficients were negative. These results indicate a lesser appropriation of knowledge and technology spillovers, as activities in simple chains may be more associated with the supply of basic goods, while little use is made of more sophisticated inputs. The results therefore show that participation in simple global value chains is not an attractive strategy for stimulating the productivity of the Brazilian economy.

For some sectors where Brazil is more competitive, according to Hollweg and Rocha (2018) and Ferraz, Gutierrez and Cabral (2015), we also find evidence that its participation in complex global value chains has had positive effects on total factor productivity. These are: mining; rubber and plastics; other non-metallic minerals; machinery not elsewhere classified; and transport equipment. These sectors may also be strategic for Brazil to move forward with its participation in global value chains so as to achieve higher long-run productivity gains. Lastly, as highlighted by Ferraz, Gutierrez and Cabral (2015), Brazil is not competitive in global value chains in more sophisticated sectors such as chemicals, electrical equipment and optics. Moreover, table A1.1 of the annex shows that these sectors' share of value added in the economy has been declining, which helps to explain the weak performance of productivity in the Brazilian economy.

The financial intermediation services segment, which exhibits a positive relationship between participation in general and complex global value chains, has a lower elasticity with respect to productivity than a number of other sectors that are less sophisticated and complex. It seems, therefore, that it is not enough for a segment to be more complex and technologically sophisticated for the country to gain by integrating into global value chains. The findings of this paper, together with those presented by Hollweg

and Rocha (2018) and Ferraz, Gutierrez and Cabral (2015), indicate that the sectors need to be competitive. An important research agenda for a better understanding of the productivity increase attributable to sectoral participation in global value chains may be to conduct studies on the sectoral characteristics other than complexity and technological sophistication that allow this increase to be appropriated, such as, for example, the competitiveness of the segment in relation to the same segment in other countries.

Although the estimated specifications are simple and the robustness of the results has not been tested because of the dearth of sectoral data, the present study helps give an idea of which sectors could deliver higher productivity gains in the long run through greater involvement in global value chains. In addition, it investigates the gains associated with the type of chain that sectors participate in, so as to identify those where an expansion into complex chains would be desirable in order to increase the productivity of the Brazilian economy. These issues are of great importance to the allocation of investments that prioritize strategies aimed at improving Brazil's performance in global trade networks.

VI. Final considerations

This study set out to measure the effects of participation in global value chains using the participation indicators developed by Wang and others (2017), who disaggregate them into simple and complex chains. We have sought to determine which sectors could be critical in enhancing Brazil's participation in globally segmented production chains, an aspect of great importance to the development of strategies for boosting Brazilian economic growth, especially given the current situation in which the country has been performing only modestly in global value chains and its productivity has stagnated. We used heterogeneous dynamic panel models for this research, applying methods that allow short- and long-term effects to be diagnosed. This study adopted a new approach to the relationship between global value chains, productivity and growth and innovated on the existing empirical literature as regards the methodology employed, the global value chain participation indicators used and their sectoral application to the Brazilian economy.

The results pointed to the existence of short-term effects only when the PMG method was used, with the indicators exhibiting positive effects for both simple and complex chains. When the overall participation indicator was considered, however, the effect was negative. In the long run, participation in global value chains seems to generate productivity gains whichever indicator is considered.

In sectoral terms, positive effects on total factor productivity from participation in global value chains were found in 15 of the 31 sectors of the sample. Elasticities were also positive in all of them when participation in complex chains was considered, mostly with magnitudes very close to or above 1%. Meanwhile, participation in simple chains showed no effect on total factor productivity in the long run, and when the coefficients were statistically significant, they were negative, indicating that the strategy of integration via simple global value chains does not seem attractive as a way of increasing sectoral productivity in Brazil.

Some results indicate that it is not enough for a segment to be more complex and technologically sophisticated to achieve gains through the participation of the Brazilian sector in global value chains. The findings of this study, which centre on sectoral participation in global value chains, together with the sectoral competitiveness results of Hollweg and Rocha (2018) and Ferraz, Gutierrez and Cabral (2015), indicate that sectors need to be competitive to achieve gains from sectoral participation in global value chains. To better understand the productivity gains accruing from sectoral participation in global value chains, it would be interesting in future research to analyse the sectoral characteristics besides complexity and technological sophistication that allow these gains to be appropriated, such as, for example, the segment's competitiveness relative to the same segment in other countries.

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Annex A1

Table A1.1
Brazil: sectoral value added as a share of total value added
(Percentages)

Sector	Year	Value added (VA)/total VA	Year	VA/total VA	Year	VA/total VA	Year	VA/VA total
Agriculture, hunting, forestry and fishing	2000	5.20	2005	5.35	2010	4.88	2014	5.25
Mining and quarrying	2000	2.58	2005	4.15	2010	3.35	2014	3.79
Food, beverages and tobacco	2000	2.40	2005	2.83	2010	2.40	2014	2.27
Textiles and textile products	2000	2.00	2005	1.53	2010	1.33	2014	1.09
Wood and products of wood and cork	2000	0.41	2005	0.37	2010	0.26	2014	0.21
Pulp, paper, printing and publishing	2000	1.02	2005	0.78	2010	0.70	2014	0.56
Coke, refined petroleum and nuclear fuel	2000	-0.31	2005	-0.34	2010	0.50	2014	-0.59
Chemicals and chemical products	2000	2.35	2005	1.83	2010	1.69	2014	1.38
Rubber and plastics	2000	0.56	2005	0.69	2010	0.65	2014	0.54
Other non-metallic minerals	2000	0.70	2005	0.66	2010	0.68	2014	0.61
Basic metals and fabricated metal	2000	1.96	2005	2.55	2010	2.08	2014	1.83
Electrical and optical equipment	2000	0.49	2005	0.45	2010	0.43	2014	0.38
Machinery not elsewhere classified	2000	0.87	2005	0.93	2010	0.94	2014	0.81
Transport equipment	2000	1.84	2005	2.19	2010	2.18	2014	1.53
Manufacturing not elsewhere classified; recycling	2000	1.51	2005	1.40	2010	1.24	2014	1.11
Electricity, gas and water supply	2000	3.18	2005	3.59	2010	2.83	2014	1.90
Construction	2000	5.68	2005	5.14	2010	6.31	2014	6.68
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	2000	2.60	2005	1.68	2010	2.00	2014	1.80
Wholesale trade and commission trade, except of motor vehicles and motorcycles	2000	3.36	2005	4.14	2010	4.55	2014	4.53
Retail trade, except of motor vehicles and motorcycles; repair of household goods	2000	5.03	2005	5.44	2010	6.14	2014	6.71
Inland transport	2000	2.92	2005	2.91	2010	2.84	2014	2.85
Water transport	2000	0.18	2005	0.16	2010	0.11	2014	0.13
Air transport	2000	0.32	2005	0.19	2010	0.19	2014	0.18
Other supporting and auxiliary transport activities; activities of travel agencies	2000	1.11	2005	1.14	2010	1.18	2014	1.28
Post and telecommunications	2000	1.82	2005	1.95	2010	1.79	2014	1.38
Hotels and restaurants	2000	1.97	2005	1.80	2010	2.14	2014	2.36
Financial intermediation	2000	5.60	2005	6.83	2010	6.85	2014	6.58
Real estate activities	2000	11.51	2005	9.20	2010	8.37	2014	9.55
Renting of machinery and equipment and other business activities	2000	8.79	2005	8.66	2010	8.88	2014	9.74
Public administration and defence and compulsory social security	2000	9.88	2005	10.54	2010	10.47	2014	10.23
Education	2000	5.16	2005	4.42	2010	5.00	2014	5.91
Health and social work	2000	3.87	2005	3.57	2010	3.95	2014	4.32
Other community, social and personal services	2000	2.04	2005	1.97	2010	1.90	2014	1.86
Private households with employed persons	2000	1.37	2005	1.32	2010	1.23	2014	1.22

Source: Prepared by the authors, on the basis of information from the World Input-Output Database (WIOD), "World Input-Output Database (WIOD) 2013" [online] <http://www.wiod.org/database/seas13>.

Table A1.2
Variables in the Groningen Growth and Development Centre (GGDC)
World Input-Output Database (WIOD)

Output	Millions of national currency
<i>GO</i>	Gross output by industry at current basic prices
<i>I</i>	Intermediate inputs at current purchasers' prices
<i>VA</i>	Gross value added at current basic prices
Labour input	Employment units
<i>EMP</i>	Number of persons engaged (thousands)
<i>EMPE</i>	Number of employees (thousands)
<i>H_EMPE</i>	Total hours worked by employees (millions)
<i>Compensation</i>	Millions of national currency
<i>COMP</i>	Compensation of employees
<i>LAB</i>	Total labour compensation
<i>CAP</i>	Capital compensation
Capital input	Millions of national currency
<i>K</i>	Nominal capital stock
Indices	2010=100
<i>GO_PI</i>	Price levels of gross output
<i>I_PI</i>	Price levels of intermediate inputs
<i>VA_PI</i>	Price levels of gross value added
<i>GO_QI</i>	Gross output, volume indices
<i>I_QI</i>	Intermediate inputs, volume indices
<i>VA_QI</i>	Gross value added, volume indices
Additional variables	2013 version
<i>LABHS</i>	High-skilled labour compensation (share in total labour compensation)
<i>LABMS</i>	Medium-skilled labour compensation (share in total labour compensation)
<i>LABLS</i>	Low-skilled labour compensation (share in total labour compensation)
<i>H_HS</i>	Hours worked by high-skilled persons engaged (share in total hours)
<i>H_MS</i>	Hours worked by medium-skilled persons engaged (share in total hours)
<i>H_LS</i>	Hours worked by low-skilled persons engaged (share in total hours)

Source: Prepared by the authors, on the basis of information from the World Input-Output Database (WIOD), "World Input-Output Database (WIOD) 2013" [online] <http://www.wiod.org/database/seas13>.

Table A1.3

Structure of sectors, versions used in the 2013 and 2016 World Input-Output Database (WIOD)

International Standard Industrial Classification of All Economic Activities (ISIC), Rev. 4	Sector description (2016 WIOD)	ISIC, Rev. 3	Agriculture, hunting, forestry and fishing
A01	Crop and animal production; hunting and related service activities	AtB	Agriculture, hunting, forestry and fishing
A02	Forestry and logging	AtB	Agriculture, hunting, forestry and fishing
A03	Fishing and aquaculture	AtB	Agriculture, hunting, forestry and fishing
B	Mining and quarrying	C	Mining and quarrying
C10–C12	Manufacture of food products, beverages and tobacco products	15116	Food, beverages and tobacco
C13–C15	Manufacture of textiles, wearing apparel and leather products	17118	Textiles and textile products
		19	Leather and footwear
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	20	Wood and products of wood and cork
C17	Manufacture of paper and paper products	21122	Pulp, paper, printing and publishing
C18	Printing and reproduction of recorded media	21122	Pulp, paper, printing and publishing
C19	Manufacture of coke and refined petroleum products	23	Coke, refined petroleum and nuclear fuel
C20	Manufacture of chemicals and chemical products	24	Chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	24	Chemicals and chemical products
C22	Manufacture of rubber and plastic products	25	Rubber and plastics
C23	Manufacture of other non-metallic mineral products	26	Other non-metallic minerals
C24	Manufacture of basic metals	27128	Basic metals and fabricated metal
C25	Manufacture of fabricated metal products, except machinery and equipment	27128	Basic metals and fabricated metal
C26	Manufacture of computer, electronic and optical products	30133	Electrical and optical equipment
C27	Manufacture of electrical equipment	27128	Basic metals and fabricated metal
C28	Manufacture of machinery and equipment not elsewhere classified	29	Machinery not elsewhere classified
C29	Manufacture of motor vehicles, trailers and semi-trailers	34135	Transport equipment
C30	Manufacture of other transport equipment	34135	Transport equipment
C31 and C32	Manufacture of furniture; other manufacturing	36137	Manufacturing not elsewhere classified; recycling
C33	Repair and installation of machinery and equipment	71174	Renting of machinery and equipment and other business activities
D35	Electricity, gas, steam and air conditioning supply	E	Electricity, gas and water supply
E36	Water collection, treatment and supply	E	Electricity, gas and water supply
E37–E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	E	Electricity, gas and water supply
F	Construction	F	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel
G46	Wholesale trade, except of motor vehicles and motorcycles	51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
G47	Retail trade, except of motor vehicles and motorcycles	52	Retail trade, except of motor vehicles and motorcycles; repair of household goods
H49	Land transport and transport via pipelines	60	Inland transport
H50	Water transport	61	Water Transport
H51	Air transport	62	Air transport
H52	Warehousing and support activities for transportation	63	Other supporting and auxiliary transport activities; activities of travel agencies
H53	Postal and courier activities	64	Post and telecommunications

International Standard Industrial Classification of All Economic Activities (ISIC), Rev. 4	Sector description (2016 WIOD)	ISIC, Rev. 3	Agriculture, hunting, forestry and fishing
I	Accommodation and food service activities	H	Hotels and restaurants
J58	Publishing activities	21t22	
J59 and J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	21t22	
J61	Telecommunications	64	Post and telecommunications
J62 and J63	Computer programming, consultancy and related activities; information service activities	71t74	Renting of machinery and equipment and other business activities
K64	Financial service activities, except insurance and pension funding	J	Financial intermediation
K65	Insurance, reinsurance and pension funding, except compulsory social security	J	Financial intermediation
K66	Activities auxiliary to financial services and insurance activities	J	Financial intermediation
L68	Real estate activities	70	Real estate activities
M69 and M70	Legal and accounting activities; activities of head offices; management consultancy activities	71t74	Renting of machinery and equipment and other business activities
M71	Architectural and engineering activities; technical testing and analysis	71t74	Renting of machinery and equipment and other business activities
M72	Scientific research and development	71t74	Renting of machinery and equipment and other business activities
M73	Advertising and market research	71t74	Renting of machinery and equipment and other business activities
M74 and M75	Other professional, scientific and technical activities; veterinary activities	71t74	Renting of machinery and equipment and other business activities
N	Administrative and support service activities	71t74	Renting of machinery and equipment and other business activities
O84	Public administration and defence; compulsory social security	L	Public administration and defence; compulsory social security
P85	Education	M	Education
Q	Human health and social work activities	N	Health and social work
R_ and S	Other service activities	O	Other community, social and personal services
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	P	Private households with employed persons
U	Activities of extraterritorial organizations and bodies		

Source: Prepared by the authors, on the basis of information from World Input-Output Database (WIOD), "World Input-Output Database (WIOD) 2013" [online] <http://www.wiod.org/database/seas13> and "World Input-Output Database (WIOD) 2016" [online] <https://www.rug.nl/ggdc/valuechain/wiod/wiod-2016-release?lang=en>.

Sectoral composition, export trade partners and value added: an input-output analysis for Brazil and Mexico¹

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Abstract

This study examines the impact of changes in the sectoral composition of exports and in trade partners on the value added of Brazil and Mexico between 2000 and 2019, within the framework of Latin American structuralism. Employing quantitative input-output structural decomposition analysis, we identify shifts in value added coefficients, production techniques, domestic demand and exports (level, product mix and trade partners). The research brings out a significant correlation between changes in trade partners and the structure of the export basket. Both Brazil and Mexico display export concentration, geographically and sectorally. While alterations in the export basket and trade partners had a negative impact on Mexico's value added growth, Brazil experienced a positive effect. This finding for Brazil is attributed in part to its specialized agricultural and mineral exports to China. Conversely, Mexico's specialization in transport equipment exports to the United States and Canada contributed to its unfavourable outcome.

Keywords

International trade, exports, export policy, value, production specialization, economic growth, economic analysis, input-output analysis, Brazil, Mexico

JEL classification

N16, C67, F14

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I. Introduction

The Brazilian and Mexican governments have been adopting strategies to stimulate export-led growth since 2015. However, as Alves-Passoni and Blancas (2022) show, this demand component has been unable to accelerate gross domestic product (GDP) growth even when it is its leading driver, mainly because of the low share of exports in final demand. However, this analysis can be complemented by an important consideration: the composition of exports.

On the Latin American structuralist view, differentiation of products and trade partners is a vital determinant of the production structure and growth pattern. According to this theoretical approach, expressed by the centre-periphery hypothesis (Prebisch, 1951; Singer, 1950), the production, export and import structures depend on the technology gap between two regions consisting of a country on the one hand and the “rest of the world” on the other.

The objective of this study is to observe how changes in the sectoral composition of exports and in trade partners affected Brazilian and Mexican value added between 2000 and 2019, using a quantitative input-output structural decomposition analysis. We decompose value added growth into the contributions of the value added coefficient, the production technique (technical coefficients), domestic demand and exports. To observe the effect of export composition, we express the sectoral export vector by considering the level of exports, their sectoral composition (product mix) and export trade partners.

The most recent study comparing the Brazilian and Mexican economies is that of Alves-Passoni (2022a), which decomposes gross output in 2000 and 2014 to identify the role of the medium-high- and high-technology manufacturing and service industries. Although this was not the author’s objective, she identifies the external sector as being more important in explaining changes in gross output in Mexico and the domestic sector as being more important in Brazil. The decomposition also shows a reduction in the importance of high-technology goods exports, especially from 2010 onward. However, gross output is only part of the analysis, as it does not reveal an economy’s capacity to appropriate value added, which is related to factors of production.

As regards trade partners, the most recent study is that of Castilho and Puchet Anyul (2012), which compares the two countries between 1985 and 2008. The authors’ main finding is that trade integration in Mexico and Brazil has different characteristics. The primary market for Mexican exports is the United States, and this relationship became more dominant from 1990 because of the North American Free Trade Agreement (NAFTA). This finding is corroborated by other studies, such as Gómez and Camacho (2020), Costa, Castilho and Puchet Anyul (2021), Fujii and Cervantes (2013) and Moreno-Brid and others (2016), showing that most Mexican exports are in the automotive sector.

In the Brazilian case, Castilho and Puchet Anyul (2012) argue that the specialization of the export structure depends on the trade partner. Higher-technology goods are exported to Latin American countries, while commodities such as agricultural and mineral products are exported to China. These results can also be seen in Castilho, Costa and Torracca (2019) and Nassif and Castilho (2020).

The contribution of this study is therefore twofold: (i) it extends the time period for the analysis of Brazilian and Mexican exports, including trade partners; (ii) it shows how changes in sectoral composition and in trade partners impact value added growth. We hypothesize that there is an intrinsic relationship between changes in sectoral and geographical contributions to value added in Brazil and Mexico.

We believe that this research is relevant because Brazil and Mexico share essential similarities. Both countries have become increasingly reliant on imported intermediate inputs, particularly parts and components, since the trade opening of the 1990s. This has directly impacted the generation of value added, which is calculated as gross value minus the consumption of domestic and imported

intermediate inputs from a production perspective. Studies by Fujii and Cervantes (2013), Moreno-Brid and others (2016), Nassif and Castilho (2020), Morceiro and Guilhoto (2020) and Alves-Passoni (2023) have all explored this issue.

Mexico and Brazil's lack of an industrial policy to promote growth has resulted in a focus on comparative advantage strategies for export growth, such as currency devaluation (Moreno-Brid and others, 2016; Ferraz, Paula and Kupfer, 2013). This has led to an increase in Mexico's maquila exports, which have a large imported content and poorly connected supply chains. Similarly, Brazil has seen a rise in exports of unprocessed agricultural products, which Alves-Passoni (2022b) attributes to regressive specialization.

Brazil and Mexico are two economically significant countries in Latin America that act as leaders in the region because of the size of their markets and the volume of their production. However, they belong to different regional integration strategies, with Brazil being part of the Southern Common Market (MERCOSUR) and Mexico of the North American Free Trade Agreement (NAFTA). This has resulted in distinct development strategies for their external and internal sectors. Comparing these two countries makes it possible to identify similarities and differences that are essential to an understanding of Latin American development.

This introduction is followed by four additional sections. Section II provides an empirical and theoretical overview of the influence of trade partners and sectoral exports on export composition, drawing on both previous studies and new data. Section III outlines the methodology (including structural decomposition analysis) and database used. Section IV discusses the results of the structural decomposition analysis. Section V offers concluding remarks.

II. The influence of export partners and the sectoral composition of exports: theoretical and empirical aspects

Latin American structuralist theory focuses on how a country's choice of trade partners and product differentiation affect its economic growth and development. This approach provides the foundation for the present study's effort to understand economic changes. According to this theory, the global South, which includes Latin American countries such as Brazil and Mexico, tends to have a productive specialization in a few products, primarily low-technology agricultural and mineral commodities with little processing. These goods are particularly subject to price competition in the international market (Singer, 1998), making countries more likely to adopt policies to stimulate exports through pricing, such as currency devaluation and subsidies to export sectors. In this context, Singer (1950 and 1998) argues that not only trade products but also trade partners should be analysed.

Thirlwall (1979) also discusses the impact of external constraints on growth, considering the elasticities of exports and imports. In a 1983 paper, the author mentions the similarities between his theory and that developed by Singer (1950), while Dávila-Fernández and Amado (2015) and Nassif and Castilho (2020) argue that Thirlwall's law can be interpreted as the mathematical formalization of the Prebisch-Singer hypothesis.

According to the Thirlwall model, elasticities play a fundamental role in determining growth constraints, since expenditure (reflected in imports) cannot grow by more than the income generated from exports; if this occurs, there will be a current account deficit problem. This idea is very similar to the Prebisch-Singer hypothesis, whereby there can only be sustained growth with balance-of-payments sustainability if the elasticity of demand of exported goods is higher than that of imported ones.

Thirlwall's original model was developed for a single economy, but McCombie (1993) and Nell (2003) extended it to include the impact of trade partners on growth. Their objective was to capture the effects of growth in one region on others, this being fundamental to an understanding of the spillover effect of economic policies. Since there is “mutual interdependence of the world economy where one country's (or a block of countries') growth rate depends on others” (Nell, 2003, p. 264), “there is not much scope for a country to increase its rate of growth relative to that of its trading partners faster than in the past” (McCombie, 1993, p. 501). Even though the analysis in this paper is not designed to observe growth determinants in different countries or capture differences in current account balances, the value added decomposition contributes to an understanding of how changing the composition of trade partners affects sectoral growth.

Torracca (2017) proposes two possible trajectories when considering the effects of sectoral composition and trading partners on the economy. One is “outward”, whereby the structure of exports determines the structure of domestic production, and the other is “inward”, whereby domestic demand is the determining factor in the type of trade specialization. The first is based on Ricardian theory and its neoclassical developments, whereby the specialization of production focuses on the export activities in which a country has comparative advantages (relative prices). The “inward” profile is guided by what Linder (1961) discusses about the need to construct dynamic competitive advantages as against so-called comparative advantages.

The theories mentioned here argue that a long-run growth strategy must be focused on non-price competitiveness. In a recent Latin American structuralist model, Cimoli, Porcile and Rovira (2010) show that the developing countries which have reduced the gap with the developed countries are those where efforts to bring about structural change have focused on sectors in which the elasticity of export income is high compared to that of imports. These sectors have high Schumpeterian and Keynesian efficiency. Keynesian efficiency is associated with a greater demand for dollars, whereas Schumpeterian efficiency is associated with a superior technological structure. In the case of Latin America, the authors show from econometric studies that the region is dominated by low-technology sectors affected by a low rate of growth in international demand.

The structure of Brazil's and Mexico's export partners is directly related to their regional integration. While Brazil plays a central role in MERCOSUR, Mexico responds to developments in other major economies, especially the United States, because of NAFTA (Beaton and others, 2017). Owing to these structural characteristics, the sectoral composition of Mexico's exports is more concentrated than that of Brazil's. However, this concentration is even greater when it comes to trade partners. Table 1 shows the composition of Mexico's exports to its six main export partners: the United States, Canada, China, Germany, Spain and Japan. Our findings are similar to those of previous studies (see, for example, Gómez and Camacho (2020), Costa, Castilho and Puchet Anyul (2021), Fujii and Cervantes (2013) and Fraga-Castillo and Moreno-Brid (2015)), showing the United States to account for more than two thirds of all Mexican exports. The figure decreased by approximately 5 percentage points between 2000 and 2019, from 80% to 74.5%. This (small) decline was associated with an increase in exports to Canada (up from 4% to 6.3%) and China (up from 0.3% to 2.9%).

Table 1
Geographical distribution of Mexican and Brazilian exports, 2000–2009
(Percentages)

Brasil	China	United States	Japan	Germany	Mexico	India	World	Total
2019	31.26	17.52	4.03	3.83	2.15	1.69	39.52	100.00
2015	14.94	11.80	3.40	2.60	1.71	2.40	63.14	100.00
2011	14.37	9.47	3.63	3.13	1.84	2.66	64.91	100.00
2008	8.25	12.76	3.35	4.05	2.48	2.42	66.68	100.00
2000	2.39	21.99	4.55	3.53	4.34	2.39	60.82	100.00

Mexico	United States	Canada	China	Spain	Germany	Japan	World	Total
2000	79.54	3.99	0.29	0.80	0.38	0.19	14.81	100.00
2008	73.70	5.02	1.15	1.34	0.34	0.28	18.16	100.00
2011	72.14	5.73	2.13	1.58	0.37	0.43	17.63	100.00
2015	74.40	5.01	1.80	1.68	0.51	0.35	16.24	100.00
2019	74.43	6.29	2.92	1.17	0.69	0.31	14.20	100.00

Source: Prepared by the author, on the basis of R. M. Consing III and others, "The wellness economy: a comprehensive system of national accounts approach", *ADB Economics Working Paper Series*, No. 631, December 2020; and Asian Development Bank (ADB), *Capturing the digital economy: a proposed measurement framework and its applications. A special supplement to key indicators for Asia and the Pacific 2021*, Manila, 2021.

The analysis of Mexico's sectoral export structure in table 2 shows that, as of 2000, 56% of exports were made by manufacturing industry, which is traditionally classified as having medium-high and high technology intensity. Most of this share was accounted for by two sectors, electrical and optical equipment (31%) and transport equipment (20%). A focus on the North American market has led the country to integrate into global value chains by importing parts and components for the assembly of automobiles that are then exported to the United States (Castilho and Puchet Anyul, 2012). Since the United States accounts for the bulk of exports, developments in that country have a critical impact on Mexico's export structure. In 2015, bilateral flows from Mexico to the United States represented the largest magnitude, followed by those to Canada and China (Beaton and others, 2017). Between 2008 and 2011, the transport sector accounted for only 15% of Mexican exports because of the global subprime crisis. With the resumption of growth in the United States, this sector grew its share substantially to 20% in 2012 and then 32% in 2019.

Table 2

Brazil and Mexico: composition of exports by sectors and trade partners, 2000, 2011 and 2019
(Percentages)

Country Sector	Brazil								Mexico							
	CHN	USA	JPN	GER	MEX	IND	World	Total	USA	CAN	CHN	SPA	DEU	JPN	World	Total
2000																
AGR	1.81	0.84	0.03	5.33	2.47	3.40	1.62	1.76	1.81	0.84	0.03	2.47	5.33	3.40	1.62	1.76
MNQ	6.24	4.67	1.49	0.45	66.14	7.21	29.48	10.07	6.24	4.67	1.49	66.14	0.45	7.21	29.48	10.07
TRM	21.88	19.37	9.24	20.02	6.46	20.54	18.98	21.18	21.88	19.37	9.24	6.46	20.02	20.54	18.98	21.18
CIM	60.30	65.64	63.88	56.72	14.78	42.32	35.39	56.42	60.30	65.64	63.88	14.78	56.72	42.32	35.39	56.42
CHM	1.71	0.82	5.46	8.19	5.21	13.55	6.12	2.41	1.71	0.82	5.46	5.21	8.19	13.55	6.12	2.41
MAC	2.37	1.68	1.78	6.60	0.16	3.82	1.93	2.28	2.37	1.68	1.78	0.16	6.60	3.82	1.93	2.28
EOP	33.22	37.11	55.95	38.02	7.58	20.67	18.68	31.08	33.22	37.11	55.95	7.58	38.02	20.67	18.68	31.08
TRA	23.00	26.03	0.69	3.91	1.84	4.29	8.66	20.65	23.00	26.03	0.69	1.84	3.91	4.29	8.66	20.65
OTH	9.77	9.48	25.35	17.48	10.14	26.52	14.53	10.58	9.77	9.48	25.35	10.14	17.48	26.52	14.53	10.58
2011																
AGR	24.19	3.07	2.54	6.87	1.87	0.77	3.04	2.56	3.07	2.54	1.87	0.77	3.04	6.87	2.56	2.91
MNQ	45.56	17.84	7.24	16.95	48.65	81.29	2.62	11.43	17.84	7.24	48.65	81.29	2.62	16.95	11.43	17.70
TRM	16.30	23.12	19.67	22.07	13.05	6.91	33.47	28.63	23.12	19.67	13.05	6.91	33.47	22.07	28.63	23.45
CIM	3.76	51.11	65.79	44.74	32.94	9.13	54.44	48.48	51.11	65.79	32.94	9.13	54.44	44.74	48.48	50.43
CHM	1.45	2.57	1.44	13.99	4.95	3.85	6.53	10.07	2.57	1.44	4.95	3.85	6.53	13.99	10.07	3.96
MAC	0.77	7.29	5.40	5.08	3.86	1.33	9.82	5.00	7.29	5.40	3.86	1.33	9.82	5.08	5.00	6.61
EOP	0.33	24.98	35.59	7.12	16.49	3.16	31.10	21.45	24.98	35.59	16.49	3.16	31.10	7.12	21.45	24.39
TRA	1.22	16.28	23.36	18.55	7.64	0.79	6.98	11.96	16.28	23.36	7.64	0.79	6.98	18.55	11.96	15.47
OTH	10.19	4.86	4.76	9.38	3.48	1.90	6.43	8.90	4.86	4.76	3.48	1.90	6.43	9.38	8.90	5.51

Country Sector	Brazil								Mexico							
	CHN	USA	JPN	GER	MEX	IND	World	Total	USA	CAN	CHN	SPA	DEU	JPN	World	Total
2019																
AGR	44.31	5.60	2.67	2.54	2.65	2.71	0.40	2.50	5.60	2.67	2.65	2.71	0.40	2.54	2.50	4.81
MNQ	35.89	4.35	0.93	9.15	15.44	62.79	1.25	11.69	4.35	0.93	15.44	62.79	1.25	9.15	11.69	6.18
TRM	14.28	17.71	17.05	18.32	11.86	6.42	9.74	11.94	17.71	17.05	11.86	6.42	9.74	18.32	11.94	16.49
CIM	1.42	69.08	74.35	42.54	59.82	16.17	64.58	46.21	69.08	74.35	59.82	16.17	64.58	42.54	46.21	65.16
CHM	0.87	1.75	1.77	9.61	3.57	2.89	4.58	3.59	1.75	1.77	3.57	2.89	4.58	9.61	3.59	2.12
MAC	0.36	6.71	6.50	5.08	3.47	1.82	5.60	3.26	6.71	6.50	3.47	1.82	5.60	5.08	3.26	6.04
EOP	0.09	25.29	27.28	16.85	40.72	5.46	36.92	19.97	25.29	27.28	40.72	5.46	36.92	16.85	19.97	24.94
TRA	0.10	35.33	38.79	10.99	12.06	5.99	17.48	19.39	35.33	38.79	12.06	5.99	17.48	10.99	19.39	32.06
OTH	44.31	5.60	2.67	2.54	2.65	2.71	0.40	2.50	5.60	2.67	2.65	2.71	0.40	2.54	2.50	4.81

Source: Prepared by the author, on the basis of R. M. Consing III and others, "The wellness economy: a comprehensive system of national accounts approach", *ADB Economics Working Paper Series*, No. 631, December 2020; and Asian Development Bank (ADB), *Capturing the digital economy: a proposed measurement framework and its applications. A special supplement to key indicators for Asia and the Pacific 2021*, Manila, 2021.

Note: USA: United States of America; JPN: Japan; CAN: Canada; CHN: China; SPA: Spain; GER: Germany; IND: India; MEX: Mexico. AGR: Agriculture, hunting, forestry and fisheries; MNQ: Mining and quarrying; TRM: Traditional (low- and medium-low-technology) manufacturing; CIM: Computer-integrated (medium-high- and high-technology) manufacturing; CHM: Chemicals and chemical products; MAC: Machinery, not elsewhere classified; EOP: Electrical and optical equipment; TRA: Transport equipment; OTH: Other industries.

The decline in the share of the mining and quarrying sector may be due to a composition effect. The oil sector increased its exports as part of the commodities boom in 2003–2013, contributing to a loss of share for other sectors in the Mexican export basket (Schneider, 2013). Likewise, the share of mining and quarrying sector exports to the United States rose from 6% of the total in 2000 to 15% in 2008 and 18% in 2011. However, the oil price decline since 2013 means that the mining and quarrying sector now accounts for only 4.3% of Mexican exports to the United States.²

The share of transport equipment has also increased because of the Mexican strategy of stimulating growth through exports, using exchange-rate devaluation and tax incentives as economic policies (Alves-Passoni and Blancas, 2022). Again, United States automotive multinationals that operate in both countries changed their strategy and transferred various operations and segments to Mexico, such as premium categories (Carrillo and Hernández, 2020), thus increasing Mexico's exports to the United States. The Mexican machinery sector was another that substantially increased its exports to the United States, from a share of 2% in 2000 to 6% in 2011, maintaining this level until 2019.

Brazil's most important export destinations, accounting for around 60% of the total, are in the "rest of the world" group, mainly because the MERCOSUR and Latin American Integration Association (LAIA) countries are not included in the Asian Development Bank database. Of the countries in the database, the ones taking the largest shares are the United States, Japan, India, China, Mexico and Germany. In this case, specialization differs depending on the trade partner (Castilho and Puchet Anyul, 2012; Nassif and Castilho, 2020). Generally speaking, the country exports medium-technology and medium-high-technology goods to MERCOSUR and LAIA and lower-technology goods to other countries, such as China, the United States and Europe. Another interesting point is that while Mexico is one of Brazil's top two trade partners, the opposite is not the case. Brazilian exports to Mexico are dominated by transport equipment (63% in 2000 and 55% in 2019).

As table 1 shows, the main changes in Brazilian exports have been in the shares of the rest of the world and China. The rest of the world accounted for 60% of all Brazilian exports in 2000 but

² As Alves-Passoni (2022c) shows, notwithstanding a significant price effect that tends to result in the share of oil being overestimated, the volume of oil exports also increased.

only 40% at the end of the period. This change occurred because of the increase in China's share, from 2% to 31% of the total. The bulk of this shift occurred from 2010 onward.

In this context, Hiratuka and Sarti (2017) argue that the 2008 economic crisis increased international competition, since countries developed strategies to stimulate their exports as a demand source to counteract the drop in their growth rate. China increased its share of the Latin American market, becoming a competitor to Brazilian exports in MERCOSUR and LAIA.

Table 2 shows the increase in China's share of Brazilian exports of commodities (agricultural and mining products). In 2000, agricultural and mining exports to the country represented 6.5% and 5.5%, respectively, of total Brazilian exports; by 2019, the figures had grown to 27% and 21%. China by itself is the destination for 50% of the goods produced by the extractive mining sector. The composition of Brazilian exports to China changed: whereas 15% of exports to China were associated with agriculture in 2000, this proportion was 44% in 2019, while the share of the mining and quarrying sector grew from 11% in 2000 to 35% in 2019.

After increasing steadily, the shares of these sectors in Brazilian exports rose particularly strongly between 2015 and 2019. The share of Brazilian exports taken by the rest of the world also decreased in the period. Although the world input-output tables published by the Asian Development Bank (ADB) do not provide information about other Latin American countries, Nassif and Castilho (2020) identify a decline in the importance of these countries, particularly Argentina. This has affected sectoral composition, since most technological goods are exported to Latin America, as Castilho and Puchet Anyul (2012) and Nassif and Castilho (2020) show. Consequently, the share of Brazilian capital-intensive manufacturing exports fell from 26% to 10%. All the sectors that compose this group lost ground, but electrical and optical equipment and chemical products were particularly affected. The finding holds for all major trade partners other than China.

III. Methodology

1. Structural decomposition analysis

Structural decomposition analysis is a methodology used within the input-output framework to examine changes in an economic variable using a set of comparative static changes in the parameters of an input-output table (Rose and Chen, 1991; Rose and Miernyk, 1989). The model is suitable for this study because it can be used for sectoral analysis, demonstrating connections through production relationships and the structure of demand for goods and services.

We focus the structural decomposition analysis on sectoral value added (v), representing the value added for each commodity at the end of the production process. This is calculated within the traditional input-output model using the value added coefficient (value added per unit of output, calculated as the share of v in gross sectoral output (x), ($c = vx^{-1}$), the inverse Leontief matrix $L = (I - A_d)^{-1}$, which incorporates the direct technical coefficients (A_d) i.e., the amount of inputs used by each sector to produce an additional unit of output) and final demand (f) (Miller and Blair, 2009):³

$$v = \hat{c} \times (I - A_d)^{-1} \times f \quad (1)$$

$$v = \hat{c} \times L \times f \quad (2)$$

³ Here we follow the regular notation, denoting matrices with bold capital letters and vectors with bold lower-case letters; vectors are column vectors, and thus a row vector is represented by a transposed column vector.

where \hat{c} is the diagonal vector of the value added coefficient, in the range $0 < c_j \leq 1$, depending on the usage of primary factors of production (wages, capital and land) in sector j .

We propose a breakdown of final demand into domestic demand (d), which is composed of household and government expenditures and gross fixed capital formation; exports (e); and changes in inventories (s), such that:

$$f = d + e + s \quad (3)$$

Putting together (2) and (3), we have:

$$v = \hat{c} \times L \times (d + e + s) \quad (4)$$

Next, we define v_d , v_e and v_s as the value added generated by domestic demand, exports and changes in inventories:

$$v_d = \hat{c}Ld \quad (5)$$

$$v_e = \hat{c}Le \quad (6)$$

$$v_s = \hat{c}Ls \quad (7)$$

So, merging (5), (6), (7) and (4), sectoral value added can be expressed as:

$$v = v_d + v_e + v_s = \hat{c}Ld + \hat{c}Le + \hat{c}Ls \quad (8)$$

The decompositions presented here will concentrate on v_d and v_e , since changes in inventories have no economic significance.

Inspired by the final demand decomposition presented by Miller and Blair (2009), we disaggregate the export vector (e) into terms of trade, composition of trade partners, sectoral composition (product mix) and level of exports. For this, we treat E as a partitioned matrix formed of the three main partners (e_{st} , e_{nd} , e_{rd} , identified by the annual averages for each country) and the rest of the world (e_{rw}):

$$E = [e_{st} \mid e_{nd} \mid e_{rd} \mid e_{rw}] \quad (9)$$

These countries are the United States, Canada and China for Mexico, and the United States, China and Japan for Brazil.

In addition, let total exports (e) be:

$$e = i'Ei \quad (10)$$

The second step is to set δ as a vector (4×1) that represents total exports for the three main partners and the rest of the world:

$$\delta = (i'r)' \quad (11)$$

Dividing δ by total exports gives the share of total exports going to the main export partners and the rest of the world (ψ , 4×1):

$$\psi = \left(\frac{1}{e}\right) \hat{\delta} \quad (12)$$

Lastly, we compute the share of products exported to each country (T , $n \times 4$):

$$T = (E)(\hat{\psi})^{-1} \quad (13)$$

Combining (10), (12) and (13) allows us to express e in terms of product mix, composition of partners and level:

$$e = T\psi e \quad (14)$$

We now have the main equation required to proceed with the structural decomposition analysis, which includes the value added generated by domestic demand and external demand while also incorporating export partners:

$$v = \hat{c}Ld + \hat{c}LT\psi e + v_s \quad (15)$$

In the structural decomposition analysis, the change in value added (Δv) between two years, 0 (v^0) (the start year) and 1 (v^1) (the end year), is given by:

$$\Delta v = v^1 - v^0 \quad (16)$$

Because each decomposition has several alternative forms, we use the mean of the polar decomposition to calculate the changes, as Dietzenbacher and Los (1998) suggest. So the structural decomposition analysis for (16), following, Miller and Blair (2009), is:

$$\Delta v = \left(\frac{1}{2}\right)\Delta\hat{c} \times (L^1 d^1 + L^0 d^0) + \left(\frac{1}{2}\right)\Delta\hat{c} \times (L^1 e^1 + L^0 e^0) + \quad (17a)$$

$$\left(\frac{1}{2}\right)(\hat{c}^1 + \hat{c}^0) \times \Delta L \times (d^1 + d^0) + \left(\frac{1}{2}\right)(\hat{c}^1 + \hat{c}^0)\Delta L \times (e^1 + e^0) + \quad (17b)$$

$$\left(\frac{1}{2}\right)(\hat{c}^1 L^1 + \hat{c}^0 L^0) \times \Delta d + \quad (17c)$$

$$\left(\frac{1}{2}\right)(\hat{c}^1 L^1 + \hat{c}^0 L^0) \times \Delta e + \quad (17d)$$

$$\left(\frac{1}{2}\right)\Delta\hat{c} \times (x_s^1 + x_s^0) + \left(\frac{1}{2}\right)(\hat{c}^1 + \hat{c}^0) \times \Delta x_s \quad (17e)$$

Following the suggestion of Oosterhaven and Van der Linden (1997) and Miller and Blair (2009), we use a hierarchical structural decomposition analysis to express the changes of ΔL (17b) as ΔA_d :

$$\Delta L = L^1 \Delta A_d L^0 \quad (18)$$

We also decompose Δe (17d), in accordance with the definition presented in (14), as:

$$\Delta e = T^1 \psi^1 e^1 - T^0 \psi^0 e^0 \quad (19)$$

$$\Delta e = \left(\frac{1}{2}\right)\Delta T \times (\psi^1 e^1 + \psi^0 e^0) + \left(\frac{1}{2}\right)(T^1 + T^0) \times \Delta \psi \times (e^1 + e^0) \quad (20)$$

$$+ \left(\frac{1}{2}\right)(T^1 \psi^1 + T^0 \psi^0) \times \Delta e$$

By combining (19) and (21) with (18), we can carry out the value added structural decomposition analysis by changes in seven sources, namely the value added coefficient ($\Delta\hat{c}$), technology (ΔA_d), domestic demand (Δd), export product mix (ΔT), composition of export partners ($\Delta\psi$), export level (Δe) and inventories (Δv_s):

Value added coefficient

$$\left(\frac{1}{2}\right)\Delta\hat{c} \times (L^1 d^1 + L^0 d^0) + \left(\frac{1}{2}\right)\Delta\hat{c} \times (L^1 e^1 + L^0 e^0) \quad (21a)$$

Technology

$$\left(\frac{1}{2}\right)(\hat{c}^1 + \hat{c}^0) \times L^1 \Delta A_d L^0 \times (d^1 + d^0) + \left(\frac{1}{2}\right)(\hat{c}^1 + \hat{c}^0) \times L^1 \Delta A_d L^0 \times (e^1 + e^0) \quad (21b)$$

Domestic demand

$$\left(\frac{1}{2}\right)(\hat{c}^1 L^1 + \hat{c}^0 L^0) \times \Delta d \quad (21c)$$

Exports (sectoral composition)

$$\left(\frac{1}{2}\right)(\hat{c}^1 L^1 + \hat{c}^0 L^0) \times \left[\left(\frac{1}{2}\right)\Delta T \times (\psi^1 e^1 + \psi^0 e^0) \right] \quad (21d)$$

Exports (composition of partners)

$$\left(\frac{1}{2}\right)(\hat{c}^1 L^1 + \hat{c}^0 L^0) \times \left[\left(\frac{1}{2}\right)(T^1 + T^0) \times \Delta \psi \times (e^1 + e^0) \right] \quad (22e)$$

Exports (level)

$$\left(\frac{1}{2}\right)(\hat{c}^1 L^1 + \hat{c}^0 L^0) \times \left[\left(\frac{1}{2}\right)(T^1 \psi^1 + T^0 \psi^0) \times \Delta e \right] \quad (21f)$$

Inventories

$$\left(\frac{1}{2}\right)\Delta\hat{c} \times (x_s^1 + x_s^0) + \left(\frac{1}{2}\right)(\hat{c}^1 + \hat{c}^0) \times \Delta x_s \quad (21g)$$

Note that Δv as presented above shows sectoral changes in value added. If we want the total for the economy, we must multiply each change by a summary vector i' (transposed column vector of ones). The $\Delta\hat{c}$ contribution represents changes in value added per unit of output over the period. As Oosterhaven and Hoen (1998) point out, a negative/positive contribution indicates an increase/decrease in production efficiency, since fewer/more primary factors of production are used to generate the same value added per unit of output. This contribution can be interpreted to ascertain whether the value added is related to more indirect or direct production techniques.

The ΔA_d contribution shows how changes in the technical coefficient impact sectoral value added. If it is positive/negative, the whole economy uses more/fewer domestic intermediate inputs to produce one additional unit of value added. We also show sectoral contributions to the supply of the domestic and external markets (the two terms of 21.b) so that the difference by demand source can be identified. The contribution associated with Δd can be positive or negative; if it is positive, changes in the domestic market in year one compared to year zero positively affected value added; the opposite applies when it is negative.

Concerning the external contribution (Δe), changes in ΔT show how differences in the product mix between years 0 and 1 positively/negatively contributed to the generation of value added. If $\Delta \psi$ is positive/negative, changes in export destinations were beneficial/disadvantageous to Δv . It also shows the magnitude and sign of the effect of the level of exports on changes in Δv , irrespective of the sectoral composition or export market. Because inventories in the national accounts have no economic significance, we only show them to keep the model consistent, and they are not analysed.

2. Database and sectoral classification

We used the world input-output tables in constant prices estimated by the Asian Development Bank (ADB), which extend those originally published by the University of Groningen (Consing and others, 2020; ADB, 2021). The database has information for both Brazil and Mexico, and its multiregional character allows the export vector to be disaggregated by trade partner. The data are deflated using sectoral deflators of gross output, a procedure very similar to the double deflation method.

The database contains 35 sectors, which we group into five categories:

- (i) Agriculture, hunting, forestry and fisheries.
- (ii) Mining and quarrying.
- (iii) Traditional manufacturing industry: food, beverages and tobacco; textiles and textile products; leather, leather products and footwear; wood and products of wood and cork; pulp, paper, paper products, printing and publishing; coke, refined petroleum and nuclear fuel; rubber and plastics; other non-metallic minerals; primary metals and fabricated metal.
- (iv) Capital-intensive manufacturing industry: chemicals and chemical products; machinery, not elsewhere classified; electrical and optical equipment; transport equipment.
- (v) Other sectors: public utilities; construction; services.

To better characterize manufacturing industry, we divided it into traditional and capital-intensive manufacturing. The first group is generally classified as low- and medium-low-technology, and the second group as medium- and high-technology (see, for example, the Organisation for Economic Co-operation and Development (OECD) technology intensity classification by Galindo-Rueda and Verger, 2016). We prefer not to use the OECD nomenclature because these technology intensity categories are based on developed countries and do not map on to the research and development done by firms in Latin American countries such as Brazil and Mexico (Cassini and Robert, 2017). We are particularly interested in the second group of sectors, so we provide disaggregated information for the sectors within capital-intensive manufacturing industry.

The database is available for the years from 2000 to 2020. We excluded the last year because of the economic crisis caused by the coronavirus disease (COVID-19) pandemic, which would have affected the analysis of general trends in the economic processes experienced by the countries. The decomposition was performed from 2000 to 2019, taking the following subperiods: 2000–2008, 2010–2014 and 2015–2019. Since not all years in the series are available, we only use the beginning and end years to calculate growth rates. This means that developments within a period cannot be examined and may affect comparisons with other research that uses a chained growth method.

IV. Discussion of results

From 2000 to 2019, Mexico and Brazil had annual value added growth rates of 1.21% and 1.22%, respectively. Table 3 provides a breakdown of the structural decomposition analysis components for the entire period (2000–2019) and subperiods (2000–2008, 2010–2014 and 2015–2019).

Table 3
Mexico and Brazil: structural decomposition of growth, 2000–2019 and subperiods
(Percentage points of value added growth)

Structural decomposition analysis variable	Brazil				Mexico				
	2000–2019	2000–2008	2010–2014	2015–2019	2000–2019	2000–2008	2010–2014	2015–2019	
Value added coefficient	Domestic	-1.99	-3.74	0.29	-0.25	-1.79	-3.57	-0.11	-0.53
	Export	-0.71	-1.13	0.52	0.26	0.60	-0.47	0.33	-0.72
	Total	-2.70	-4.87	0.81	0.01	-1.19	-4.04	0.22	-1.24
Technology	Domestic	-2.70	-0.53	-1.76	-0.38	-2.90	-1.54	-1.93	0.39
	Export	-0.53	0.18	-0.76	-0.42	-0.29	0.45	0.28	-0.80
	Total	-3.23	-0.34	-2.52	-0.80	-3.19	-1.08	-1.65	-0.41
Domestic demand	40.11	24.38	8.01	0.77	38.09	24.75	7.80	0.38	
Exports	Product	0.40	0.02	0.01	0.34	-3.24	0.72	-0.35	-1.82
	Partners	0.24	0.10	0.00	0.06	-0.37	0.12	0.02	-0.48
	Level	12.53	6.73	1.88	3.75	12.85	6.63	1.85	3.87
	Total	13.17	6.86	1.89	4.15	9.25	7.47	1.52	1.56
Inventories	-1.13	0.97	-0.27	0.36	-2.85	-0.28	-1.55	2.20	
Cumulative growth	46.22	27.00	7.93	4.49	40.10	26.82	6.34	2.49	
Annual growth	1.22	1.51	1.68	1.46	1.21	1.51	1.59	1.26	

Source: Prepared by the author, on the basis of R. M. Consing III and others, “The wellness economy: a comprehensive system of national accounts approach”, *ADB Economics Working Paper Series*, No. 631, December 2020; and Asian Development Bank (ADB), *Capturing the digital economy: a proposed measurement framework and its applications. A special supplement to key indicators for Asia and the Pacific 2021*, Manila, 2021.

Over the whole period, the contribution of the value added coefficient was negative in Mexico and Brazil, with approximately -4% total growth in value added. This suggests a decrease in these economies’ ability to generate value added per unit of output, but it could also mean an increase in production efficiency. In Mexico, interestingly, the export-related value added coefficient made a positive contribution (0.60 percentage points), while that for the domestic sector had a negative effect (-1.79 percentage points). In Brazil, changes in \hat{c} related to the domestic sector (-1.99 percentage points) and external sector (-0.71 percentage points) both made negative contributions to value added growth.

Regarding the domestic contribution of technology, Brazil and Mexico experienced a decrease in the use of intermediate production inputs, as evidenced by their negative technical coefficients. This could mean a loss of linkages in production activities, but it could also indicate that more efficient production techniques were utilized.

Between 2000 and 2019, most value added growth in Mexico and Brazil came from domestic demand. This is classified as “inward” value added generation by Torracca (2017), because domestic demand components contributed the most significant portion to the overall creation of value added. Specifically, 95% of total value added growth in Mexico and 87% in Brazil are attributed to domestic demand. In nations with large populations and extensive territories, there is often a need to meet domestic requirements by producing goods and services locally. Alves-Passoni and Blancas (2022) have noted that in Mexico and Brazil, approximately 80% and 90%, respectively, of final demand consists of domestic components such as household consumption, gross fixed capital formation and government expenditure.

Significant differences between the two countries are found when the contribution of exports to value added growth is analysed. In Mexico, the shift in the product mix from 2000 to 2019 affected value added growth. However, when changes in gross output are examined, the outcome is entirely different. Table 4 shows that the transport sector had the largest share of gross output, but its value added coefficient was lower because imports were included. Only the agricultural sector contributed positively to the changes in the product mix.⁴ Conversely, the mining and quarrying sector (-1.34 percentage points) and other sectors (-1.5 percentage points) were negatively affected by the changes in the product mix.

⁴ The value added coefficient of this sector was 0.65 in 2000 and 0.69 in 2019.

Table 4
Mexico: structural decomposition analysis, 2000–2019 and subperiods
(Percentage points of value added growth)

	$\Delta\hat{c}$			ΔA_d			Δv_D	Δe			Δv_s	Δv	
	Domestic	Export	Total	Domestic	Export	Total		ΔT	$\Delta\psi$	Δe			Domestic
2000–2019													
AGR	0.05	-0.18	-0.13	-0.75	1.05	0.29	0.62	1.05	-0.03	1.03	2.04	-1.19	1.64
MNQ	-0.42	0.09	-0.33	0.06	-1.34	-1.28	0.01	-1.34	-0.01	2.77	1.42	0.61	0.43
TRM	1.02	-0.24	0.78	-0.62	-0.57	-1.19	3.61	-0.83	-0.45	2.60	1.32	0.69	5.20
CIM	0.02	-0.94	-0.93	-0.38	1.31	0.93	2.38	-0.64	-0.29	1.27	0.33	-0.55	2.16
CHM	-0.13	-0.16	-0.28	-0.15	-0.08	-0.23	0.78	-0.11	-0.04	0.44	0.30	0.15	0.71
MAC	0.06	-0.18	-0.12	-0.07	0.65	0.58	0.46	-0.06	-0.06	0.25	0.14	-0.47	0.58
EOP	0.33	-0.48	-0.16	-0.28	-0.72	-1.00	0.23	-0.27	-0.06	0.20	-0.13	1.21	0.15
TRA	-0.24	-0.12	-0.37	0.11	1.46	1.57	0.92	-0.21	-0.13	0.38	0.03	-1.44	0.71
OTH	-2.46	1.87	-0.59	-1.20	-0.74	-1.94	31.46	-1.48	0.42	5.19	4.13	-2.40	30.67
Total	-1.79	0.60	-1.19	-2.90	-0.29	-3.19	38.09	-3.24	-0.37	12.85	9.25	-2.85	40.10
2000–2008													
AGR	-0.04	-0.07	-0.10	-0.48	0.14	-0.34	0.73	0.14	0.00	0.20	0.34	0.13	0.76
MNQ	0.14	0.02	0.16	0.36	1.53	1.89	1.44	1.53	0.13	1.21	2.87	-1.61	4.74
TRM	-2.31	-0.05	-2.36	-0.14	-0.25	-0.39	1.92	-0.34	-0.13	1.38	0.92	-0.18	-0.09
CIM	-1.41	-0.42	-1.83	0.21	0.16	0.38	2.27	-0.10	-0.07	0.80	0.62	0.11	1.55
CHM	-0.96	-0.02	-0.98	0.00	0.08	0.08	0.34	0.01	-0.02	0.22	0.20	-0.27	-0.62
MAC	-0.08	-0.13	-0.20	0.02	0.39	0.41	0.43	0.02	-0.02	0.16	0.16	-0.27	0.52
EOP	-0.19	-0.22	-0.41	-0.11	-0.14	-0.25	0.08	-0.10	-0.02	0.14	0.02	0.31	-0.24
TRA	-0.19	-0.05	-0.24	0.30	-0.17	0.14	1.42	-0.03	-0.01	0.28	0.24	0.35	1.89
OTH	0.04	0.06	0.10	-1.49	-1.13	-2.62	18.39	-0.51	0.19	3.03	2.72	1.27	19.86
Total	-3.57	-0.47	-4.04	-1.54	0.45	-1.08	24.75	0.72	0.12	6.63	7.47	-0.28	26.82
2010–2014													
AGR	-0.03	-0.01	-0.04	-0.05	0.17	0.12	0.17	0.17	0.00	0.09	0.27	-0.25	0.27
MNQ	-0.12	0.10	-0.02	-0.10	-0.42	-0.52	0.26	-0.42	0.05	0.48	0.11	0.27	0.09
TRM	1.00	-0.04	0.96	-0.99	0.10	-0.89	0.40	0.08	0.00	0.39	0.46	-0.19	0.75
CIM	0.22	0.08	0.30	-0.20	0.14	-0.06	0.32	-0.06	-0.01	0.17	0.10	-0.21	0.45
CHM	0.06	-0.01	0.05	-0.07	0.00	-0.07	0.11	0.01	0.00	0.06	0.07	0.03	0.19
MAC	0.04	0.00	0.04	-0.06	-0.04	-0.10	0.02	0.00	0.00	0.03	0.03	0.06	0.06
EOP	0.13	0.02	0.15	-0.07	-0.21	-0.28	0.05	-0.03	0.00	0.02	-0.01	0.19	0.10
TRA	-0.02	0.08	0.06	0.00	0.39	0.40	0.14	-0.04	-0.01	0.05	0.00	-0.49	0.10
OTH	-1.17	0.20	-0.97	-0.59	0.29	-0.30	6.65	-0.12	-0.03	0.72	0.57	-1.17	4.78
Total	-0.11	0.33	0.22	-1.93	0.28	-1.65	7.80	-0.35	0.02	1.85	1.52	-1.55	6.34
2015–2019													
AGR	0.07	-0.09	-0.02	-0.25	0.25	0.00	0.21	0.25	-0.01	0.42	0.66	-0.46	0.39
MNQ	-0.29	-0.16	-0.45	0.32	-1.43	-1.10	-0.46	-1.43	-0.04	1.00	-0.46	2.20	-0.27
TRM	0.71	-0.19	0.51	0.34	-0.69	-0.35	0.62	-0.39	-0.16	0.70	0.16	1.16	2.11
CIM	0.35	-0.38	-0.03	-0.06	0.81	0.75	0.17	-0.20	-0.07	0.29	0.02	-0.26	0.65
CHM	0.11	-0.07	0.05	-0.01	-0.18	-0.18	0.15	-0.07	0.00	0.12	0.05	0.34	0.40
MAC	0.05	-0.01	0.04	0.01	0.03	0.03	0.02	-0.01	-0.02	0.07	0.03	0.01	0.14
EOP	0.07	-0.01	0.06	-0.01	0.09	0.07	0.06	-0.04	-0.01	0.03	-0.02	-0.06	0.11
TRA	0.11	-0.29	-0.17	-0.04	0.87	0.83	-0.06	-0.08	-0.04	0.08	-0.04	-0.54	0.01
OTH	-1.36	0.10	-1.26	0.04	0.25	0.29	-0.16	-0.06	-0.21	1.46	1.19	-0.45	-0.39
Total	-0.53	-0.72	-1.24	0.39	-0.80	-0.41	0.38	-1.82	-0.48	3.87	1.56	2.20	2.49

Source: Prepared by the author, on the basis of R. M. Consing III and others, “The wellness economy: a comprehensive system of national accounts approach”, *ADB Economics Working Paper Series*, No. 631, December 2020; and Asian Development Bank (ADB), *Capturing the digital economy: a proposed measurement framework and its applications. A special supplement to key indicators for Asia and the Pacific 2021*, Manila, 2021.

Note: $\Delta\hat{c}$: value added coefficient; ΔA_d : technical coefficients; Δv_D : domestic value added; Δe : sectoral exports; ΔT : product mix; $\Delta\psi$: composition of export partners; Δe : export level; Δv_s : value added from changes in inventories; Δv : sectoral value added; AGR: Agriculture, hunting, forestry and fisheries; MNQ: Mining and quarrying; TRM: Traditional (low- and medium-low-technology) manufacturing; CIM: Computer-integrated (medium-high- and high-technology) manufacturing; CHM: Chemicals and chemical products; MAC: Machinery, not elsewhere classified; EOP: Electrical and optical equipment; TRA: Transport equipment; OTH: Other industries.

In section 2, it was observed that Mexico's trade partners had changed. The share of the United States has declined, while those of China and Canada have increased. This has negatively affected value added growth by -0.37 percentage points, with the greatest impact in the traditional manufacturing and transport equipment sectors. However, the contribution of the export vector has been positive, with a 9.25 percentage point increase. This is because the level effect (12.85 percentage points) outweighs the negative contribution of other factors. The export vector has contributed 23% of total value added growth.

The difference in the decompositions for Mexican value added and gross output is interesting. When performing the same decomposition for gross output, we observed a considerable difference in the importance of the transport equipment sector. While this sector has contributed only 2% of value added growth, its contribution to gross output is 11%. One of the main differences between the decompositions of gross output and value added is the value added coefficient, which weights all the structural decomposition components. Since it was only 0.40 in 2000 and 0.39 in 2019, the transport equipment sector has a limited capacity to generate value added. This result is one of the points addressed by Fujii and Cervantes (2013) and Fuentes, Brugués and González (2020): that although this sector is an essential part of Mexican production, its capacity to generate value added is limited. Other factors that could increase the importance of the sector, even with this value added coefficient, could be indirect effects such as the generation of well-paid jobs. However, as Murillo, Puchet Anyul and Fujii (2018) point out, the sector's capacity to generate jobs is limited.

Brazil's economy experienced positive growth in 2000–2019 because of changes in export products (0.40 percentage points), trade partners (0.24 percentage points) and the level effect (12.5 percentage points). These factors contributed 28% of total growth, as shown in table 5. Agriculture (1.98 percentage points) and mining (1.37 percentage points) had a positive impact on the product mix breakdown, while traditional manufacturing (-0.83 percentage points) and capital-intensive manufacturing (-0.64 percentage points) had a negative impact. The agricultural and mining industries also played a positive role in the recomposition of trade partners, mainly because of China's importance to the Brazilian economy. Traditional industry was the most important sector as regards the level of exports, contributing 2.6 percentage points, followed by the agricultural and mining sectors, contributing 2.0 percentage points and 1.5 percentage points, respectively. It is worth noting that a relationship exists between ΔT and $\Delta \psi$.

It is crucial to note that the primary sectors and service industries have a high value added coefficient because they require fewer inputs. This means they have greater value added per unit of output than manufacturing and other industries that require more inputs. For example, the agricultural sector coefficient was 0.57 and 0.59 and that of mining and quarrying 0.62 and 0.49 in 2000 and 2019, respectively. Thus, when the economy specializes in these sectors, it will positively affect value added. In interpreting the results, the impact of relative prices must be considered. Although the series used is in constant prices, eliminating the effect of inflation, this does not apply to relative prices. Alves-Passoni (2022c) has demonstrated that these sectors were particularly affected by higher relative prices during the period, which may lead to their significance being overestimated.

Table 5
Brazil: structural decomposition analysis, 2000–2019 and subperiods
(Percentage points of value added growth)

	$\Delta\hat{c}$			ΔA_d			Δd	Δe				Δv_s	Δv
	Domestic	Export	Total	Domestic	Export	Total		ΔT	$\Delta\psi$	Δe	Total		
2000–2019													
AGR	0.13	0.10	0.23	-0.57	-0.18	-0.75	1.32	1.98	0.33	2.01	4.32	-0.10	5.02
MNQ	-0.70	-0.65	-1.35	0.08	0.03	0.11	1.33	1.37	0.23	1.47	3.07	0.01	3.18
TRM	1.02	0.34	1.37	-0.62	-0.19	-0.81	3.61	-0.83	-0.45	2.60	1.32	-0.28	5.20
CIM	0.02	-0.04	-0.02	-0.38	-0.07	-0.45	2.38	-0.64	-0.29	1.27	0.33	-0.08	2.16
CHM	-0.13	-0.03	-0.15	-0.15	-0.03	-0.18	0.78	-0.11	-0.04	0.44	0.30	-0.03	0.71
MAC	0.06	0.02	0.07	-0.07	-0.02	-0.09	0.46	-0.06	-0.06	0.25	0.14	0.00	0.58
EOP	0.33	0.05	0.38	-0.28	-0.04	-0.32	0.23	-0.27	-0.06	0.20	-0.13	0.00	0.15
TRA	-0.24	-0.07	-0.32	0.11	0.02	0.13	0.92	-0.21	-0.13	0.38	0.03	-0.05	0.71
OTH	-2.46	-0.46	-2.92	-1.20	-0.13	-1.33	31.46	-1.48	0.42	5.19	4.13	-0.68	30.67
Total	-1.99	-0.71	-2.70	-2.70	-0.53	-3.23	40.11	0.40	0.24	12.53	13.17	-1.13	46.22
2000–2008													
AGR	-0.13	-0.04	-0.17	0.38	0.10	0.48	0.98	0.11	0.09	0.66	0.86	0.08	2.24
MNQ	0.07	0.04	0.11	0.51	0.11	0.62	0.81	0.86	0.02	0.86	1.74	0.16	3.44
TRM	-2.31	-0.58	-2.89	-0.14	0.02	-0.12	1.92	-0.34	-0.13	1.38	0.92	0.08	-0.09
CIM	-1.41	-0.36	-1.77	0.21	0.06	0.28	2.27	-0.10	-0.07	0.80	0.62	0.15	1.55
CHM	-0.96	-0.24	-1.19	0.00	0.01	0.01	0.34	0.01	-0.02	0.22	0.20	0.02	-0.62
MAC	-0.08	-0.02	-0.10	0.02	0.01	0.03	0.43	0.02	-0.02	0.16	0.16	0.01	0.52
EOP	-0.19	-0.04	-0.23	-0.11	-0.02	-0.13	0.08	-0.10	-0.02	0.14	0.02	0.00	-0.24
TRA	-0.19	-0.06	-0.25	0.30	0.07	0.37	1.42	-0.03	-0.01	0.28	0.24	0.12	1.89
OTH	0.04	-0.19	-0.15	-1.49	-0.11	-1.60	18.39	-0.51	0.19	3.03	2.72	0.49	19.86
Total	-3.74	-1.13	-4.87	-0.53	0.18	-0.34	24.38	0.02	0.10	6.73	6.86	0.97	27.00
2010–2014													
AGR	-0.05	-0.02	-0.08	-0.12	-0.05	-0.17	0.33	0.32	0.02	0.26	0.61	0.01	0.70
MNQ	0.30	0.30	0.60	0.14	0.02	0.16	0.32	-0.21	0.02	0.34	0.15	0.03	1.25
TRM	1.00	0.29	1.28	-0.99	-0.24	-1.23	0.40	0.08	0.00	0.39	0.46	-0.17	0.75
CIM	0.22	0.04	0.25	-0.20	-0.05	-0.25	0.32	-0.06	-0.01	0.17	0.10	0.03	0.45
CHM	0.06	0.01	0.07	-0.07	-0.02	-0.09	0.11	0.01	0.00	0.06	0.07	0.02	0.19
MAC	0.04	0.01	0.06	-0.06	-0.02	-0.08	0.02	0.00	0.00	0.03	0.03	0.03	0.06
EOP	0.13	0.02	0.15	-0.07	-0.01	-0.09	0.05	-0.03	0.00	0.02	-0.01	0.00	0.10
TRA	-0.02	0.00	-0.02	0.00	0.00	0.00	0.14	-0.04	-0.01	0.05	0.00	-0.02	0.10
OTH	-1.17	-0.08	-1.25	-0.59	-0.44	-1.02	6.65	-0.12	-0.03	0.72	0.57	-0.17	4.78
Total	0.29	0.52	0.81	-1.76	-0.76	-2.52	8.01	0.01	0.00	1.88	1.89	-0.27	7.93
2015–2019													
AGR	0.03	0.02	0.05	-0.87	-0.28	-1.15	-0.08	0.84	0.29	0.78	1.91	0.03	0.77
MNQ	0.03	0.03	0.05	0.16	0.03	0.19	0.23	0.15	0.20	0.52	0.87	0.01	1.36
TRM	0.71	0.21	0.92	0.34	0.02	0.37	0.62	-0.39	-0.16	0.70	0.16	0.05	2.11
CIM	0.35	0.08	0.43	-0.06	-0.02	-0.08	0.17	-0.20	-0.07	0.29	0.02	0.12	0.65
CHM	0.11	0.03	0.14	-0.01	0.00	-0.01	0.15	-0.07	0.00	0.12	0.05	0.07	0.40
MAC	0.05	0.01	0.06	0.01	0.00	0.00	0.02	-0.01	-0.02	0.07	0.03	0.02	0.14
EOP	0.07	0.01	0.08	-0.01	0.00	-0.02	0.06	-0.04	-0.01	0.03	-0.02	0.01	0.11
TRA	0.11	0.03	0.14	-0.04	-0.01	-0.06	-0.06	-0.08	-0.04	0.08	-0.04	0.02	0.01
OTH	-1.36	-0.08	-1.44	0.04	-0.16	-0.12	-0.16	-0.06	-0.21	1.46	1.19	0.14	-0.39
Total	-0.25	0.26	0.01	-0.38	-0.42	-0.80	0.77	0.34	0.06	3.75	4.15	0.36	4.49

Source: Prepared by the author, on the basis of R. M. Consing III and others, “The wellness economy: a comprehensive system of national accounts approach”, *ADB Economics Working Paper Series*, No. 631, December 2020; and Asian Development Bank (ADB), *Capturing the digital economy: a proposed measurement framework and its applications. A special supplement to key indicators for Asia and the Pacific 2021*, Manila, 2021.

Note: $\Delta\hat{c}$: value added coefficient; ΔA_d : technical coefficients; Δv_p : domestic value added; Δe : sectoral exports; ΔT : product mix; $\Delta\psi$: composition of export partners; Δe : export level; Δv_s : value added from changes in inventories; Δv : sectoral value added; AGR: Agriculture, hunting, forestry and fisheries; MNQ: Mining and quarrying; TRM: Traditional (low- and medium-low-technology) manufacturing; CIM: Computer-integrated (medium-high- and high-technology) manufacturing; CHM: Chemicals and chemical products; MAC: Machinery, not elsewhere classified; EOP: Electrical and optical equipment; TRA: Transport equipment; OTH: Other industries.

Brazil and Mexico had similar growth rates not only over the whole period but also in the subperiods. Between 2000 and 2008, value added growth was approximately 1.51% in both. Mexico grew slightly less than Brazil between 2010 and 2014, by 1.59% a year as compared to 1.68% a year. The most significant difference was in 2015–2019, when Mexico grew by 1.26% a year and Brazil by 1.46% a year.

In the subperiods 2000–2008 and 2010–2014, the domestic sector was vital in generating value added in these countries. Alves-Passoni and Blancas (2022) and Fraga-Castillo and Moreno-Brid (2015) identify a considerable increase in gross fixed capital formation in both countries between 2000 and 2008, which contributed to the importance of the domestic sector in explaining changes in value added, since it has an “inward” pattern. In the 2000–2008 period, Δd accounted for 92% (24.75 percentage points) of total value added growth in Mexico and 90% (24.38 percentage points) in Brazil.

In 2010, the two countries adopted special measures to combat the effects of the 2008 subprime crisis. The Brazilian government increased public investment and implemented subsidies, lower interest rates and tax incentives to stimulate private investment, especially in residential properties. The Mexican government likewise introduced expansionary fiscal policies. These policies lasted a few years and contributed to the positive role of the domestic sector in the generation of value added, representing 123% of value added growth in Mexico (7.8 percentage points) and 101% in Brazil (8 percentage points).

However, the subperiods analysed differ in two respects. The first is the contribution of the value added associated with export products, which was negative during 2000–2008 (-0.47 percentage points and -1.12 percentage points in Mexico and Brazil, respectively) and positive during 2010–2014 (0.33 and 0.52 percentage points).

Meanwhile, the change in the composition of exported goods had a positive effect on value added in the Mexican economy in the first subperiod (0.72 percentage points) and a negative one in the second (-0.35 percentage points). In both cases, the mining and quarrying sector contributed decisively to the trend. The commodity boom of 2003–2008 entailed an increase in the production of goods that relied on the mining and quarrying sector, such as steel, iron and oil exports for industrial production.

The boom experienced by Brazil and Mexico was primarily due to the rise in demand from China (Carvalho, 2018; Schneider, 2013). As was seen in table 1, China increased its share of Mexico's exports between 2000 and 2008. As Alves-Passoni (2022a) points out, part of this increase may have been due to relative sectoral goods prices. The share of mining and quarrying in the Mexican economy rose from 6% of total value added to 8% between 2000 and 2008. The negative contribution of sectoral composition in Mexico in 2010–2014 was also related to the transport equipment sector, which showed the second-highest contribution for ΔT (-0.12 percentage points) and the most negative one for $\Delta \psi$ (-0.03 percentage points). In this period, economic recovery in the United States helped to stimulate growth in Mexican exports of transport equipment.

In the Brazilian case, the change in the product mix made a positive contribution in 2000–2008 (0.02 percentage points) and 2010–2014 (0.01 percentage points). While the mining and quarrying sector was most influential in the first subperiod, agricultural industry had a positive effect in the second. Regarding the impact of changes in trade partners, the mining and quarrying and agricultural sectors had a positive effect in both subperiods. Both effects (ΔT and $\Delta \psi$) were associated with the increase in Chinese demand for their products.

The subperiod that differed most from the others was 2015–2019. It was the only one in which the contribution of exports was more significant than that of domestic demand in Brazil and Mexico. In Brazil, this was partially because the government implemented robust fiscal policies, such as reductions in social transfers, the overall budget and government investment (mainly in the area of civil construction) and increases in taxation to expand revenues. As an induced effect, gross fixed capital formation declined in the period (Alves-Passoni and Blancas, 2022).

In the Mexican case, the government adopted a strategy of stimulating growth through private investment and exports. The instruments used were interest rate cuts, reductions in public

investment (based on the assumption of a crowding out effect), exchange-rate devaluation and tax incentives to stimulate exports. All these policies concentrated on price competitiveness as opposed to non-price competitiveness.

There was a difference between the two countries in 2015–2019 where the contribution of exports was concerned. In Brazil, changes in the export agenda and trade partners positively affected the generation of value added associated with the exports to China of the agriculture and mineral extraction sectors. In Mexico, the opposite occurred, with exports of automotive goods to the United States increasing and the transport equipment sector contributing negatively to the value added growth associated with exports. Although the effect of changes in the product mix and trade partners was negative, the change in the level of exports offset this.

V. Final remarks

This study has employed a quantitative input-output structural decomposition analysis with a view to ascertaining how sectoral changes and shifts in export trade partners affected Brazilian and Mexican value added between 2000 and 2019. We found a strong relationship between changes or stability in trade partners and the structure of the export basket, considering product quality, design and differentiation.

There is a crucial difference between the changes in the composition of Brazilian and Mexican exports. While movements in the export basket and trade partners had a negative effect on value added growth in Mexico, the repercussions were positive in Brazil. In part, the difference in this result arises from the export composition of the two countries. Brazil has specialized (regressively) in agricultural and mineral goods exports to China, whereas Mexico has maintained its specialization in the transport equipment sector, exporting to the United States and Canada.

Even though exports contributed more to value added growth than the domestic sector between 2015 and 2019, average value added growth did not increase in these countries. From a sectoral point of view, changes in the composition of the manufacturing export basket and trade partners made a largely negative contribution to value added growth in all subperiods in both Brazil and Mexico. This effect was partly offset by the positive contribution of the level of exports, but it indicates that structural changes in exports did not contribute to the countries' ability to generate value added from these.

After analysing the structural decomposition results for both countries in the context of Latin American structuralist theory, we recommend a re-evaluation of the continued focus on these specific activities. In the case of Brazil, the increase in commodity exports to China has had some positive effects. However, these are limited. Singer (1950 and 1998) and Prebisch (1951) have already argued that relative price effects tend not to last. This increase in exports may also have skewed Brazil's production structure. In seeking to specialize in activities with higher international prices, production activities such as manufacturing may neglect others with a greater chain effect. It is important to consider the potential negative impact of these activities on the environment, including deforestation. According to Pérez (2008), investing in nanotechnology, biotechnology, new materials and energy generation is a good way for Brazil to benefit from these "regressive" markets. This would encourage the development of technology and capabilities, thereby contributing to long-term growth. The aim of these strategies is to create non-price competitiveness, but they often require time and political effort to put into effect.

Mexico faces even greater challenges because of its export dependency, with 70% of exports going to a single destination and 40% being in the transport and electronic equipment sectors. Unfortunately, the high import coefficient of these industries means that only a portion of their output contributes to value added. Additionally, the relative prices of these goods have fallen recently. Although they are industrial sectors, they have limited capacity for generating economic development because the country lacks the technological infrastructure to support them.

Latin American structuralist studies have shown that improving non-price competitiveness is the most effective way to positively impact value added, especially in the manufacturing sector. These studies include works by Prebisch (1951) and Singer (1950), as well as more recent ones by Cimoli, Porcile and Rovira (2010), Thirlwall (1979), McCombie (1993) and Nell (2003). Additionally, manufacturing sectors can compete through product differentiation and mark their prices up by more than producers of more uniform products like commodities. It is crucial to prioritize domestic capacity-building. A weak production structure can result in excessive dependence on imported materials, which has the potential for severe disruption of production chains and ultimately hinders growth. This makes it imperative to take the measures needed to strengthen a country's production structure and reduce its reliance on external sources.

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The impact of public funding for research and development on business performance in Mexico

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Abstract

This study evaluates the impact of financial incentives for corporate innovation on the performance of Mexican companies. It also analyses the priorities underlying the incentive programmes by constructing a profile of the types of firm that are the main recipients of this kind of support. Propensity score matching – in this case, matching based on the probability of receiving such support – of data from the 2017 Research and Technological Development Survey (ESIDET) is used for this purpose. When corporate and governments funds are both taken into account, the results indicate that public funding fosters higher levels of expenditure on research and development, but when public funds are deducted from the total, the results show that these incentive programmes have had no net effect on the initial foreseen level of private research and development expenditure. The findings also indicate that government funding has a positive impact on corporate performance and in terms of human capital and that the types of firm that tend to receive this kind of support more often are in the services sector, those that are more innovative, larger and more competitive, and those that engage in the development of technological applications that are nearer to the market rather than those devoted to basic research.

Keywords

Research and development, technological innovations, financing, public sector, industrial enterprises, programme evaluation, statistical methodology, Mexico

JEL classification

H81, L25, O25

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I. Introduction¹²

Governments provide incentives for corporate innovation for a number of reasons. First, innovation is considered to be a key element in international competitiveness. This is particularly important for Mexico, since its productivity growth has been flat since the 1990s. In fact, in 2021 its productivity index was lower than it had been in 1993. Another rationale for providing stimulus for corporate investment in research, development and innovation (RDI) is that market incentives for this type of investment are lacking. Market failures lead to underinvestment in this area, and the economy therefore falls short of the socially optimal level of RDI activity (Nelson, 1959; Arrow, 1962). Because of the high cost and risk levels associated with innovation, commercial lenders are reluctant to finance innovation, and companies therefore must mainly use their own funds to cover R&D costs (Hall, 2002; Spielkamp and Rammer, 2009). In addition, in the wake of the international financial crisis of 2008, RDI spending dropped sharply for two reasons. The first is that the corporate funds used to finance RDI are primarily derived from corporate profits, which dropped during that period. The second is that the supply of financing from alternative lenders shrank as a consequence of the credit crunch.

Mexico has launched numerous programmes to support corporate innovation and R&D, including programmes that provide direct financial support to business enterprises. Total R&D spending has still not exceeded 0.5% of GDP, however. Although in 2004 the government pledged to devote no less than 1.0% of GDP to this effort (SEGOB, 2004), expenditure peaked at 0.45% in 2010 and has fallen since then, slipping to 0.30% of GDP in 2020 (see table 1).

Table 1

Mexico: labour productivity and investment in research and development (R&D), 1993–2021

	1993	2000	2005	2010	2015	2020	2021
Labour productivity ^a	19.80	20.40	18.80	18.70	19.80	19.60	18.90
Total R&D expenditure (<i>Percentages of GDP</i>)	0.22	0.31	0.41	0.45	0.43	0.30	-
Public R&D budget (<i>Percentages of GDP</i>) ^b	-	0.19	0.22	0.29	0.32	0.20 ^c	-
Corporate R&D expenditure (<i>Percentages of GDP</i>)	0.03	0.09	0.17	0.16	0.07	0.05	-
Corporate share of total R&D expenditure (<i>Percentages</i>) ^d	10.40	29.80	46.90	35.00	18.60	2.50	-

Source: Prepared by the authors. 1993 data: Organisation for Economic Co-operation and Development (OECD), “Main Science and Technology Indicators” and OECD.Stat.

^a GDP per hour worked, in United States dollars at constant 2015 prices at purchasing power parity (PPP).

^b Government budget allocations for R&D.

^c Figure for 2019.

^d Corporate R&D expenditure as a percentage of total gross R&D expenditure.

The public R&D budget (as a percentage of GDP) had risen almost continually from its 2000 level of 0.19% of GDP to 0.32% by 2015 but then began to decline steadily, dropping to 0.20% by 2019, which was practically as low as it had been at the start of this century. Importantly, in parallel with these downward trends, corporate innovation efforts have dwindled. Whereas corporate R&D spending had jumped from 10.4% of total gross expenditure on R&D in 1993 to 46.9% by 2005, the business sector accounts for only 21.5% of total R&D expenditure now. In 2020, companies’ R&D spending amounted to just 0.05% of GDP, which is a far cry from the 0.17% level recorded in 2005. Even with the provision of public funding, the Mexican government has not managed to boost total public and private R&D spending in order to bring about a clear-cut, stable trend towards technological change.

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An assessment of the programmes implemented to date is thus needed in order to provide input for the design of government incentives that will put public funds to good use and help to ensure that the attendant policies achieve their objectives in terms of both efficiency and effectiveness.

The main objective of such an assessment should be to conduct a cost-benefit analysis in terms of social well-being, since the net social benefits have to outweigh the net social costs in order for government action to be justified.³ The problem is that such an analysis is nearly impossible to carry out. The proper role of the State can be discerned only on the basis of a large number of assumptions about the cause-and-effect relationship entailed in the interaction between public and private activities. Because of the difficulty of attributing an isolated increase in social well-being to a given technology policy, intermediate variables have to be employed in order to analyse these effects. In the case of public support for corporate RDI, these intermediate variables are the increase in private sector spending on RDI (financial additionality) and variables related to business performance and results.

According to the literature, the allocation of public funding is not random. This poses a methodological problem of selection bias when the time comes to evaluate its impact. One way to overcome this problem is to use propensity score matching (PSM) (in this case, matching on the probability of being a beneficiary) to pair each subsidized firm with an unsubsidized one (a control). Using this methodology, the variables of interest for beneficiary firms can be compared with those for firms that have not received any assistance; the difference will reflect the impact of the public policy in question (additionality). The presence of additionality will indicate that the assistance channelled through these firms has made the country more competitive and that, therefore, the policy is justified.

Few studies have been done on government support for innovation in developing countries (Zúñiga-Vicente and others, 2014; Vergara Reyes and others, 2021), and the impact of this kind of assistance in such countries therefore needs to be assessed. This is also true of Mexico, where empirical studies on the impact of innovation incentives using data at the company level are few and far between (see box 1). The studies that do exist are based on data from the twentieth century for a sample of small and medium-sized enterprises and, surprisingly, do not analyse the effect of expenditure on R&D or innovation. Clearly, then, there is a need for evaluations of technology policies, which are all the more necessary in times of international crises and upheavals during which Mexican companies have sharply dialled back their innovation efforts and are faced with a tighter credit situation when they do try to undertake such efforts.

In view of the above, the objective and principal innovative aspect of this study is, first, its effort to determine if public funding of corporate R&D work encourages innovative companies to spend more of their own funds on RDI than they would have spent in the absence of that support and, second, to weigh the effect that the support has on other corporate performance variables. It also seeks to outline the profile of the companies that have enjoyed preferential treatment by assistance agencies based on an analysis of the businesses that most often receive public support. This profile, which reflects the types of firm that are accepted into government programmes the most often, in contradistinction to those that have not been included in those programmes, can shed light on what could be regarded as the revealed priorities of those programmes.

This study is structured as follows. Following this introduction, section II describes the propensity score matching (PSM) methodology that was used. Section III focuses on the types of data and the variables used to measure the impact. Sections IV and V present the core analysis of this study regarding the impact of public funding and the revealed policy priorities based on the profiles of the most frequent corporate participants in the relevant programmes.

³ This analysis must also take into account the opportunity costs involved and the negative effects on businesses that have not received government support.

Box 1

Mexico: an assessment of the impact of public support for corporate innovation

Several studies evaluate support for R&D and innovation in Mexico using propensity score matching, but most of them employ data compiled around the turn of the century and thus prior to the 2008 international financial crisis (1994–2005) (Tan and López-Acevedo, 2007; López-Acevedo and Tan, 2005 and 2010; López-Acevedo and TinajeroBravo, 2013). These studies analyse the effect of such support on employment, productivity and sales, but not —possibly owing to a lack of data— on corporate R&D spending. A few recent studies present the results of ad hoc surveys of firms in the Innovation Incentive Programme (PEI) (Dávila-Borbón, León-Balderrama and Preciado-Rodríguez, 2019; Pastor Pérez, Rodríguez Gutiérrez and Ramos Ávila, 2017; Moctezuma, López and Mungaray, 2017) and have found, overall, that this assistance has had a positive impact on innovation efforts. These studies' usefulness is limited by the fact that the number of respondent firms was quite small,^a which impedes the use of econometric models and the generalization of their findings to innovating companies as a whole.

There are three studies that used unconventional methods of analysis in this field. Chávez (2020) uses a fuzzy regression discontinuity approach and finds that assistance has a positive influence on the number of staff working on innovation but finds no effect in terms of the number of patents or on the actual level of R&D expenditure in absolute terms.

Martínez-Covarrubias, Lenihan and Hart (2017) analyse the effect of assistance in terms of improvements in global value chains using the Heckman two-step selection method but find no significant impact. Meanwhile Moctezuma, López and Mungaray (2017) offer descriptive statistics on the effects of a number of different variables, including investment, external linkages, the participation of researchers and students, publication and dissemination, and competitiveness. The authors conclude that a number of projects would not have been conducted if it were not for government assistance, although others would have gone ahead anyway, which implies that some firms exhibited a crowding-out effect.

Thus, generally speaking, all these studies indicate that assistance has had a positive impact, but their widely varying natures in terms of both methodology and the variables used to measure the impact make comparisons or generalized conclusions difficult. Most surprisingly of all, only one study (Chávez, 2020) analyses the effect on R&D expenditure by the firms in question, which, internationally, is the most commonly used variable for this type of study.

Source: H. Tan and G. López-Acevedo, "How Well Do Small and Medium Enterprise Programs Work? Evaluating Mexico's SME Programs Using Panel Firm Data", Washington, D.C., World Bank, 2007; G. López-Acevedo and H. W. Tan, *Impact Evaluation of Small and Medium Enterprise Programs in Latin America and Caribbean*, Washington, D.C., World Bank, 2010; and *Evaluating Training Programs for Small and Medium Enterprises: Lessons from Mexico*, World Bank, 2005; G. López-Acevedo and M. Tinajero-Bravo, "Evaluating different types of enterprise support programs using panel firm data: evidence from the Mexican manufacturing sector", *Economía*, vol. 14, No. 1, 2013; C. Dávila-Borbón, J. I. León-Balderrama and J. M. Preciado-Rodríguez, "La efectividad del Programa de Estímulos a la Innovación (PEI) en Sonora. ¿Qué factores influyen en el impacto del programa Rodríguez sobre la innovación y la competitividad de las empresas?", *Estudios Sociales. Revista de Alimentación Contemporánea y Desarrollo Regional*, vol. 29, No. 53, 2019; M. D. P. Pastor Pérez, P. I. Rodríguez Gutiérrez and A. E. Ramos Ávila, "Effects of public financing for innovation: microeconomic perspective based on a study of small businesses", *Región y Sociedad*, vol. 29, No. 70, 2017; P. Moctezuma, S. López and A. Mungaray, "Innovación y desarrollo: programa de estímulos a la innovación regional en México", *Problemas del Desarrollo*, vol. 48, No. 191, 2017; E. Chávez, "The effects of public R&D subsidies on private R&D activities in Mexico", *PSE Working Paper*, No. 2019-73, *HAL Open Science*, 2020 [online] <https://shs.hal.science/halshs-02355106v3>; and J. L. Martínez-Covarrubias, H. Lenihan and M. Hart, "Public support for business innovation in Mexico: a cross-sectional analysis", *Regional Studies*, vol. 51, No. 12, 2017.

^a For the study by Dávila-Borbón, León-Balderrama and Preciado-Rodríguez (2019), 39 companies were surveyed and, in the study by Pastor Pérez, Rodríguez Gutiérrez and Ramos Ávila (2017), responses were received from 10 firms.

II. Propensity score matching as an evaluation methodology⁴

The additionality effect of public support can be understood as the amount by which performance indicators change as a result of government action when that change would not have occurred in the absence of that action and is thus basically the outcome of the public policy incentives that were introduced. The desired effect of the financial injection — derived from public funds — is that the firm in question will spend an additional amount on R&D (Georghiou, 1994). If a suitable evaluation method is used, the amount of additional expenditure will represent the estimated effect (the financial additionality) that has clearly been produced by the support provided and that is not attributable to other possible explanatory factors (demonstrated causality).

The allocation of subsidies is not random but instead entails two separate steps. Companies first have to decide whether they are willing to assume the cost of applying for public funding and, if they do, then government agencies will select which ones will receive the support based on their criteria and objectives. Thus, the evaluation has to take account of both the businesses' self-selection and then the selection made by the agencies in charge of the support programme. In fact, subsidized companies may differ in important ways from non-subsidized ones, and the support programme selection process must therefore be taken into consideration (Heckman, 1979; Imbens and Wooldridge, 2009).

Various econometric techniques have been developed for addressing and correcting for this selection bias, such as regression discontinuity design, the difference-in-differences technique and the instrumental variables approach (Hünernund and Czarnitzki, 2019). Given the data available for this study, however, propensity score matching appears to be the best option (Angrist, 1998; Gerfin and Lechner, 2002; Smith and Todd, 2005).

Sample matching based on the probability of a firm becoming a beneficiary makes it possible to determine, by direct means, how much a subsidized company would have invested in R&D in the counterfactual situation (without public support). Since that counterfactual is never observable, it has to be estimated in order to see what the effect of the government support measure has been. Assuming that all the important characteristics leading to selection can be observed, or, in other words, that the assumption of conditional independence is borne out (Rubin, 1977), it is possible to approximate this counterfactual situation by looking at companies that have the same, or very similar, characteristics as the subsidized ones but that have not received public funds. In order to find these matches, the subsamples of subsidized and non-subsidized firms are matched up according to the probability of receiving a subsidy. On the basis of a probit estimate, the conditional probability of a firm receiving a subsidy can be obtained: $Pr(Sub_i = 1 | X = x)$. Thus, subsidized firms are being compared with firms that had the same probability of receiving subsidies but did not. On the basis of this index, a nearest-neighbour matching estimate is made comparing each subsidized firm with its projected counterfactual to estimate the impact (Rosenbaum and Rubin, 1983; Dehejia and Wahba, 2002).

Accordingly, the average effect on subsidized firms is estimated as follows:

$$ATT = \frac{1}{N^T} \sum_{i=1}^{N^T} (Y_i^T - \hat{Y}_i^C) \quad (1)$$

where Y_i^T is the value of the variable of interest of subsidized companies; \hat{Y}_i^C is the counterfactual situation; and N^T is the number of firms that received public funds.

⁴ The propensity score matching manual of Vergara Reyes and others (2021) is a good source for detailed methodological information and for information on the development of the models and the selection variables used (detailed in section IV).

Finally, in order for matching to be adequate, there must be sufficient commonality between the sample of treated firms and the potential control sample, so there must be a sufficient overlap between the sample of treated firms and the control sample in terms of the probability of receiving a subsidy. Consequently, observations of treatment-group companies for which the probability is higher than the highest level of the potential control group or lower than the lowest level of the potential control group are eliminated.

III. Data sources, treatment variables and impact indicators

The innovation surveys conducted by many countries have provided solid databases that can be used to estimate the impact of subsidies. Econometric models are used to simulate experimental methods and compare the performance of firms that have received innovation subsidies with the performance of firms that have not. Mexico conducted its Technological Research and Development Survey (ESIDET)⁵ in 2006, 2008, 2012, 2014 and 2017 but, since the data from the different survey years cannot be matched, this analysis will be based on the data obtained from the 2017 survey. The survey covers Mexican companies having at least 20 employees. Its sectoral coverage corresponds to the branches of industry identified by the Organisation for Economic Co-operation and Development (OECD) of the North American Industry Classification System (NAICS) (INEGI, 2013).

The survey includes questions on firms' structural features and their innovation and commercial activities. These data make it possible for the analysis to cover a wide range of variables in calculating the probability that a firm will receive a subsidy or not and in evaluating the effectiveness of this use of public funds by looking at more than just expenditures on innovation as such.

The database provides information both on companies that are innovating and on those that are not doing so. The decision was made to restrict the analysis to innovative firms, in line with the approach used in the existing literature (Czarnitzki and Licht, 2006; Czarnitzki and Lopes-Bento, 2013). After applying this criterion and eliminating the companies for which information on the variables of interest is not available, the sample ended up being composed of 2,438 observations.

The 2017 survey provides information for each year that it covers (2014, 2015 and 2016) in most cases, but there are some variables for which only aggregate data for the whole period are available. This is the case for the information on incentive programmes, which is aggregated for the three years covered by the survey, and it is therefore impossible to determine whether any given company participated in that programme in one, two or all three years. Nonetheless, information on the amount of direct support for R&D that was provided in each individual year is available, so a more accurate analysis can be undertaken by lagging the control variables in order to avoid endogeneity in the estimates. Consequently, we feel that the best option is to analyse the effect of the provision of public funds without looking at firms' participation in other types of programme.

The analysis is broken down into two main parts. In the first, the treatment involves a dichotomous variable that takes a value of 1 if companies have received public funds and a value of 0 if they have not. This variable is used to calculate the probability that a company will receive support. In the second, in order to estimate the effect that the receipt of public funds has on corporate outcomes, the approach favoured in the empirical literature⁶ was used, and the effect is therefore measured using variables for

⁵ National Institute of Statistics and Geography (INEGI) and National Council of Science and Technology.

⁶ For a review of recent empirical information focusing on an analysis of subsidies, see Zúñiga-Vicente and others (2014), Dimos and Pugh (2016) and Dimos and others (2022).

innovation effort and for corporate performance. We thus use the logarithm of R&D spending⁷ and, in addition, R&D spending as a percentage of the sales volume, in order to shield the calculations from the distorting effect that the largest firms can have on the mean.

Given the availability of information on the amount of public funds channelled into business enterprises, the analysis includes net and gross outlays. Net expenditure on R&D corresponds to R&D expenditure financed out of a company's own funds, whereas gross expenditure on R&D also includes government subsidies. In other words, when the figures for net expenditure are used, public funds are not taken into account in estimating the treatment effect.

When net R&D expenditure is used as the treatment outcome, a positive result indicates that the company used, at the least, all the additional funds that it received, and increased its spending on R&D above the level of expenditure that had initially been planned, allocating additional private funds that had not initially been intended for that purpose (full additionality). A negative result indicates that the assistance had a partial or full crowding-out effect. For the estimates based on gross R&D expenditure, a positive value signals the presence of at least partial additionality. In this case, however, it is not clear whether the increase in R&D expenditure is equal to or less than the amount of public funding received.

Using a combination of these results for the treatment effects, three mutually exclusive types of additionality effects can be identified (see table 2): (i) full additionality: the funding received prompts the company to raise its planned level of net R&D expenditure by more than the amount of public funds received; (ii) partial crowding out: the company increases its R&D expenditure from what was initially planned, but by less than the amount of public funds received; and (iii) full crowding out: the company uses the public funds received instead of the private funds initially allocated for R&D expenditure, with the level of spending remaining the same as (or lower than) it would have been before the public funds were received. In this latter case, there is no financial additionality at all, giving way to what is known in the literature as “free riding”.

Table 2
Types of additionality

		Effect of financial support on net expenditure ($\hat{\tau}_i^{net}$)	
		$\hat{\tau}_i^{net} > 0$	$\hat{\tau}_i^{net} \leq 0$
Effect of financial assistance on gross expenditure ($\hat{\tau}_i^{gross}$)	$\hat{\tau}_i^{gross} > 0$	Full additionality	Partial crowding out ^a
	$\hat{\tau}_i^{gross} \leq 0$	Impossible ^b	Full crowding out

Source: J. Heijs, A. J. Guerrero and E. Huergo, “Understanding the heterogeneous additionality of R&D subsidy programs of different government levels”, *Industry and Innovation*, vol. 29, No. 4, 2022.

^a Or partial additionality effect.

^b This is not observable because net expenditure will always be less than gross expenditure, and a positive value for net expenditure will therefore never occur when gross expenditure is negative.

Since the provision of public funds can influence companies' performance in various ways, in addition to their innovation effort, performance and entrepreneurial capacity variables were also included (Crespi, Tacsir and Vargas, 2016). Specifically, the logarithms of sales and export volumes are used as performance variables that can then be used to compare the positive effect of public support for R&D based on indicators of a firm's profitability and sustainability over time. Finally, the study looked at the effect of public funding on human capital, measured by the number of employees with tertiary degrees as a percentage of all employees. This indicator can be used to determine if this type of public assistance is also conducive to the presence of a more technically sophisticated and more highly specialized company workforce.

⁷ Logarithmically transformed variables have been widely used. See, for example, Czarnitzki and Licht (2006), Neicu (2019) and Huergo and Moreno (2017).

IV. Independent variables: company profile

As stated, because of the possibility of selection bias, a clone control group is needed. Using the PSM method, such a control group is created based on the probability of receiving these incentives, which is calculated using the variables⁸ that will influence that likelihood. Thus far, there is no theoretical framework that would indicate what the relevant variables are (Heijs, Guerrero and Huergo, 2022; Vergara Reyes and others, 2021), although there is a large body of literature arguing for the inclusion of certain variables for the assignment of treated and control-group companies (see Zúñiga-Vicente and others, 2014; Vergara Reyes and others, 2021).

A large number of empirical studies that use PSM have tended to coalesce around the inclusion of a given group of variables in the models. In practice, there is some degree of standardization around the selected variables, but there are very few studies that offer theoretical arguments for why certain variables are appropriate for matching up treated and control-group companies. This study will therefore follow the predominant model and include the same variables as have been used in previous studies.⁹

Table 3 shows the results, coefficients (column 1) and marginal effects (column 2) of the estimation of the determinants of the probability of being a beneficiary using a probit model. For the estimation, all the variables were lagged one year in order to avoid problems of double causality, especially in the case of variables related to the variables of interest (expenditures on innovation or human capital).¹⁰ This first step makes it possible to obtain the profile of the companies that receive support, which indicates the revealed priorities of the public agency in question. In other words, it implicitly reveals the types of company that, *ceteris paribus*, have benefited most often, whether this has been by design of the policy or not, and those that have been discriminated against. A first set of variables that reflect the implicit priorities at work are structural characteristics, such as a firm's size, sector, the length of time it has been in existence, export behaviour and ownership structure.

Company size proves to be the most noteworthy variable in this set because it plays a fundamental role as an explanatory variable for the allocation of public funds. It could be that small and medium-sized enterprises (SMEs) have greater difficulty in securing support because they have less logistical capacity for identifying possible sources of funds and for preparing the corresponding proposals. They may also have few eligible projects. Large firms, meanwhile, have access to more information and are likely to have more eligible projects. In addition, they have, in all likelihood, gone through a learning process in applying for grants, thereby creating advantages of scale with respect to the costs—in terms of both money and time—of preparing grant applications (Heijs, 2001; Aerts and Schmidt, 2008; Neicu, 2019). Furthermore, large firms tend to have better contacts with public agencies and officials involved in the allocation process. They are also more likely to innovate and apply the results to various production lines. This is an important feature, as government agencies will seek to maximize the probability of producing positive outcomes by choosing companies with greater innovation capacity (Heijs, 2001; Hud and Hussinger, 2015).

⁸ For a description of these variables, see table A1.1 in annex A1.

⁹ The selection of the variables used here is based on a review of 55 studies that use PSM to evaluate R&D and innovation incentives in which an indication is given of the control variables used in each and the sign of the estimated effect on the probability of obtaining government support (see Vergara Reyes and others, 2021).

¹⁰ Earlier studies incorporate lagged variables or components of variables of interest in estimating the probability of receiving support (Aristei, Sterlacchini and Venturini, 2017; Afcha and Lucena, 2022).

Table 3
Factors influencing the probability that firms will be involved in government research and development (R&D) incentive programmes, probit model

	Government support = 1			
	(1)	(2)		
	Coefficient	S.E.	dy/dx	S.E.
Company size				
0<x<100	-0.067	0.115	-0.012	0.021
100<x<200	Reference			
200<x<500	-0.337***	0.131	-0.061***	0.024
x>500	-0.170	0.121	-0.031	0.022
Age (log)	-0.114**	0.045	-0.021**	0.008
Export activity	0.274***	0.086	0.050***	0.016
Publicly owned	0.047	0.135	0.009	0.025
Multinational (>50%)	-0.506***	0.155	-0.092***	0.028
Group	-0.138*	0.077	-0.025*	0.014
Human capital	0.865***	0.185	0.158***	0.034
Basic research	-0.283**	0.131	-0.052**	0.024
Applied research	0.419***	0.105	0.076***	0.019
Technological development	0.710***	0.085	0.130***	0.016
Sector of activity:				
- Traditional industrial producers	-0.116	0.129	-0.021	0.023
- Traditional industrial suppliers	-0.108	0.131	-0.020	0.024
- Specialized industrial suppliers	0.052	0.165	0.009	0.030
- Scale-intensive industries	0.143	0.127	0.026	0.023
- Science-based industries	0.319*	0.171	0.058*	0.031
- High-tech services	0.429***	0.120	0.078***	0.022
Year: 2014	-0.202***	0.070	-0.037***	0.013
Wald test				
Sector dummies χ^2 (6)	33.18***			
LR Chi ² (20)	321.7			
Log-likelihood	-814.9			
Pseudo R ²	0.165			
Observations	2.438			

Source: Prepared by the authors, on the basis of data from the 2017 Survey on Research and Technological Development (ESIDET).

Note: S.E.: robust standard errors. All the variables have been lagged by one period. Marginal effects (dy/dx) have been calculated from sample means. All models include a constant term. *** p < 0.01; ** p < 0.05; * p < 0.1 (significant at 1%, 5% and 10%, respectively).

Meanwhile, there are arguments for assuming that SMEs ought to apply for aid more often. Czarnitzki and Delanote (2015) point out that such support would be more important for small firms, as they are more sensitive to the negative effects of market failures,¹¹ such as the appropriability problem (Arrow, 1962) and uncertainty (Dixit and Pindyck, 1994), as well as imperfect information as reflected in its asymmetric distribution and especially in such firms' more limited access to it (Czarnitzki and Delanote, 2015). Moreover, SMEs are under many more financial constraints and are therefore more likely to need to seek financing outside the market (Heijs, 2001; Canepa and Stoneman, 2008; Czarnitzki and Delanote, 2015). In addition, there are programmes designed specifically for SMEs. However, the net effect of all these possible factors on the size-based bias in the allocation of funding is not fully defined. Most of the empirical studies find that it is more frequent for larger firms to participate than smaller ones (Almus and Czarnitzki, 2003; Czarnitzki and Lopes-Bento, 2013 and 2014; Guerzoni and

¹¹ The idea that the innovative activities of SMEs are more constrained by market failures has been empirically proven in studies by Lerner (1999), Czarnitzki and Hottenrott (2011) and Hall and Lerner (2010).

Raiteri, 2015). Other studies, however, have found that the trend in terms of size is non-linear (Czarnitzki and Licht, 2006; Huergo and Moreno, 2017; Heijs, Guerrero and Huergo, 2022). These studies indicate that, as a firm's size increases, so does its probability of participating in incentive programmes but that there is a point at which the increase in size has a diminishing effect on the likelihood of participation. They conclude that, while the largest firms are likely to participate more often than smaller firms, medium-sized firms are less likely to be in these programmes. In order to capture the effect of firm size, a variable is included that takes a value of 1 when the firm has 200 or more workers. As can be seen in table 3, this study, meanwhile, shows that large firms receive government support less frequently and that there is no difference in the frequency of participation in incentive programmes between small firms and medium-sized ones. It therefore points to the presence of positive discrimination towards smaller firms, as they, *ceteris paribus*, are more likely to participate in government incentive programmes.

The big differences existing between sectors in terms of the probability of innovating, technological opportunity and technological level reflect the heterogeneity existing in terms of both the need to apply for funding and the probability of receiving it. Accordingly, a set of dichotomous variables referring to the sector to which a company belongs has been included. Although the survey furnishes disaggregated data on the types of activity carried out, the sample is quite small, especially in certain sectors, which precludes a highly disaggregated analysis. This is why this study employs sectoral aggregation based on firms' technological behaviour in line with the proposal of Pavitt (1984) and Bogliacino and Pianta (2016). Using this approach, it becomes clear that there are two sectors in which the percentage of firms participating in such programmes is disproportionately high: science-based industries and the high-tech services sector.

Science-based industries are the ones that have benefited the most of all.¹² This could be due to the important role of this sector in the Mexican economy and the country's interest in attracting foreign investment, which tends to benefit this type of company more than others. Given the available data, however, it is not possible to verify this supposition. Similarly to the situation in European countries (Herrera and Bravo, 2010; Hud and Hussinger, 2015; Afcha and García Quevedo, 2016), Mexican firms in the high-tech services sector and science-based industries have benefited from positive discrimination in terms of the selection of firms for inclusion in these programmes.

A structural characteristic frequently used in such evaluations is the age of the firm, whose explanatory value in terms of the probability of being a beneficiary is ambiguous. On the one hand, more experienced (older) firms are expected to be more likely to be beneficiaries, as they are more likely to have developed closer relationships with the managers or officials responsible for administering these programmes. It is also true, however, that it may be more likely for older firms to belong to more traditional sectors, which would generally equate with a lower technological level and fewer technological opportunities and, hence, a lower participation rate (Cerulli and Poti, 2012). On the other hand, younger firms tend to be more financially constrained, and some of them, such as at least some technology-based start-ups, are highly innovative, so they may have a larger number of projects that are eligible for support and could therefore be more likely to receive such grants or incentives (Czarnitzki and Lopes-Bento, 2013). In this study, we have included the logarithmically transformed number of years that a firm has been in business. In the probit model (see table 3), the variable capturing the age effect shows that it has a negative impact leading to a lower level of participation in government incentive programmes for older firms.

Another aspect frequently included in empirical studies is export capacity, and the variable included for that characteristic takes a value of 1 if the firm has engaged in export activity (exporting probability). The effect is expected to be positive, as the international market is more competitive than

¹² The estimated results for each sector are interpreted in relation to the reference sector (which is excluded from the model). In this case, that is the "other sectors" category, which includes agriculture, low-tech services and construction.

the local market, which would indicate that exporting firms will have a greater capacity for converting their research into product innovations (Czarnitzki and Licht, 2006). The higher participation rate for these firms would be due, in part, to the fact that these firms will have more innovative and entrepreneurial skills, as well as more experience in preparing proposals for an eligible project. But another part of the explanation could be that many government agencies opt for a policy of picking “winners” (Wallsten, 2000; Blanes and Busom, 2004; Cantner and Kösters, 2012) and so select the most competitive firms that have demonstrated that they can perform successfully in international markets, which are much more demanding with regard to innovation. Indeed, many countries have active export promotion policies, including some that focus particularly on innovation, as is the case in Mexico.¹³ The results presented in table 3 also show that export firms have a clearly greater likelihood of being included in incentive programmes.

Empirical evidence shows that a firm’s ownership structure is an influential factor in determining which companies receive support. For this reason, variables have been included that indicate whether firms are publicly owned, privately owned or have foreign (multinational) equity participation,¹⁴ while individually owned firms are implicitly included in the analysis as a reference variable. Since positive discrimination towards local or national firms has been detected, the presence of foreign equity is expected to have a negative impact on the receipt of support. This study provides confirmation of the findings of previous empirical works (Aerts and Schmidt, 2008; Czarnitzki and Lopes-Bento, 2011; Aristei, Sterlacchini and Venturini, 2017) showing that also in Mexico the participation rate of partially foreign-owned firms, as well as firms belonging to business groups is lower. Meanwhile, publicly or partially publicly owned companies participate to the same extent as individually owned companies; it can therefore be concluded that ownership structure is an important predictor of funding allocation.

A second group of variables used in the model reflect the revealed priorities of government agencies in Mexico¹⁵ with regard to the innovative activities and results achieved by different companies (see table 3). The first variable has to do with the focus of R&D. Although some programmes support only basic R&D, which is more distant from market applications, most of them are designed to support a wide range of innovative activities and would thus theoretically accept applications from all sorts of firms. However, many programmes issue a call for proposals requiring the submission of a specifically designed and planned project, which implicitly excludes incremental innovation efforts. It therefore makes sense to analyse how a firm’s chosen orientation towards innovation influences the likelihood of that firm being selected for an incentive programme. Three binary variables have therefore been included that take a value of 1 if the companies’ activities are oriented towards basic or applied research or towards the development of technology.

Theoretically, firms engaged in basic R&D research should have a greater likelihood of securing government support than companies involved in the development of technology, since basic research generates strong social gains but also entails a great deal of risk. It is therefore probable that opportunities for realizing a high level of private gain would not in themselves attract a socially desirable volume of resources (Nelson, 1959). Therefore, it is to be expected that the authorities will encourage this type of research by providing support for it. Contrary to theoretical expectations, the orientation towards basic research is found to have had a negative influence on the likelihood of receiving support. One possible explanation is that basic research is mainly carried out by CONACYT, universities or other research institutions or centres and that the number of companies carrying out such activities is relatively

¹³ In Mexico, some programmes (e.g. the Joint Export Promotion Commission (COMPEX)) combine the promotion of exports with support for innovation.

¹⁴ For the purposes of this analysis, firms are classified as multinationals if 50% or more of the equity in the firm is held by foreign entities.

¹⁵ In Mexico, support is provided by federal institutions such as the State Secretariats and decentralized government agencies such as CONACYT.

small.¹⁶ Meanwhile, firms oriented towards activities closer to the market (technological development) are more likely to participate in the programmes. One possible explanation for this could be that, as has been observed in other countries,¹⁷ government agencies in Mexico are opting for projects that offer the prospect of a certain level of success in the short term and products that have an immediate application in the market. Moreover, the level of risk of failed projects is higher in the case of basic R&D, and the likelihood that projects closer to the market will be successful appears to be higher. This may be the reason why the State seems to prefer to support innovative companies that are more oriented towards innovations that can be applied in the short run.

Yet a company's performance is determined not only by its approach to innovation but also by the skilfulness of its managers and researchers. Firms with higher-quality human resources can therefore be expected to be more likely to turn in a strong performance in terms of innovation and to prepare successful project proposals for submission to public agencies that provide production incentives (Cerulli and Potì, 2012). A variable was therefore introduced to reflect the number of employees with tertiary degrees as a percentage of all employees working in R&D (human capital). Using the model employed in this study, it can be confirmed that the presence of more highly qualified personnel has a significant positive effect on a firm's likelihood of securing government funding.

V. Analysis of the effect of incentives for innovation based on the propensity score matching model

Once a profile of subsidized firms has been developed, the next step is to look at the effect of that support in terms of financial additionality and corporate performance. Various matching algorithms have been used in this study to see how robust the findings are. First, matching has been used for the estimates only for firms within the same common support area,¹⁸ and the re-use of control-group firms is allowed, so that a single firm not receiving support can be a control-group firm for more than one treated firm.

Table 4 presents the results for the different matching algorithms. Column (1) shows the results for the matching of beneficiary firms with a single control-group company (the one for which the probability of being a beneficiary is the closest). Column (2) shows the results for the use of the algorithm for the maximum distance between the treated and the control-group firms (caliper), which means that firms without a corresponding control-group firm with a probability of being a beneficiary of less than 0.015 are not included in the estimation. Since the matching with a single firm may be influenced by outliers for certain firms, column (3) shows the estimates obtained by matching each benefiting firm with up to five control-group firms. Finally, column (4) shows the estimates for the kernel matching algorithm, which uses all observations as controls, weighting each one on the basis of the probability of receiving support. Table 4 shows that the results are robust to the different matching algorithms, although the preferred model is matching with a control-group firm and caliper of 0.015 (column 2).

¹⁶ On the basis of the Oslo Manual classification, ESIDET divides activities into three types: basic research (carried out by 9% of the firms in the sample), applied research (12.5%) and technological development (28.7%).

¹⁷ See, for example, Cantner and Kösters (2012); Hottenrott and Richstein (2020); Heijs, Guerrero and Huerigo (2022).

¹⁸ The analysis is performed with comparable firms whose probability of becoming beneficiaries is similar. Firms with extreme values, for which the probability of becoming a beneficiary is higher than the maximum or lower than the minimum of the control group are not included in the effect estimate.

Table 4
Average treatment effect on treated firms (ATET)

	(1)		(2)		(3)		(4)	
	NNM(1) Comm		NNM(1) Comm cal(0.015)		NNM(5) Comm		Kernel matching	
	ATET	S.E.	ATET	S.E.	ATET	S.E.	ATET	S.E.
Total R&D expenditure (over sales)	0.131***	0.043	0.136**	0.053	0.147***	0.040	0.134***	0.043
Total R&D expenditure (over sales)	0.047	0.040	0.035	0.039	0.064**	0.028	0.046	0.029
Total R&D expenditure (log)	1.006**	0.449	0.932**	0.442	1.192***	0.360	0.991***	0.240
Gross expenditure on R+D (log)	0.326	0.437	0.221	0.479	0.511	0.388	0.329	0.297
Human capital	0.059*	0.033	0.074***	0.020	0.060**	0.026	0.216***	0.011
Sales (log)	0.546**	0.248	0.361**	0.179	0.543**	0.245	0.111	0.151
Exports (log)	1.341**	0.544	1.022***	0.353	1.476***	0.552	1.269***	0.337

Source: Prepared by the authors, on the basis of data from the 2017 Survey on Research and Technological Development (ESIDET).

Note: NNM (n) = Nearest-neighbour matching with *n* control-group companies.

Comm = Estimate restricted to units within the common support area.

cal(-) = Maximum permitted distance for matching between the probability of receiving support of a treated firm and a control-group firm.

ATET: Average treatment effect on the treated.

S.E. = Bootstrap standard error estimates with 200 repetitions.

Total number of treated firms: total = 116; common support = 111; common support and caliper of 0.015 = 102.

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$ (significant at 1%, 5% and %, respectively).

Table 4 shows that the effect of government funding for R&D on private innovation effort (total R&D expenditure in absolute values and as a percentage of sales) is positive and statistically significant. The result indicates that companies participating in incentive programmes exhibit a greater innovation effort than counterfactual non-participating companies. Firms receiving R&D funds spend around 13 percentage points more on R&D (as a percentage of sales) than non-participating firms. These results line up with the findings of earlier studies (Crespi, Tacsir and Vargas, 2016; Fernández-Sastre and Montalvo-Quizhpi, 2019; Huergo and Moreno, 2017) and confirm the presence of partial additionality. However, the net variables (private expenditure less the funds received) show no statistically significant effect in either absolute terms or as a percentage of sales. These results are also in line with those of previous studies (Busom, 2000; Hottenrott, Lopes-Bento and Veugelers, 2017; Neicu, 2019; Heijis, Guerrero and Huergo, 2022) and indicate that the presence of a partial crowding-out effect, i.e. that some of the companies may not be using the funds properly, cannot be ruled out.

With regard to the performance and entrepreneurial capacity variables, table 4 shows that support has had a positive effect on all three indicators. Firms receiving government funds have a higher percentage of staff with tertiary studies (7 percentage points). In terms of performance, the results indicate that, although the effect is positive for sales and exports, the main effect is on exports.

To check that the matching was statistically correct, the means of the control variables were compared. This test makes it possible to analyse the similarity between the control group and the treated group used to estimate the effect of receiving support by looking at the mean values for each of the variables of the estimation of the probability of being a beneficiary. The means test (see table A1.2 in annex A1) shows that, after matching the means of these variables for the treated group and the control group, they are statistically equal, and therefore the two groups can also be considered to be equal.

VI. Conclusions

Although R&D and innovation are regarded as being highly important in supporting competitiveness and the economic development of a country, the severe financial constraints associated with the crisis and the difficulty of obtaining credit in the financial market represent major obstacles for investment at the company level. The role of the State in fostering R&D and innovation investment in order to correct market failures is therefore all the more important. In the case of Mexico, current financial constraints also make it imperative for such support policies to be implemented efficiently and effectively, and it is therefore essential to evaluate the performance of government bodies in correcting those market failures.

From a methodological standpoint, an assessment of the impact of incentives runs into problems of selection bias. To mitigate them, the propensity score matching method, which is a non-parametric technique, was used. This method provides two types of result. First, it identifies the revealed or implicit priorities of the government agencies that allocate this type of support by examining the profile of the firms that most frequently participate in these incentive programmes. In the case of Mexico, the firms receiving the most support are companies in the services sector, the most competitive (export) firms, those with the highest level of human capital and those more oriented towards technological development. This indicates that government bodies are channelling support into the firms that are most likely to show positive results. This profile is very similar to the profile reflected in the results of most of the previous empirical studies on this subject (Herrera and Heijis, 2007; Czarnitzki and Lopes-Bento, 2011; Busom, Corchuelo and Martínez-Ros, 2017; Sterlacchini and Venturini, 2018).

The second type of result yielded by the PSM method is the measurement of the impact of this type of support on the firms in question, which is the main purpose for using this method. In this case, it is found that the support programmes of Mexican public agencies have a positive effect on total R&D expenditure, measured both in absolute values and as a percentage of the value of sales. Specifically, in the case of firms receiving these funds, R&D expenditure as a proportion of sales is, on average, around 13 percentage points higher than that of firms not participating in incentive programmes. However, once the amount received is deducted, it turns out that the firms are not significantly increasing their spending. In other words, government incentive programmes are not prompting participating firms to increase their private innovation effort. The entire increase in R&D expenditure in the firms receiving support is financed by the government subsidy, while the firms are not increasing the amount of their own funds devoted to R&D and innovation. In table 2 this is presented as a partial crowding-out effect.

Nonetheless, the financial additionality generated by government incentives is important, as the companies that are spending more in total can devote more time, human capital and assets to innovation. As noted earlier, innovation is a high-risk activity in both technological and economic terms, and some companies therefore either do not engage in this type of activity at all or limit themselves to lower-risk projects. It is, however, clear that these types of activity should be encouraged, so that companies will strengthen their technological capabilities, which in turn will enable them to compete more successfully in the market, thereby boosting the competitiveness of the country as a whole.

The novel aspect of this study is, as explained in box 1, that it, along with the study by Chávez (2020), is one of the very few that directly assess the impact of government support for corporate RDI in Mexico. To this end, it uses a micro-level sample with individual firm data and the propensity score matching method. While there are other studies that estimate the quantitative impact of such support in financial terms, those studies are based on a sample with very few observations or use a methodology—although skilfully applied—that is atypical in this field and that produces results that are difficult to compare at the international level. Interesting future lines of research include the analysis of the types of company in which government funding for R&D and innovation has a greater or lesser impact, which would make it possible to adjust the programmes and assess which types of programme are more effective. Thus far, given the limited size of the sample, it has not been possible to analyse these aspects.

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Annex A1

Table A1.1
Variables used

Variable	Description
Total R&D expenditure (log)	Total private expenditure on R&D (in logarithms)
Net R&D expenditure (log)	Private expenditure on R&D (in logarithms), less the funding received (in logarithms)
Total R&D expenditure as a percentage of sales	Total private expenditure on R&D as a percentage of sales
Net R&D expenditure as a percentage of sales	Private expenditure on R&D (in logarithms), less the funding received, as a percentage of sales
Human capital	Number of employees with a postgraduate degree as a percentage of the total number of employees
Sales (log)	Total volume of sales in period t (in logarithms)
Exports (log)	Total volume of exports in period t (in logarithms)
Pavitt1	= 1 Traditional industrial producers
Pavitt2	= 1 Traditional industrial suppliers
Pavitt3	= 1 Specialized industrial suppliers
Pavitt4	= 1 Scale-intensive industries
Pavitt5	= 1 Science-based industries
Pavitt 6	= 1 High-tech services
Company size	
0–100	= 1 if the firm has between 0 and 100 employees
101–200	= 1 if the firm has between 101 and 200 employees
201–500	= 1 if the firm has between 201 and 500 employees
Over 500	= 1 if the firm has over 500 employees
Age of company (log)	Natural logarithm of the number of years the firm has been in existence
Export activity	= 1 if the firm engaged in export activity
Publicly owned	= 1 if the firm is publicly owned
Multinational	= 1 if 50% or more of the equity in the firm is held by foreign entities
Group	= 1 if the firm belongs to a corporate group
Basic research	= 1 if the firm channels innovation expenditure into basic research
Applied research	= 1 if the firm channels innovation expenditure into applied research
Technological development	= 1 if the firm channels innovation expenditure into technological development

Source: Prepared by the authors.

Table A1.2
Test of equality of means

Variable	Before matching			After matching		
	Treated	Control	p> t	Treated	Control	p> t
Firm size						
0<x<100	0.525	0.476	0.057	0.402	0.314	0.190
200<x<500	0.116	0.173	0.004	0.147	0.147	1.000
x>500	0.219	0.203	0.429	0.333	0.412	0.249
Age (log)	2.715	2.819	0.012	2.860	2.903	0.753
Export activity	0.451	0.282	0.000	0.422	0.422	1.000
Publicly owned	1.058	1.026	0.028	1.049	1.039	0.827
Multinational (>50%)	0.111	0.174	0.001	0.127	0.206	0.134
Group	1.483	1.467	0.692	1.343	1.225	0.322
Human capital	0.183	0.005	0.000	0.111	0.110	0.977
Basic research	0.090	0.007	0.000	0.147	0.186	0.455
Applied research	0.235	0.009	0.000	0.284	0.235	0.427
Technological development	0.507	0.018	0.000	0.608	0.578	0.671
Sector of activity:						
- Traditional industrial producers	0.145	0.309	0.000	0.127	0.127	1.000
- Traditional industrial suppliers	0.116	0.222	0.000	0.108	0.088	0.640
- Specialized industrial suppliers	0.069	0.068	0.960	0.029	0.000	0.082
- Scale-intensive industries	0.161	0.112	0.003	0.118	0.147	0.538
- Science-based industries	0.077	0.032	0.000	0.078	0.059	0.582
- High-tech services	0.269	0.097	0.000	0.382	0.422	0.570
2014	0.409	0.501	0.000	0.373	0.412	0.568
2015	0.591	0.499	0.000	0.627	0.588	0.568

Source: Prepared by the authors.

Note: Values refer to NNM(1) matching, imposition of common support and caliper of 0.015.

Drivers of the adoption of organic farming in Brazil: a combinatorial analysis

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Abstract

The general objective of this study is to identify the combinations of eco-innovation drivers associated with Brazilian municipalities in which a large proportion of farms report that they engage in organic farming. To this end, a theoretical review identified 11 drivers, which were classified as internal and external to the farms. The data were obtained from the 2017 agricultural census, published by the Brazilian Institute of Geography and Statistics (IBGE). Qualitative comparative analysis was used to identify the combinations of drivers associated with organic farming. The results showed that no single driver can be considered necessary. Nonetheless, two combinations of internal drivers and three combinations of external drivers were found to be sufficient to explain the existence of a large proportion of properties engaged in organic farming. These findings contribute to the literature on eco-innovation in agriculture and to the monitoring of public policies.

Keywords

Agriculture, agricultural ecology, innovations, organic farming, agricultural production, rural development, Brazil

JEL classification

Q18, Q16, Q15

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I. Introduction

Brazil is considered one of the world's largest food producers, in terms of both diversity and the quantity and quality of its agricultural production (MAPA, 2022). Population growth projections, increasing per capita income in developing countries, and restrictions on land use for the expansion of cultivated area fuel expectations that Brazilian agriculture will meet the world's food demand (MAPA, 2022) and, at the same time, minimize the environmental and socioeconomic problems generated by conventional agriculture (Gerten and others, 2020).

Such problems include the following: (i) the artificial introduction of nitrogen (N), which has impaired water quality and biodiversity (Foley and others, 2005; Therond and others, 2017); (ii) climate changes resulting from the intensive use of nitrogenous nutrients, methane production in flooded soils and originating from the fermentative digestion processes of ruminant animals, production of manure, deforestation and the burning of agricultural waste, and conventional tillage systems (Shukla and others, 2008); (iii) poisoning of human beings and contamination of food by pesticides (Carneiro and others, 2015) and increased insect resistance, with negative effects on the ecosystem services of biological regulation (Therond and others, 2017); (iv) soil degradation, with an estimated 40% of agricultural soils potentially suffering from some degree of erosion and reduced fertility (Therond and others, 2017).

Given the numerous problems associated with conventional agriculture, there is a need to change the system as a whole, or at least in large part (Blazy, Carpentier and Thomas, 2011). Organic farming is an alternative for minimizing the problems related to the agricultural system based on chemical inputs (Antunes, Dias and Maehler, 2016). In Brazil, an organic system of farming is defined as

[...] one in which specific techniques are adopted, by optimizing the use of available natural and socioeconomic resources and respecting the cultural integrity of rural communities, in pursuit of economic and ecological sustainability; maximization of social benefits; minimization of reliance on non-renewable energy (employing biological and mechanical methods and practices, wherever possible, as opposed to using synthetic materials); elimination of the use of genetically modified organisms and ionizing radiation at all stages of the production, processing, storage, distribution and marketing process, and environmental protection (Brazil, 2003).

According to data from the 2017 agricultural census, just 1.3% of crop or livestock farming in Brazil is organic (IBGE, n.d.) —still a very small proportion. The problem of adopting new environmentally superior agricultural systems can be understood through the theoretical approach of eco-innovation (Yuan, 2016; Galliano and others 2018; Shih and others 2018; Kiefer, Del Rio Gonzalez and Carrillo-Hermosilla, 2019; Dudek and Wrzaszcz, 2020, Fernandes, Souza and Belarmino, 2020). An analysis of research on eco-innovation (Shih and others, 2018) reveals that most of the studies that have been conducted refer to the drivers of this process (Díaz-García, González-Moreno and Sáez-Martínez, 2015). Research on drivers seeks to identify the precursors of eco-innovation at different levels and focuses mainly on the motivations underlying the adoption, development or implementation of those innovations (Díaz-García, González-Moreno and Sáez-Martínez, 2015).

A review of studies on the drivers of eco-innovation shows that few have been conducted in the agriculture sector (Shih and others, 2018; Dudek and Wrzaszcz, 2020; Fernandes, Souza and Belarmino, 2020). Moreover, Blazy, Carpentier, and Thomas (2011) and Fernandes, Souza, and Belarmino (2020) state that, as much attention has been paid to the adoption of comprehensive and environmentally better agricultural systems and farming practices, the factors that foster the adoption of such systems and practices need to be identified. However, the authors of the studies on the drivers of eco-innovation were only concerned with describing these factors individually, and did not analyse their potential combination to encourage the adoption of integrated farming systems. The study by Dias and Braga (2022), which performs a combinatorial analysis of the drivers, is an exception.

After considering the environmental problems associated with conventional farming practices and the possibility of understanding the factors that influence the adoption of the organic system — on the basis of eco-innovation drivers—, the following research question was formulated: what combinations of eco-innovation drivers in agriculture foster the adoption of organic farming systems?

The qualitative comparative analysis (QCA) method was used to identify the combinations. It uses combinatorial logic and applies logical operators to explain how the drivers that influence the adoption of agricultural systems combine to create specific outcomes (Dias and Braga, 2022).

The results indicate that two combinations of internal drivers and three combinations of external drivers are sufficient to explain greater adoption of organic farming in the Brazilian municipalities analysed. Drawing on these findings, this study aims to contribute to the literature on eco-innovation in agriculture by relating the drivers to the adoption of the organic farming system by Brazilian farmers. It also seeks to contribute to the dissemination of the QCA method, which has not yet been widely discussed in Latin America as in other developed countries. Lastly, the identification of combinations of eco-innovation drivers for agricultural systems is useful for monitoring public policies aimed at promoting, encouraging and improving the adoption of the organic system in developing countries.

II. Drivers of eco-innovation in agriculture

The concept of eco-innovation stems from two terms: the prefix “eco”, associated with the environmental dimension, and the word “innovation”. While the general definition of innovation is neutral in terms of the type of change involved, the concept of eco-innovation emphasizes innovation related to sustainable development, which reduces environmental damage (Rennings, 2000). Meanwhile, Kemp and Pearson (2007) defined eco-innovation as the production, application or exploitation of a good or service that is new to an organization or user.

According to Schiederig, Tietze and Herstatt (2012), the concept is referenced through various terms and definitions, such as eco-innovation, environmental innovation and green innovation. In their discussion, those authors argue that the various definitions are similar because they have several aspects in common. Eco-innovation can be understood as a special type of innovation (Schiederig, Tietze and Herstatt, 2012, p. 182). It should be noted that not all innovations are eco-innovations, but all eco-innovations are innovations, with certain key characteristics that distinguish them (Bossle, 2015, p. 32).

The Organisation for Economic Co-operation and Development (OECD) defines eco-innovation as the development or implementation of new or significantly improved products (goods and services), processes, marketing methods or organizational systems in business practices, workplace organization or external relations (OECD/Eurostat, 2005, p. 47, cited in OECD, 2009).

Hasler and others (2017) sought to determine the factors affecting eco-innovation in agriculture, which is the focus of this research. They identified 11 main drivers of eco-innovation: (i) participation in external or cooperative groups; (ii) information; (iii) access to credit; (iv) market access; (v) gender; (vi) age; (vii) education; (viii) farm size; (ix) land ownership; (x) quality of technical assistance; and (xi) expectations.

Participation in groups, cooperatives or advisory boards can stimulate process innovations and ensure good information exchange (Hasler and others, 2017). It can also stimulate the adoption of service innovations because these groups can provide professional support or establish contacts (Huang and others, 2015). Cooperation among rural producers is a social process based on associative relationships, through which people seek solutions to their common problems in a cooperative way (Thesing, 2015).

Access to agricultural information is the second driver of eco-innovation (Hasler and others, 2017). Watcharaanantapong and others (2014) noted that farmers who obtained agricultural information from crop consultants, university extension programmes, other farmers, trade fairs, Internet or the media

were more likely to adopt eco-innovations. While information can be seen as an important precursor to eco-innovation, capacity is required to obtain and process it. Information plays an important role in the process of distinguishing between potentially valuable opportunities and others of less value, and also in the ability to exploit them effectively. Access to certain types of information and the capacity to use it effectively determine whether a given individual is better able than another to recognize a good opportunity (Baron and Shane, 2007).

Access to credit is another eco-innovation driver. If a new process requires further investment, access to credit can motivate adoption of the innovation in question. The establishment of credit lines for small- and medium-scale producers advances the eco-innovation transition process (Hasler and others, 2017).

Market access can generate knowledge about the desired eco-innovation. It can also foster good information exchange, which is important for the adoption of process innovations (Hasler and others, 2017). Producers integrated into more structured marketing channels, which offer certain market guarantees for production, are those that adopt the most capital-intensive environmental technologies (Hasler and others, 2017).

With regard to gender, male farmers tend to adopt more radical innovations, such as a new farming system, sooner than female farmers. One reason may be that male farmers are more risk-tolerant. Gender differences are important in technology adoption and farming practices in many agricultural systems, mainly because access to resources and management of rural properties and natural resources are often determined by culturally defined and unequal gender roles (Ndiritu, Kassie and Shiferaw, 2014).

Age is another factor affecting eco-innovation, with younger people tending to be more positive towards its adoption. Younger farmers have longer planning horizons and, therefore, greater incentives to consider new investments in equipment or changes in management practices than older farmers. Younger farmers are more readily attracted to new ideas and are more likely to be early adopters (Anosike and Coughenour, 1990; D'Souza, Cyphers and Phipps, 1993; Rahm and Huffman, 1984). Greater experience, as measured by age or the number of years in farming, could also be considered a positive factor for the adoption of sustainable practices, by potentially indicating greater management capacity. However, older farmers may have less energy, be more change-averse, or have a shorter planning horizon (Hasler and others, 2017).

Higher education levels can be a stimulating factor, because they may mean that farmers are more willing to engage in lifelong learning and cooperation. Higher levels of education appear to stimulate the adoption of new technologies (Hasler and others, 2017).

Larger farms can give farmers a better foundation for financial investments and thus encourage the adoption of eco-innovation (Hasler and others, 2017). Smallholder farmers are particularly susceptible and risk-averse, especially those whose immediate survival depends directly on the outcome of current production (Hasler and others, 2017). In Brazil, the vast majority of small-scale farmers, even those who are better capitalized, do not have institutional protection mechanisms to cushion the impact of negative production outcomes and are therefore more reticent about adopting technological and environmental innovations (Almeida and Buainain, 2005).

When the land belongs to the farmer who works it, the willingness to invest in new technologies to maintain soil fertility and quality is much greater (Hasler and others, 2017). Conversely, the terms of a lease or partnership contract may not create incentives to adopt certain eco-innovation practices. Tenants or partners may judge that they will not receive the benefits of land improvement. When a property is managed by the landowner, the likelihood of investing in technologies is greater (Nowak, 1987). Small-scale leasing in Brazil revealed that short-term and informal contracts do not provide tenant farmers with the conditions needed to invest in technology; and they further hinder access to credit and more stable marketing channels (Almeida and Buainain, 2005).

Quality technical assistance can stimulate farmers to trial a new product (Chianu, Chianu and Mairura, 2012). Ensuring quality technical assistance is easier when producers are grouped together, as there is an exchange of experiences among farmers that increases learning for all, including technical consultants in rural extension.

Lastly, Hasler and others (2017) also highlight the importance of expectations: farmers who have higher expectations for innovation outcomes are more inclined to adopt new technologies.

Drivers can also be classified in two categories: internal and external (Bossle and others, 2016). External drivers are those determined by circumstances outside the farm under analysis. On the basis of the literature review, the following drivers were classified in this group (see table 1): participation in external groups or cooperatives, information, access to credit, market access and quality of technical assistance. Internal drivers are those determined by circumstances prevailing within the farm (Bossle and others, 2016), such as farm size, ownership of the land, gender, age and education.

Table 1
Internal and external drivers of eco-innovation

Internal drivers	External drivers
Farm size	Participation in external groups or cooperatives
Ownership of the land	Information
Gender	Access to credit
Age	Market access
Education	Quality of technical assistance
Expectations	

Source: Prepared by the authors, on the basis of M. B. Bossle, "Drivers for adoption of eco-innovation and enhancement of food companies' environmental performance", PhD thesis, Federal University of Rio Grande do Sul, 2015; and K. Hasler and others "Drivers for the adoption of different eco-innovation types in the fertilizer sector: a review," *Sustainability*, vol. 9, No. 12, November 2017.

III. Methodological procedures

Qualitative comparative analysis was the research method used in this study (Ragin, 1987). The data were obtained from the 2017 agricultural census published by the Brazilian Institute of Geography and Statistics (IBGE, n.d.).

1. Cases, causal conditions and indicators

In qualitative comparative research, the cases are what is to be compared —in this study, the 120 Brazilian municipalities with the largest proportion of farms reporting organic farming and the 20 municipalities with the smallest proportion. This procedure aimed to obtain a sample with a gradient of municipalities that varied between those with a large proportion of organic farms and those with a small proportion of organic farms, as recommended by Schneider and Wagemann (2010).

Once the 140 municipalities had been selected, the drivers established in the literature (see table 1) were associated with the questions formulated by IBGE, and indicators were developed for each driver. Annex A1 describes the identification codes, the classification, the drivers, the 2017 agricultural census questions to which they refer, the reply alternatives, the formulas for calculating the indicator by municipality and the numbers of the tables referring to the census in the IBGE Automatic Retrieval System (SIDRA) platform. These associations were then used to create the database for the analysis.

2. Calibration of the indicators associated with the drivers

For each driver, descriptive statistics were calculated to identify the maximum (N1), median (N2) and minimum (N3) values, and thus support the definition of the three anchors needed for the calibration process (see annex A2).

These results were then used for the driver calibration process. The definition of the driver “purpose of production (subsistence or commercial sale)” is an exception, because it is a binary variable. For this reason, 50% was set between production for commercial purposes and subsistence, as a midpoint between the two classes. Calibration is the process of converting continuous data to an interval of 0 to 1. All drivers were calibrated with the fuzzy set qualitative comparative analysis (fsQCA) programme (Ragin and Davey, 2017). In the process of calibrating the outcome (proportion of organic farms in the municipality), the value 0.10 was chosen, because it was considered that this value could best distinguish municipalities that have a high proportion of organic farms from those that do not. Following calibration, the drivers and the result were designated with capital letters to differentiate them from the other uncalibrated drivers.

3. Analysis of the drivers

The calibration process was followed by the two-step QCA (fsQCA): analysis of necessity and analysis of sufficiency (Schneider and Wagemann, 2012).

Firstly, the necessity of individual drivers was assessed. Necessary conditions are essential to management theory and practice, because if the factors in question are not present, the outcome will not occur. Moreover, other causal conditions cannot make up for their absence (Dul, 2016). A consistency threshold of 0.9 was established to infer a necessary causal condition (Schneider and Wagemann, 2012). The consistency criterion assesses the degree to which cases sharing a given condition agree in displaying the outcome in question (Ragin, 2008, p. 44). For Ragin (2000, cited in Bol and Luppi, 2013), a necessary condition is calculated as the sum of the minimum values of a condition associated with an outcome, divided by the sum of the values of that outcome in all cases.

A second criterion for defining whether or not a driver can be considered necessary is coverage, which is measured as the proportion of cases manifesting the driver and the outcome being investigated (Schneider and Wagemann, 2012). Coverage can thus be understood as an indicator of relevance or trivialness. A low level of coverage implies trivialness (Schneider and Wagemann, 2012).

Once completed, the analysis of necessity gave way to the second stage: the analysis of sufficiency. A driver can be considered sufficient if it is present in all cases of the subset, and the outcome being analysed is also present in that subset (Schneider and Wagemann, 2012, p. 57). Sufficiency was analysed using the truth table algorithm (fsQCA programme) and comprised the following stages (Rihoux and De Meur, 2009): (i) truth table analysis; (ii) decision on contradictory configurations; (iii) Boolean minimization procedure; (iv) consideration or otherwise of logical remainders, which are defined as sets of logically possible drivers that were not observed in the cases investigated.

For the first and second stage, all existing configurations of the observed drivers were listed. To exclude contradictory configurations (solutions for products that were both negative and positive for the outcome), a consistency rule of 80% was used, as well as the minimum proportional reduction in inconsistency indicator of 0.5 (Schneider and Wagemann, 2012). The Boolean minimization stage was performed with the standard analysis, since it is a very useful strategy for managing limited diversity (Schneider and Wagemann, 2012).

The standard analysis can produce three solutions: (i) a complex solution, which does not consider the logical remainders; (ii) a parsimonious solution, which does consider the logical remainders; and (iii) an intermediate solution, which selects logical remainders on the basis of theoretical guidelines or directional expectations.

In terms of directional expectations, necessary drivers are those that must be present in the solutions. Eco-innovation drivers that were not necessary were considered possibly present or absent (Schneider and Wagemann, 2012). Lastly, the intermediate solution, in which the use of logical remainders is controlled by the researcher, is presented and analysed (Schneider and Wagemann, 2012).

IV. Results

1. Analysis of necessity of the drivers of Brazilian organic crop and livestock farming

An analysis was made of whether the presence or absence of a given driver is always, or nearly always, associated with a municipality in which a large proportion of farms report organic farming (see table 2).

Table 2
Analysis of necessity of drivers of organic farming in Brazil

Driver	Midpoint – median of data distribution ^a	Consistency	Coverage
Higher education level	Average schooling greater than 7.6 years	0.816678	0.790529
Lower education level	Average schooling less than 7.6 years	0.743155	0.814223
Greater external participation	External participation in more than 31.96% of farms	0.693259	0.840580
Less external participation	External participation in less than 31.96% of farms	0.824322	0.735309
Greater diversity of assistance	Origin of technical assistance more than 0.60 sources	0.827936	0.825069
Less diversity of assistance	Origin of technical assistance less than 0.60 sources	0.782071	0.829941
Larger proportion of farms with own land	Proportion of farms with own land greater than 83.42%	0.729534	0.832514
Smaller proportion of farms with own land	Proportion of farms with own land less than 83.42%	0.847394	0.792333
Greater male predominance	Proportion of farms run by men greater than 84.64%	0.723419	0.760854
Lesser male predominance	Proportion of farms run by men less than 84.64%	0.764420	0.768264
Older age	Average age older than 54.34 years	0.862266	0.763946
Younger age	Average age younger than 54.34 years	0.672133	0.822589
Greater diversity of access to information	Average number of information sources greater than 1.60	0.684225	0.850113
Less diversity of access to information	Average number of information sources less than 1.60	0.837526	0.734073
Greater access to credit	Average number of credit sources greater than 0.09303	0.643641	0.756082
Less access to credit	Average number of credit sources less than 0.09303	0.809173	0.739302
Larger average farm size	Average farm size larger than 48.6 hectares	0.622376	0.811526
Smaller average farm size	Average farm size smaller than 48.6 hectares	0.842807	0.714926
Commercial farming	Subsistence as a production purpose in fewer than 50% of the farms	0.782487	0.694976
Subsistence farming	Subsistence as the purpose of production in more than 50% of the farms	0.534398	0.651806

Source: Prepared by the authors, on the basis of the fsQCA programme.

^a A value of 0.5 was used to classify production purpose.

The analysis of necessity of the drivers found that none attained the 0.9 consistency limit, which is usually applied to define a causal condition as necessary.

2. Analysis of sufficiency of the drivers of Brazilian organic farming

This section analyses the results of the combinations of drivers internal and external to the farm that are positively associated with a large proportion of organic farming properties in a given municipality.

(a) Internal drivers

The results of the fsQCA programme for the internal drivers indicate that the sample can be described by a total of two highly consistent configurations (above 90%), as described in table 3. These two configurations identify the combinations of drivers that are positively associated with a municipality in which a large proportion of farms are organic.

Table 3
Configurations of internal drivers of organic farming in Brazil

Configurations	Gross coverage	Unique coverage	Consistency
Older AND less male dominated AND larger average farm size AND smaller proportion of farms with own land	0.481862	0.0433634	0.920850
Older AND less male-dominated AND larger average farm size AND lower education level	0.449757	0.0112578	0.928284
Frequency threshold: 2			
Consistency threshold: 0.920077			
Solution coverage: 0.49312			
Consistency of the solution: 0.915613			

Source: Prepared by the authors, on the basis of the fsQCA programme.

The results show that the two configurations have high consistency measures of 92.08% and 92.82%, respectively. This means that 9 out of 10 municipalities thus configured reported a high proportion of organic farms. The consistency of the overall solution indicates that, when the two configurations are present, there is a 92.00% probability that the municipality in question has a large proportion of organic farms (Rihoux and De Meur, 2009).

The results also show that the two configurations have high coverage rates (gross coverage between 48.18% and 44.97% and unique coverage between 4.33% and 1.12%). For example, for the first configuration, the gross coverage measure indicates that 48.18% of municipalities in which more than 10% of farms are organic contain the first subset of cases. The solution coverage means that 49.31% of the municipalities with a large proportion of organic farms are covered by one of these two configurations.

Unique coverage ranged from 1.1% to 4.3%. This is drawn from the subsets that have the same configuration and indicates the proportion of those configurations that can produce the outcome variable without the addition of any other causal condition (Rihoux and De Meur, 2009).

(b) External drivers

The results obtained with the fsQCA programme for the external drivers indicate that the sample can be described by three highly consistent configurations (above 90%), as described in table 4.

Table 4
Configurations of external drivers of organic farming in Brazil

Configurations	Gross coverage	Unique coverage	Consistency
Commercially run AND less access to credit AND less external participation	0.613203	0.0924253	0.881518
Commercially run AND greater diversity of assistance AND less external involvement	0.545517	0.0229326	0.923530
Marketing AND greater diversity of assistance AND greater diversity of access to information	0.558721	0.0118138	0.938595
Frequency threshold: 2			
Consistency threshold: 0.928415			
Solution coverage: 0.723974			
Consistency of the solution: 0.869616			

Source: Prepared by the authors, on the basis of the fsQCA programme.

The results show that the three configurations are highly consistent with a large proportion of organic farms in a municipality, reporting values of 88.15%, 92.35% and 93.85%, respectively. This means that 9 out of 10 municipalities so configured displayed a positive outcome. The consistency of the overall solution indicates that, when the three configurations are present in a municipality, there is an 86.96% likelihood that a large proportion of its farms are organic (Rihoux and De Meur, 2009).

The results also show that the three configurations have high coverage (gross coverage rates of 61.32%, 54.55% and 55.87%, respectively, and unique coverage rates of 9.24%, 2.29% and 1.18%, respectively). Gross coverage indicates that 61.32% of municipalities in which more than 10% of agricultural properties engage in organic farming contain the first subset of configurations, 54.55% of municipalities contain the second subset, and 55.87% contain the third. The coverage of the solution means that 72.39% of the municipalities with a high proportion of organic farms are covered by one of these three configurations (Rihoux and De Meur, 2009).

Unique coverage ranged from 1.1% to 9.2%. This is drawn from the subsets that have the same configuration and indicates the proportion of those configurations that can produce the outcome variable without the addition of any other causal condition (Rihoux and De Meur, 2009).

V. Analysis of results

The QCA method makes it possible to identify configurations of drivers that explain the large proportion of properties reporting organic farming in a municipality.

Firstly, all drivers were analysed in isolation (see table 2). The results indicate that none of the drivers, individually, can be defined as necessary for the presence of a high proportion of properties reporting organic farming in the municipality. In other words, none of the drivers analysed in isolation is always associated with a large proportion of organic farms.

Secondly, combinations of internal and external drivers were analysed for sufficiency. In the case of internal drivers (see table 1), two explanatory configurations were found for the large proportion of properties reporting organic farming in a municipality. These two configurations identify internal drivers common to municipalities with a large proportion of organic farms, namely older age and lesser male predominance and larger average farm size.

The older average age of organic farmers (over 54.34 years) corroborates the earlier finding of Lourenço and Schneider (2022) that organic farmers are predominantly more than 55 years old. It is also consistent with what is happening in family farming, where an ageing process can be discerned

among those responsible for the farms — a phenomenon that is well documented in the literature on the rural world and has intensified in recent decades (Camarano and Abramovay, 1999)— since most organic farmers are also family farmers (Lourenço and Schneider, 2022). Another likely feature that can be inferred is that the greater experience of these farmers —who have often already confronted problems related to conventional farming (such as pesticide poisoning, high production costs and indebtedness)— makes them switch to organic farming later in life.

The lesser predominance of men running organic farms in the municipalities (less than 84.64%) may be explained by several studies that highlight the important role played by women in processes of transition to organic farming (Karam, 2004). Alternatively, it may suggest that the organic farming system involves the family to a greater extent (Shultz, de Souza and Jandrey, 2017), or even enable a greater role for women farmers in these farms (Schmitt and others, 2020). However, this is not entirely clear from the results obtained from the 2017 Agricultural Census (Lourenço and Schneider, 2022).

Larger average farm size (greater than 48.6 hectares) was another driver associated with a high proportion of properties reporting organic farming in a municipality. The literature did not suggest an explanation for this result. Nonetheless, in municipalities with larger average farm size, a possible complementarity with the adoption of organic farming is inferred as larger farms are generally associated with the production of commodities, while organic farming tends to be associated with growing vegetables and legumes (Valarini and others, 2005). Complementarity may arise from the demand for organic food from the larger farms to sustain the rural families working on them, or else for the subsistence of the organic farms.

These three internal drivers (older age, less male predominance and larger average farm size) are combined with two others: (i) smaller proportion of farms with owned land (less than 83.42%), which made it possible to infer the category of farms run by older men, with the participation of women and less owned land, representing 48.18% of municipalities with a high proportion of organic farms; or (ii) lower level of education (less than 7.6 years of schooling), which made it possible to infer the category of establishments headed by older men, with the participation of women and low levels of education, which represents 44.97% of the municipalities with a large proportion of organic farms.

These two internal drivers (smaller proportion of farms with their own land and lower education levels) stem from the origins of organic farming, associated with producers who were involved in various social movements in rural areas, especially those who were excluded from the “green revolution”, which occurred between the 1960s and 1980s. The green revolution involved increased concentration of properties, the exclusion of some producers from the modernization process, and worsening inequalities. Thus, an alternative to the effects of that process was diversification of production or the transition to ecologically based farming systems (Lourenço and Schneider, 2022).

In the case of external drivers, three configurations were identified: (i) commercially run, less external participation and less access to credit; (ii) commercially run, less external participation and greater diversity of assistance; (iii) commercially run, greater diversity of assistance and greater diversity of access to information. All of these are associated with a high proportion of organic farms in a municipality.

These three configurations indicate a common external driver, namely commercial sale as the production purpose. The result regarding the commercial purpose of production (more than 50% of farms) corroborates the proposal, made by Hasler and others (2017), that the market can foster knowledge about the desired eco-innovation; and it also supports the results reported by Mier y Terán and others (2021), who state that commercial purpose is a condition for the adoption and adaptation of agroecological systems by farmers.

In addition to the driver related to the purpose of production (commercial sale or subsistence), the following three pairs of drivers were associated:

- (i) Less external participation (less than 31.96% of the farms) and less diversity of access to credit (less than 0.09303 sources), which made it possible to infer the category of farms that are commercially run, isolated and without credit, which represented 61.32% of the municipalities with a large proportion of organic farms.
- (ii) Greater external participation (over 31.96% of the farms) and greater diversity of assistance (over 0.60 sources), which made it possible to infer the category of farms that are commercially run, technically assisted and non-participatory, which represented 54.55% of the municipalities with a high proportion of organic farms.
- (iii) Greater diversity of assistance (more than 0.60 sources) and greater diversity of access to information (more than 1.60 sources), which made it possible to infer the category of farms that are commercially run, technically assisted and informed, which represented 55.87% of the municipalities with a high proportion of establishments engaged in organic farming.

Less external participation can hinder the adoption of a constructivist teaching and learning practice that encourages active inclusion of traditional, local and contemporary knowledge, as well as the development of autonomy. Predominantly horizontal pedagogies can ensure collective participation, horizontal learning, diverse discussions and joint creation of knowledge and dialogues on different knowledge sources (Mier y Terán and others, 2021). When a family is engaged in organic farming but does not participate in a cooperative or class entity, their learning from new experiences and from other families is limited. Otherwise, learning can occur more easily and have a multiplier effect (Mier y Terán and others, 2021).

While it was expected that agricultural credit would also be associated with a large proportion of properties reporting organic farming in a municipality, this was not detected in the results. Hasler and others (2017) note that credit can motivate the start of the process of transition to eco-innovation. However, the absence of credit as a driver of organic farming is also consistent with Aquino, Gazolla and Schneider (2021), who found that credit policies for Brazilian organic farming occupy a marginal place in the national credit programme, owing to problems in its regulatory design and the persistence of implementation obstacles.

Notwithstanding the arguments presented thus far, and the advantages of greater external participation and credit, it is impossible to claim that a lesser presence of these drivers means there are no municipalities with a high proportion of properties reporting organic farming, as shown by the municipalities included in the configuration “commercial purpose, less external participation and less access to credit”, characterized as farms that are commercially run, isolated and without credit and farms that are commercially run, technically assisted and non-participatory.

Technical assistance and access to information can facilitate the learning of simple and effective agroecological practices related to proper soil, water and invasive plant management, crop rotation and soil correction with organic matter. In the case of soil and plant management, knowledge of cultivation techniques such as crop rotation and mulching is necessary (Souza, Gomes and Gazzola, 2021; Mier y Terán and others, 2021).

Lastly, it is possible to associate some of the configurations found in the results with the characteristics of low-income farmers. Aquino, Gazolla and Schneider (2016) characterized this group of farmers through five types of asset: natural, physical, human, social and financial.

In relation to assets that are internal to the farm, Aquino, Gazolla and Schneider (2016) characterized low-income producers as those with less, or even, no land of their own (natural assets), of older age and low education levels (human assets). These characteristics are present in the two categories determined by combining the internal drivers, which jointly represent 49.31% of the municipalities

with a high proportion of organic farms, namely: (i) farms run by older men, with the participation of women and less land of their own; (ii) farms run by older men, with the participation of women and low education levels.

In relation to assets external to the farm, Aquino, Gazolla and Schneider (2016) characterized low-income farmers as those that lack technical support (human asset), have little social participation (social asset) and did not generate economic surpluses (financial asset).

The characteristic of low social participation was found in the category of farms that are commercially run, isolated and without credit (commercial purpose, less external participation and less diversity of access to credit). This is the most important category, since it represents 61.32% of the municipalities with a high proportion of organic farms.

The characteristic of low social participation was also found in the category of farms that are commercially run, technically assisted and non-participatory (commercial purpose, greater diversity of assistance, less external participation). This is the third most important category, representing 54.55% of the municipalities with a high proportion of organic farms.

Lastly, the characteristics related to assets external to the farm that Aquino, Gazolla and Schneider (2016) associate with low-income producers are not present in the category of farms that are commercially run, technically assisted and informed, represented by the following configuration: commercial purpose, greater diversity of assistance and greater diversity of access to information. This is the second most important category, representing 55.87% of the municipalities with a high proportion of organic farms.

VI. Final thoughts

The general objective of this research was to identify the combinations of drivers of agricultural eco-innovation that foster the adoption of organic farming. The results showed that no single driver can be defined as necessary; but combinations of internal and external drivers were found to be sufficiently explanatory of a high proportion of properties reporting organic farming in a municipality.

The two configurations of internal drivers that were identified involved municipalities with older farm operators, a lesser predominance of men and larger average farm size. These three characteristics were combined with a smaller proportion of farms with their own land in the municipality, or a lower level of education among the operators of these farms. The two configurations were characterized as: (i) farms run by older men, with the participation of women and less owned land; and (ii) farms run by older men, with the participation of women and low education levels.

The three configurations of external drivers encountered were characterized as: (i) commercial purpose, isolated and without credit facilities; (ii) commercial purpose, technically assisted and non-participatory and (iii) commercial purpose, technically assisted and informed.

Farms run by older men, with female participation and less owned land; farms run by older men, with female participation and low levels of education; farms that are commercially run, isolated and without credit; and farms that are commercially run, technically assisted and non-participatory have drivers associated with multiple productivity shortcomings, characteristic of poor farmers.

The study's main shortcoming was the fact that it was impossible to work with microdata — that is, data collected from the farms directly — owing to confidentiality agreements between IBGE and the respondents. Access to the microdata would have enabled direct inferences to be made about the farms. Given this constraint, aggregate data (averages) were used to represent the set of farms in each municipality. This may have restricted the diversity of the results, because the averages may conceal the diversity of farm characteristics. Nonetheless, it was possible to draw inferences on the drivers of organic farming in the Brazilian municipalities, even working with aggregate data.

It is also worth noting that organic farming is found to be associated with municipalities in which the average farm size is larger. No possible explanation for this result was found in the literature. Although a potential complementarity is inferred between larger and smaller properties, this explanation is recognized as insufficient. Accordingly, this is an issue that would merit future research.

For future studies, it would also be worth evaluating drivers not envisaged in the IBGE questionnaire that could improve understanding of the factors that might foster organic farming. These include expectations (Hasler and others, 2017), the perception of crises that challenge conventional systems, constructivist teaching and learning processes, the presence of a mobilizing discourse and favourable public policies, and political opportunities (Mier y Terán and others, 2021).

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Annex A1

Table A1.1
Drivers of Brazilian organic crop and livestock farming and corresponding questions

Identification code	Internal or external driver	Drivers	Questions from the 2017 agricultural census	Response options	Indicator calculation procedure	IBGE Automatic retrieval system (SIDRA) charts
AssocEnvExt	EXTERNAL	Participation in external groups or cooperatives	5.1 Is the farmer a member of a cooperative or class entity?	(1) No; (2) Yes. If yes: (3) Cooperative; (4) Class entity - trade union; (5) Producer associations or movements; (6) Resident associations	Option Yes (question 5.1)/ number of crop and livestock farms in the municipality	6846
Inform	EXTERNAL	Information	5.5 How does the farmer obtain technical information?	(1) Television; (2) Radio; (3) Internet; (4) Magazines; (5) Newspapers; (6) Non-governmental organizations (NGOs); (7) System S; (8) Other	Σ options 1–8 (question 5.5)/ number of farms in the municipality	6846
AcCred	EXTERNAL	Access to credit	38.4 From which agents did the farmer obtain financing or loans?	(1) Banks; (2) Credit unions; (3) Governments; (4) Commodity traders; (5) Suppliers; (6) Integrator firms; (7) Other financial institutions; (8) NGOs; (9) Family and friends; (10) Others	Σ options 1–10 (question 38.4)/ number of farms in the municipality	6895
FinalProd	EXTERNAL	Market access	2.14 What is the purpose of the farming?	(1) Consumption by the farmer and family; (2) Commercial sale, barter or exchange	Option 1 (question 2.14)/ number of farms in the municipality	6762
TerrasTam	INTERNAL	Farm size	1.18 What is the total area of the farm on the reference date?	0<0,1; 0,1<0,2; 0,2<0,5; 0,5<1; 1<2; 2<3; 3<4; 4<5; 5<10; 10<20; 20<50; 50<100; 100<200; 200<500; 500<1000; 1000<2500; 2500<10.000; x>10.000	Σ (class frequency X class mean)/number of farms	6906
Propr	INTERNAL	Land ownership	3.2 Own land area	(1) Total; (2) Owned; (3) Awarded; (4) Leased; (5) In partnership; (6) On loan (<i>comodato</i>); (7) Occupied	Option 2 (question 1.18)/ Option 1 (question 1.18)/ Option 2 (question 1.18)	6845
GEn	INTERNAL	Gender	2.4 Gender	(1) Male; (2) Female	Option 1 (question 2.4)/ Σ options 1 and 2	6779
Idade	INTERNAL	Age	2.5 Age	()	-	6779
Educ	INTERNAL	Education	2.8 What is the highest-level course the farmer has attended?	(1) Never attended school; (2) Basic literacy class (CA); (3) Youth and adult literacy (AJA); (4) Former primary education (elementary); (5) Former basic secondary education (lower secondary); (6) Regulated primary education or first grade; (7) Youth and adult education (EJA) of primary school or supplementary first grade; (8) Former scientific, classical or other baccalaureate (upper secondary); (9) Regular secondary education or second grade; (10) Secondary education or second grade technician; (11) Youth and adult education (YAE) of secondary education or supplementary second grade; (12) Higher education degree; (13) Master's degree or PhD	(A) Definition of the number of years studied at each school level investigated in question 2.8 (B) Determination of the number of farms in each response option for question 2.8 - AXB/ Σ B calculation	6779
QualSup	EXTERNAL	Quality of assistance	5.4 What is the origin of the technical assistance?	(1) Government; (2) Self or farmer; (3) Cooperative; (4) Integrator firm; (5) Private planning firm; (6) NGO; (7) System S; (8) Other	Σ options 1-8 (question 5.4)/ number of farms in the municipality	6846

Source: Prepared by the authors.

Annex A2

Calibration process

compute: PRODORG = calibrate(PropOrg,1,0.1,0)

compute: EDUC = calibrate(Educ,12.88,7.63,0.35)

compute: FINALPROD = calibrate(FinalProd,0.93272,0.5,0)

compute: ASSOCEVENTEXT = calibrate(AssocEnvExt,1.56552,0.31961,0)

compute: QUALSUP = calibrate(QualSup,6.0,0.6,0)

compute: TERRASPROP = calibrate(Propr,1;0.83,0.07)

compute: GEN = calibrate(GEn,1,0.84644,0.64679)

compute: IDADE = calibrate(Idade,60.5,54.34,27.57)

compute: INFORM = calibrate(Inform,8.93,1.60,0.36)

compute: ACCRED = calibrate(AcCred,0.48,0.09,0)

The shrinking State: exploring the links between public spending and class, race and gender vulnerability in Brazil¹

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Abstract

The objective of this article is to understand the class, race and gender profile of persons who would be most affected if the Brazilian State were to stop providing health and education services. The article begins with a review of class, race and gender inequalities in Brazil, and then examines the role of the State in that regard. The second section presents an analysis of public education and health expenditures through a discussion of the class, race and gender profiles of users and a simulation of the elimination of public health and education spending. The third section contains concluding remarks. The article proposes that the elimination of public services would plunge poorer, Black² and female populations (categories which often overlap) into severe financial hardship and negatively affect their well-being and could deepen poverty or lead to extreme poverty.

Keywords

Public expenditures, social security, social policy, health, education, equality, gender, social classes, ethnic and racial groups, poverty, Brazil

JEL classification

H4, N16, B54

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² Racial categories in Brazil are self-identified in official censuses and surveys. The options provided by the Brazilian Institute of Geography and Statistics (IBGE) for official statistics are: *preto* (black), *pardo* (literally brown, meaning mixed), *branco* (white), *Indigeno* (Indigenous), and *amarelo* (literally yellow, meaning of Asian descent). This article will focus on the categories of *branco* and on the additional concept of “*negros*” (which is translated in this article as English as “Black”, but is in fact a combination of the *preto* and *pardo* categories).

I. Introduction

As highlighted in González (2020) and Carneiro (2011), race and gender remain fundamental to the discussion of class issues. In Brazil, where the public provision of goods and services remains precarious and has been undergoing cuts since 2015, it is important to understand the involvement of the State in historic vulnerabilities.

This article highlights the issue by discussing the links between public spending (especially on education and health care) and vulnerabilities related to gender and race in Brazil. As in Silveira and others (2021), the 2017–2018 Household Budget Survey (*Pesquisa de Orçamentos Familiares*)³ is used to map the use of public services, which is found by these authors to lower the Gini coefficient in the country. The 2019 National Household Sample Survey (PNAD) and the 2019 National Health Survey (PNS) are also examined. Finally, as in Nassif-Pires, Cardoso and Oliveira (2021), the study reflects on the impact of public spending in Brazil on vulnerabilities related to class, race and gender, thus adding to the literature.

Seguino and Heintz (2012) argue that, in racially heterogeneous communities in the United States, the burden of vulnerability (in their paper, related to unemployment resulting from monetary policy tightening) weighs more heavily on the Black population than it does on women. In other words, race is a more important marker than gender for understanding poverty, inequality and vulnerability in racially heterogeneous communities. On the other hand, in more racially homogenous communities, inequality would be more closely tied to gender. We propose that the first case applies to Brazil and explore the thesis in this article.

The article begins with a review of class, race and gender inequalities in Brazil and then reviews the role of the State as it relates to those inequalities. The second section presents an analysis of public education and health expenditure — discussing the class, race and gender profiles of users— and a simulation of the elimination of public health and education spending. The third section contains the conclusions of the study.

The article proposes that public service cuts would plunge poorer, Black and female populations (categories which very commonly overlap) into severe financial hardship and worsen their well-being and could deepen poverty or lead to extreme poverty. It highlights that when public spending is curtailed, because of financial constraints, families will not necessarily resort to market substitutes for those services or will find precarious substitutes. Therefore, the real effect of such cuts is not only worse budgetary conditions (as estimated in this study) but also denial of the opportunity to obtain health care and education altogether.

II. Class, race and gender inequalities in Brazil and the role of the State

Brazil has a long history of various types of inequality, but especially regarding race, gender and class. With regard to race, Brazil is a country that has been profoundly shaped by slavery.⁴ Over the 388 years of the slavery regime, 5.1 million Africans arrived in the country (Slave Voyages, 2022).

³ See [online] <https://www.ibge.gov.br/estatisticas/sociais/saude/24786-pesquisa-de-orcamentos-familiares-2.html>.

⁴ In Brazil, sexual assaults were historically perpetrated by white men against Black and Indigenous women. This, according to Carneiro (2011), was the “glue” for all gender and race hierarchies, while the role of Black women in shaping national culture has been denied. The concept of *Americanidade*, a blend of “American” and “African” identity, is used by González (1988) to highlight the impact of the Black population in shaping all of Latin American culture. González (1988) argues that this heritage was rendered invisible and classified as “popular culture” or “national folklore”. She argues that this denial of the Black roots of the country explains how racism turns against those who are the living testimony of this impact: the Black population. Even today, Black women are objectified and undervalued by the white women for whom they labour as domestic workers, or are eroticized (Carneiro, 1995).

With regard to gender, the patriarchy, which was established through colonization, is another pillar of Brazilian society, whereby power is concentrated in the hands of white men,⁵ and women's and girls' physical and economic autonomy and decision-making is limited (Matos de Oliveira and Fares, 2021; ECLAC, 2021). Lastly, with regard to class,⁶ the concentration of power and wealth in the hands of the few is related to racial, gender and regional issues, and also dates back to the colonial model adopted in Brazil (González, 2020; Carneiro, 2011).

As the country is structured around the aforementioned inequalities and few reforms have been enacted that use all available instruments to tackle them, inequality in Brazil remains high and power remains concentrated in the hands of upper-class white men. As an example, according to the Gender Equality Observatory for Latin America and the Caribbean, only 15.2% of seats in the national parliament are held by women (ECLAC, 2022a), and although Black persons make up 55.9% of the population (IBGE, 2022b), they hold only 17.8% of parliamentary seats (O Globo, 2019). Women, Indigenous persons, LGBTQI+ persons and young Black persons are targeted by violence (perpetrated both by the State and by individuals and encouraged by systemic inequalities). The proportion of women and girls aged 15–49 who have suffered physical or sexual violence at the hands of their current or former partner in the 12 months preceding the study is 6.5% (ECLAC, 2022b). In 2019, the homicide rate for Black men was 56.19 per 100,000, while the rate for other men was 20.85 per 100,000 (IPEA, 2022). More recently, Moïse Kabagambe, a Black immigrant, was beaten to death for demanding his wage, which exemplifies how intersectionality is important in analysing vulnerabilities in Brazil. According to the National Association of Transvestites and Transsexuals of Brazil (ANTRA, 2022), Brazil has been the country with the highest murder rate in the world for transsexual persons for 13 years.

Lastly, the intersection of race, gender and class places women and the Black population in the lower echelons of society in terms of class, and they face restricted access to social rights, lower income, and higher unemployment and informality rates. According to the Brazilian Institute of Geography and Statistics (IBGE, 2022a), in 2020, the female unemployment rate was 16.5% and that of men was 11.7%; the Black rate was 15.9% and the white rate was 11.1%; and 44.7% of Black workers were in informal employment, while the rate for white workers was 31.8%.⁷

Disguised as a “racial democracy” (González, 1984; Carneiro, 1995), Brazil is characterized by sexual and racial division of labour. This delegates both paid and unpaid domestic and care work to women. Domestic workers (mostly Black women) are underpaid and undervalued, and yet they are a structural feature of society: they were only recognized as workers in 2013 and obtained partial labour rights with the approval of Constitutional Amendment No. 72 of 2013 (Government of Brazil, 2013).

⁵ In economies of colonial origin, the role of master attributed to white men shaped, by opposition, the roles of Black men and women and of white women. Using biological criteria to justify making others feel inferior and subjugating them on the basis of race and sex made slavery “acceptable” and made women (white) servants of the men whose “property” they were (either their fathers or husbands). In addition, the characteristics attributed to white women (purity, fragility and therefore lack of aptitude for productive work) antagonizes the role imposed on Black women (promiscuity and brutality, suitable for heavy work, whether productive, domestic or sexual) (Saffioti, 2013). Therefore, the sexual division of labour established has historically determined that men focus on the productive sphere and white women on the reproductive sphere. Black women were responsible for productive and reproductive work, very often performing reproductive work for pay for a white family and then performing the domestic work of their own families as well. In this manner, the system skilfully devalues both the productive work of women, since it is not their main job, and their reproductive work, since it is done for “natural reasons” and “out of love” (Saffioti, 2013).

⁶ Although class is discussed as a category in this article, our analysis will focus solely on income. For a deeper analysis of class, see Mills (1951), Bourdieu and Passeron (2013), Saffioti (2013), Hirata (2014), Engels (1995) and Pochmann (2015).

⁷ González (1979) argues that it is not a “coincidence” that most Black Brazilians are marginalized by unemployment, informality and vulnerability (González, 1979). Like the female workforce, the Black workforce functions as a “buffer” that is activated and deactivated according to the economic cycle. The author argues that racial privilege is an important characteristic of Brazilian society, benefiting not only white capitalism but also the poor white population, because when Black persons are competing for a position with material or symbolic rewards, even if they possess the same skills, the results always favour white competitors. In a pluricultural, multiracial and racist society such as Brazil, racism has a considerable impact on gender relations and hierarchies. In this regard, the poverty to which Black persons in Brazil remain condemned to this day is part of the racist strategy of naturalizing social inferiority (Carneiro, 2005).

Throughout history, the Brazilian State has influenced (and been influenced by) these inequalities. Changes in the political system have always been controlled by the ruling forces, thus controlling popular aspirations and blocking opportunities for social reform to reduce inequalities. As income, wealth and power are very concentrated, revolutionary initiatives have always been torn down by conservative forces (Pochmann, 2015, p. 34). More recently, the transition from the military dictatorship to democracy that lasted from 1964 to 1985 was negotiated and controlled by the armed forces themselves. However, following this process and eluding the aforementioned control, Brazil adopted a new Federal Constitution in 1988, which was nicknamed the “citizen Constitution” owing to its avant-garde enshrinement of rights in Brazil, especially the right to health and education. The 1988 Federal Constitution is considered an outlier in Brazilian history (Fagnani, 2017), as it seeks to reduce inequalities. Its third article reads as follows (Government of Brazil, 2023):

Article 3. The fundamental objectives of the Federative Republic of Brazil are:

I - to build a free, just and solidary society

II - to guarantee national development

III - to eradicate poverty and substandard living conditions and to reduce social and regional inequalities

IV - to promote the well-being of all, without prejudice as to origin, race, sex, colour, age and any other forms of discrimination

Regarding Brazil’s health-care system, after pressure from the health movement in the 1980s, a Unified Health Care System (*Sistema Único de Saúde - SUS*) was established in the 1988 Federal Constitution. This public system is not connected to employment or social assistance status and is thus available to everyone on Brazilian soil regardless of their contributory status. The system is decentralized and responsibility for it is split between the federal union, the states and Federal District,⁸ and the municipalities. However, Brazil’s private health-care system is also very expansive: 48.4 million Brazilians (22.7% of the total population) had access to it⁹ in 2021 (ANS, 2021), and in 2019, domestic private health spending accounted for 59.1% of total current health expenditure in Brazil (World Bank, 2022).

With regard to education, the 1988 Federal Constitution is the first Brazilian constitution to define education as a right. It provides for the prioritization of certain educational levels among the federative entities (the union, the states and the Federal District, and the municipalities). According to article 211, the union manages the federal education system, finances federal public education institutions (mainly focused on higher education) and exerts a redistributive and supplementary function to ensure equalization of educational opportunities through technical and financial assistance to the states, the Federal District and the municipalities. The states and the Federal District focus mainly on primary and secondary education and the municipalities focus mainly on primary and early childhood education. Such a division is also consistent with the constitutionally mandated minimum spending for each of the entities (a fixed percentage of their budget). According to the National Institute of Educational Studies and Research (INEP, 2022), in 2021, 82.57% of students in primary and secondary school were enrolled in public institutions (0.81% in federal institutions, 32.18% in State institutions and 49.57% in municipal institutions), while 17.43% of students at the same levels were studying in private institutions.

Although reducing inequalities is a fundamental objective of the Constitution, the State has not used all the available tools to counter them. For example, the literature shows that although the Brazilian State can reduce inequality by spending on public health and education (Silveira and others, 2021),

⁸ Brazil has 26 states and the Federal District, where the capital is located.

⁹ This does not mean that they are not also users of the Unified Health Care System, as it provides health monitoring, medication, vaccines, and high-complexity procedures such as transplants, for example, including for those covered by health insurance.

the taxation system is highly unequal (Fagnani, 2018), which allows inequalities to persist. This article focuses on the impacts of public spending (mainly on education and health care) on social inclusion, leaving the issue of taxation for future research.

More recently, the retrenchment of social policies and adoption of austerity (Dweck, Rossi and Oliveira, 2020)¹⁰ have also weakened the State's redistributive capacity.¹¹ The simulation in this paper is therefore merely an extreme case of the same. Matos de Oliveira and Alloatti (2022) argue that most of the burden of cuts to social spending in Brazil has been borne by women and the Black population, generally those in the lower classes and users of public services. First of all, because the sectors most affected by cuts, such as health and education, are dominated by female workers,¹² these cuts lead to job losses and to a decline in women's labour market participation. Second, retrenchment affects work-life balance, as it reduces the scope for "defamiliarization", which is to say reducing the burden for families of providing these services without pay (Guerrina, 2015; Tepe-Belfrage and Steans, 2016; Gálvez and Rodríguez-Modroño, 2016; Périver, 2018; Power and Hall, 2018). The cuts include a reduced budget for policies that support social reproduction, such as day-care centres, and the curtailment of policies to combat gender-based violence and guarantee women's economic autonomy. Third, the regression of welfare states, through a contraction of social rights and public policies aimed at reducing gender inequalities, worsens conditions for the most underprivileged women (including Black women), risking an increase in the feminization of poverty (Martínez, Dueñas and Meireles, 2020). Underfunding of social policies leads to the entrenchment of temporary solutions, which produces a protracted emergency (Grotti and others, 2019; Thomson, Niedzwiedz and Katikireddi, 2018). Lastly, gender equality and women's rights are directly jeopardized when support for bodies that promote equality is reduced through budget cuts.

Following this overview of gender, race and class inequalities in Brazil and the impacts of cuts on their reproduction, the next section contains an analysis of the gender, class and race profiles of users of public services.

III. Analysis of education and health user profiles and simulations

This section presents an analysis of public expenditure on education, health and pension systems, using the 2019 Continuous National Household Sample Survey (PNAD Continua) to map the profile of education users in Brazil and the 2019 National Health Survey to map the profile of health service users. Figure 1 shows the share of the population that uses education services, both public and private, by per capita household income. The use rates for education services are higher in the lower income strata, although the rates of use are still significant in the sixteenth to twentieth ventiles (also known as vigintiles), where an average of 19.5% of people use education services. The thirteenth ventile, an outlier in which the income level is concentrated around the minimum wage, corresponds to retirees.¹³

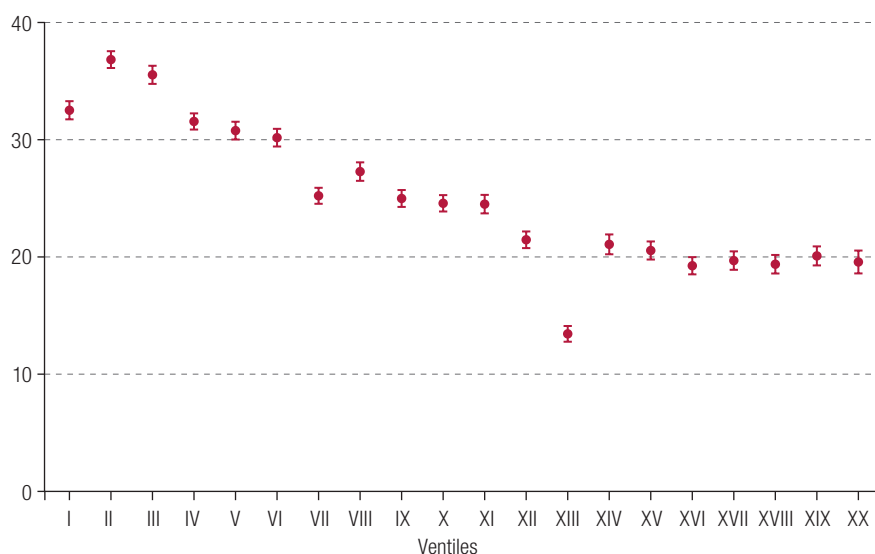
¹⁰ Since 2015, Brazil has shifted its fiscal policy towards what is defined in the literature as austerity (Blyth, 2013). This policy was constitutionalized through Constitutional Amendment No. 95 of 2016. For more information, see Dweck, Rossi and Oliveira (2020) and Matos de Oliveira and Alloatti (2022).

¹¹ Reducing the role of the State in this way is also a public policy choice, and it can occur at the same time as growing authoritarianism, as exemplified by Pinochet in Chile (Hyman, 2001).

¹² With regard to education, see Matos de Oliveira (2022).

¹³ In Brazil, most pensioners receive the monthly minimum wage as a pension.

Figure 1
Brazil: education users, by per capita household income ventile, 2019
(Percentages)

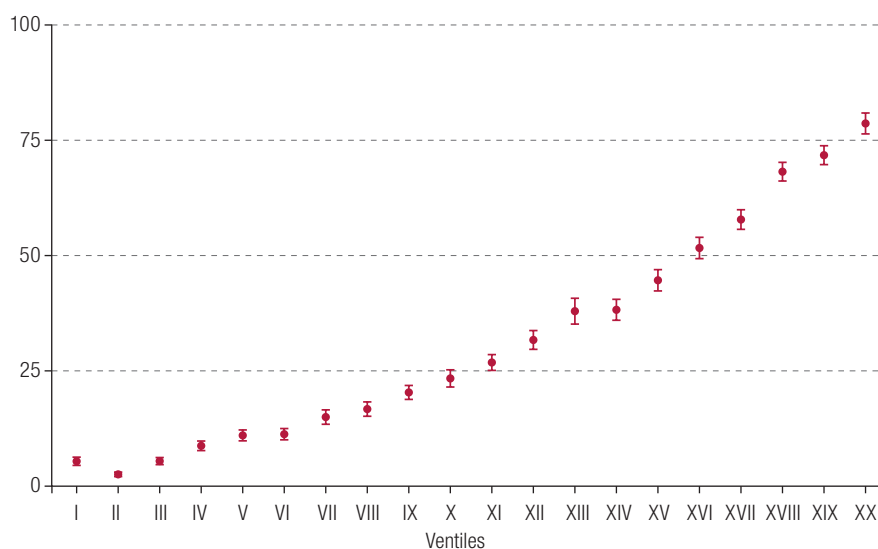


Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Continuous National Household Survey (PNAD Continua), 2019.

Note: 95% confidence interval.

Figure 2, which includes only declared users of education services, shows the share who use private education services, by income ventile. As expected, a higher proportion of those in higher income ventiles use private services: in the first ventile, the figure is 5.3%; in the last ventile, it is 78.6%. This means that 94.7% of those in the first ventile use public education services, compared with 21.4% in the last ventile.

Figure 2
Brazil: users of private education, by per capita household income ventile, 2019
(Percentages)



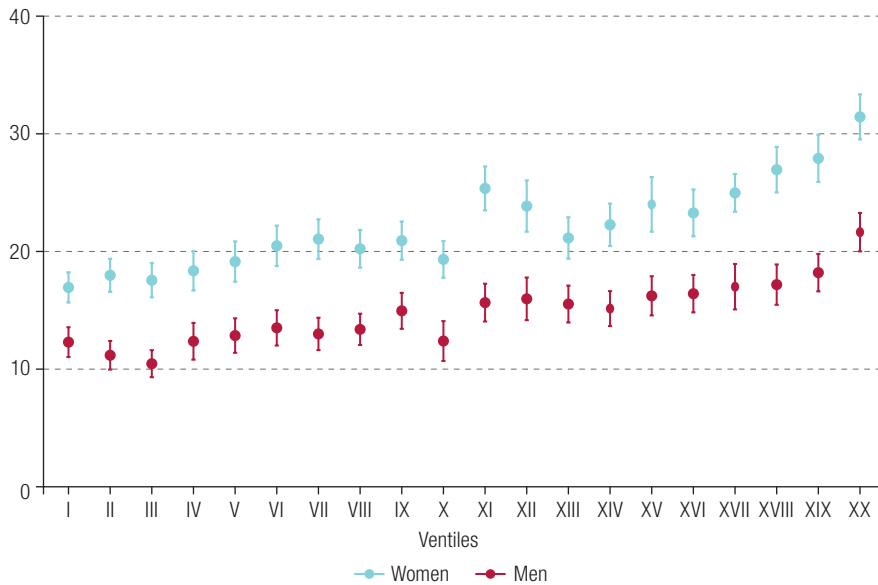
Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Continuous National Household Survey (PNAD Continua), 2019.

Note: 95% confidence interval.

Figures 1 and 2 therefore show that lower-income populations in Brazil are more dependent on public education services and are more vulnerable to service cuts.

Turning to health services, figure 3 shows the share of the population that sought health-care services in the two weeks prior to the survey, by per capita household income and sex. The data show that women were more frequent users of health-care services in all income ventiles, but also that the higher people's income, the more they sought health-care services.

Figure 3
Brazil: health-care users in the two weeks prior to the survey,
by per capita household income and sex,^a 2019
(Percentages)



Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), National Health Survey (PNS), 2019.

Note: 95% confidence interval.

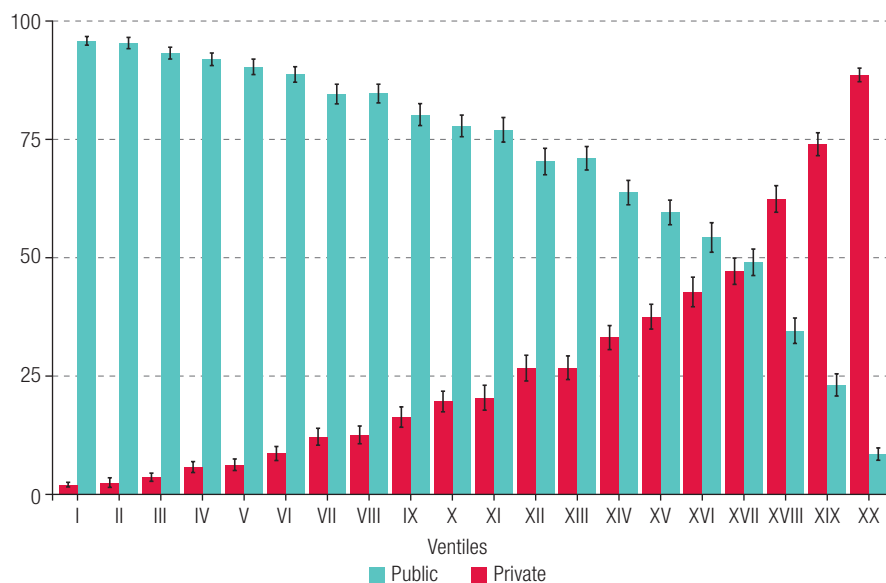
^a Refers to the sex of the user, not to the sex of a parent or guardian of a person (such as a minor) who accesses health care.

Figure 4 shows that the lower an individual's income, the more likely they are to access public health services. Only at ventile 18 does access to private health services become more prevalent.

Methodologically, the use of health and education services is calculated by individual, but per capita household spending is used to calculate the cost of services. The reason is that spending takes place within a consumption unit (a family or a household). For example, although children do not contribute to education spending, they are the most likely to use those services.

Figure 5 summarizes the distribution of per capita monthly household health-care spending for private health-care users. The median amount spent on health care is 130.43 reais (equivalent to US\$ 25.31 on 19 June 2022).

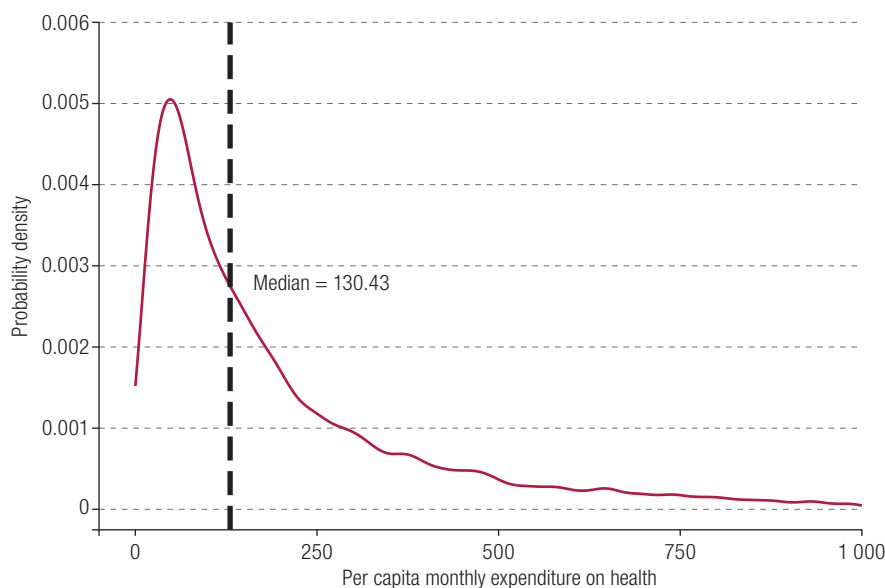
Figure 4
Brazil: public and private health care use, by per capita household income, 2019
(Percentages)



Source: Prepared by the authors on the basis Brazilian Institute of Geography and Statistics (IBGE), National Health Survey (PNS), 2019.

Note: 95% confidence interval.

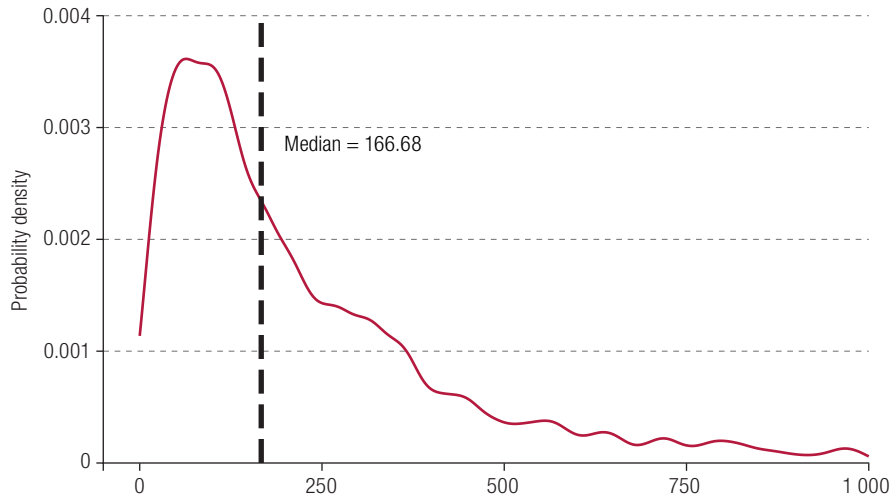
Figure 5
Brazil: distribution of per capita monthly household health-care spending
for users of private health care, 2017–2018
(Probability density and reais)



Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Household budget survey (2017–2018), Rio de Janeiro.

With respect to education, figure 6 shows the distribution of per capita monthly household spending on education services. The median amount spent is 166.68 reais (US\$ 32.34 as of June 19, 2022).

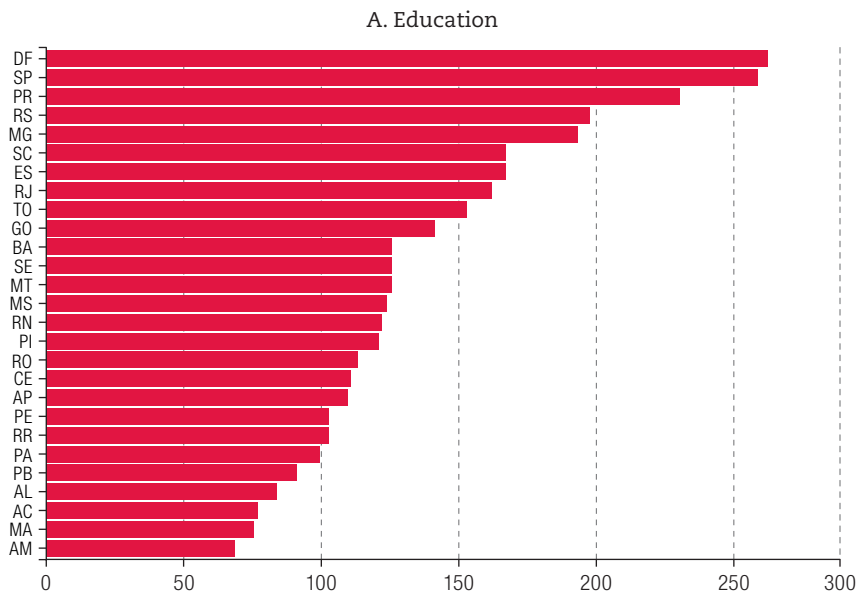
Figure 6
Brazil: distribution of per capita monthly household education spending
for users of private education, 2017–2018
(Probability density and reais)



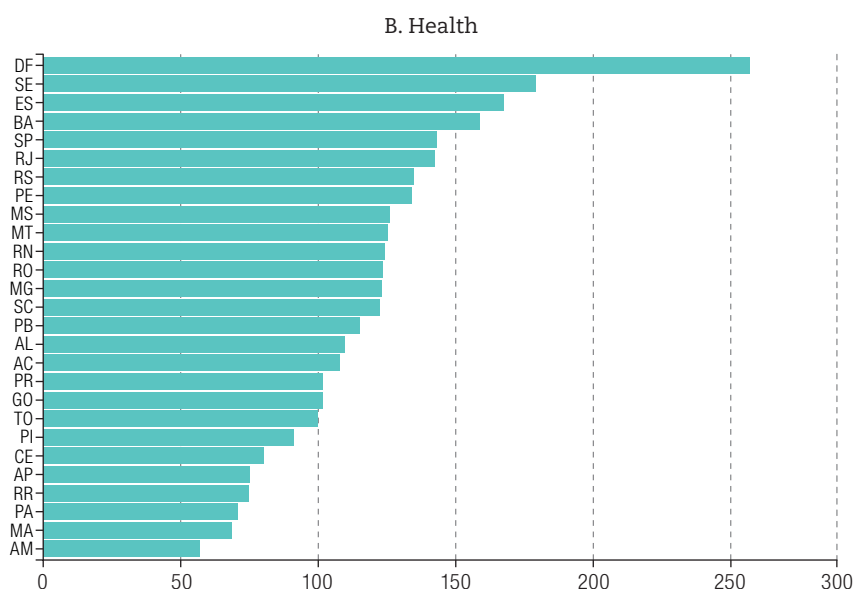
Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Household budget survey (2017–2018), Rio de Janeiro.

However, to illustrate how different the realities are across the country, figure 7 shows how median health and education spending varies by state and in the Federal District.¹⁴ For example, the median disbursement required in the Federal District to access private health care and education is much higher than in the State of Amazonas.

Figure 7
Brazil: median per capita monthly household spending on private health
and education services, by state and in the Federal District, 2017–2018
(Reais)



¹⁴ The Brazilian Institute of Geography and Statistics (IBGE) has divided the country into regions on the basis of the socioeconomic and physical characteristics of its states. The five regions are north (Acre, Amazonas, Amapá, Pará, Rondônia, Roraima and Tocantins), northeast (Alagoas, Bahia, Ceará, Maranhão, Piauí, Pernambuco, Paraíba, Rio Grande do Norte and Sergipe), midwest (Goiás, Mato Grosso do Sul, Mato Grosso and Distrito Federal), southeast (Sao Paulo, Rio de Janeiro, Minas Gerais and Espírito Santo) and south (Paraná, Rio Grande do Sul and Santa Catarina). The human development index is higher in the south and southeast.

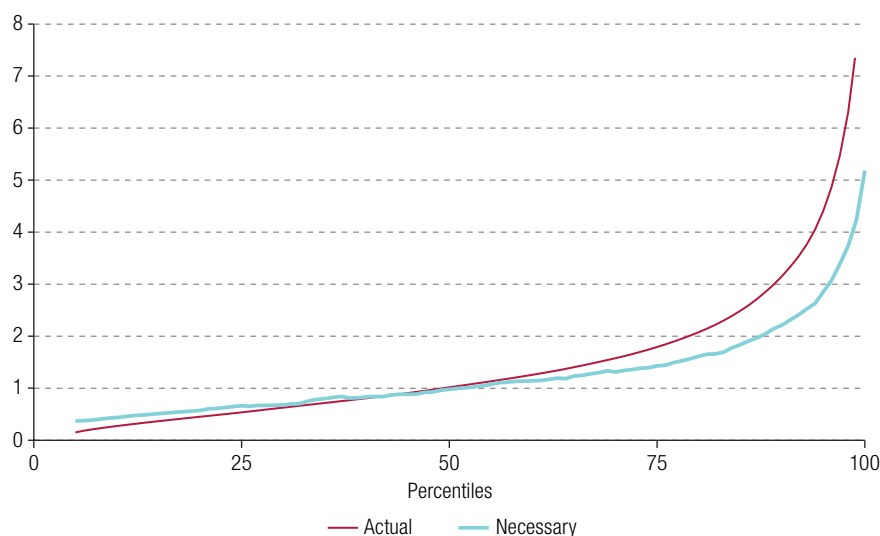


Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Household budget survey (2017–2018), Rio de Janeiro.

Note: AC: Acre; AL: Alagoas; AM: Amazonas; AP: Amapá; BA: Bahia; CE: Ceará; DF: Distrito Federal; ES: Espírito Santo; GO: Goiás; MA: Maranhão; MG: Minas Gerais; MS: Mato Grosso do Sul; MT: Mato Grosso; PA: Pará; PB: Paraíba; PE: Pernambuco; PI: Piauí; PR: Paraná; RJ: Rio de Janeiro; RN: Rio Grande do Norte; RO: Rondônia; RR: Roraima; RS: Rio Grande do Sul; SC: Santa Catarina; SE: Sergipe; SP: São Paulo; TO: Tocantins.

Turning to the effects of hypothetical public service spending cuts, figure 8 represents estimated household budget needs compared with the budget effectively available. This shows how stretched household budgets already are, even though lower-income households have access to public health and education services. Households below the thirty-eighth income percentile report that their actual income is not sufficient for their needs. Individuals whose budget does not meet their needs would be in a very vulnerable situation if public health and education spending were cut, either fully or partially.

Figure 8
Brazil: minimum necessary monthly household budget and actual household budget,
by per capita household income percentile, 2017–2018
(Thousands of reais)



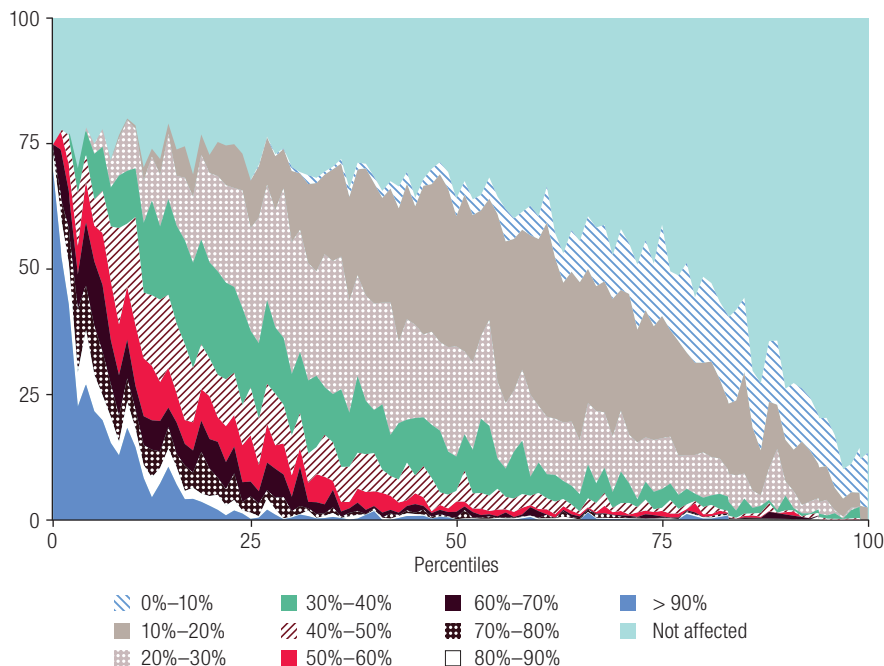
Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Household budget survey (2017–2018), Rio de Janeiro.

However, it is not only those below the necessary threshold who would be vulnerable: figure 9 shows the additional household spending that would be needed to pay for private health and education services. It is important to highlight that this exercise considers what would happen if households were to take over health-care and education costs, paying the median amount in figure 7 for users of private services. In short, the regional amounts calculated in figure 7 are used to simulate the amount that would be needed to pay directly for health and education services if the State ceased to do so. Using the regional median instead of the average median allows for a deeper understanding of the picture, as poverty and vulnerability levels vary greatly from state to state within Brazil, as does median spending on services (which is usually higher in states with a higher human development index). However, owing to financial constraints, households might be forced to opt out of a health or education service or find more precarious solutions, and might not incur the entire additional expense calculated.

That said, figure 9 demonstrates that, for 65.83% of those in the first percentile, if public health and education ceased to exist, spending would increase by at least 90% of their current income, and that for 66.2% of those up to the tenth income percentile (the first decile), public health and education service cuts would trigger at least a 50% increase in spending relative to their current income. The burden of shouldering the costs currently incurred by society through the State would be too great, and households would most likely not be able to afford the services or would be forced to resort to more precarious alternatives. The grey section represents survey participants who did not report having used public health and education services in the week before the data were collected.

Figure 9

Brazil: projected additional spending on private education and health care in the absence of State funding, as a share of income, by per capita household income percentile, 2017–2018
(Percentages)



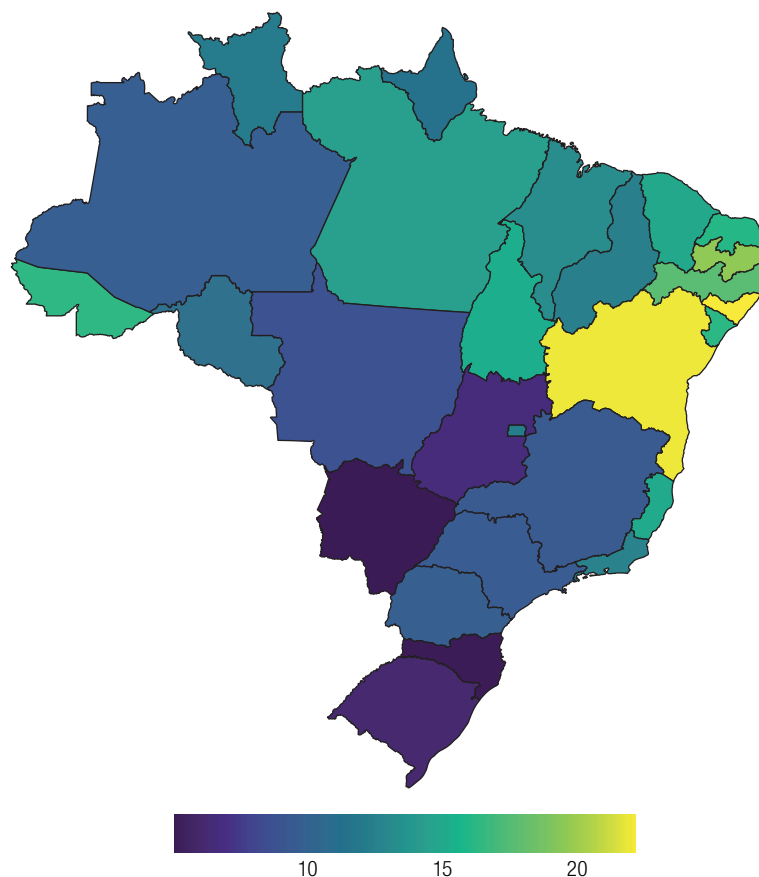
Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Household budget survey (2017–2018), Rio de Janeiro.

Map 1 shows the regional impact of this scenario. As the north-east has a higher incidence of poverty and vulnerability, more of the population would be affected (defined as people for whom spending would increase by more than 50% of their current income). For example, 23.5% of the population of

Alagoas and 22.1% of the population of Bahia would be affected. However, in the Federal District and Espírito Santo, which are located in the mid-west and south-east respectively and where median spending on private services is higher, 15.3% and 15.1% of the population would be affected.

Map 1

Brazil: population affected by a hypothetical retrenchment, by state, 2017–2018
(Percentages)



Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Household budget survey (2017–2018), Rio de Janeiro.

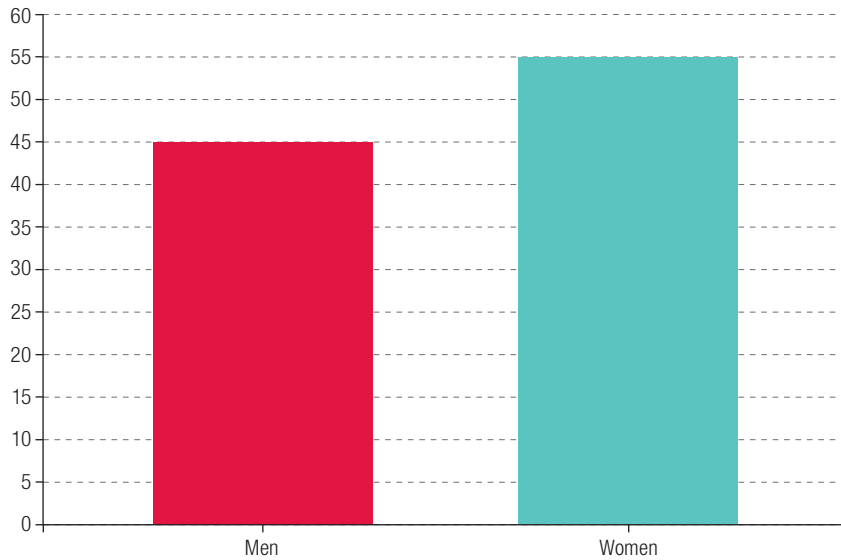
Note: Affected population is defined as people whose spending would increase by more than 50% of their current income.

Finally, figure 10 depicts how gender inequalities would increase if health and education services were cut: the number of women who would have to incur an increase in spending of more than 50% of their income is higher (women account for 55.3% of the affected population but only 51.6% of the total population).

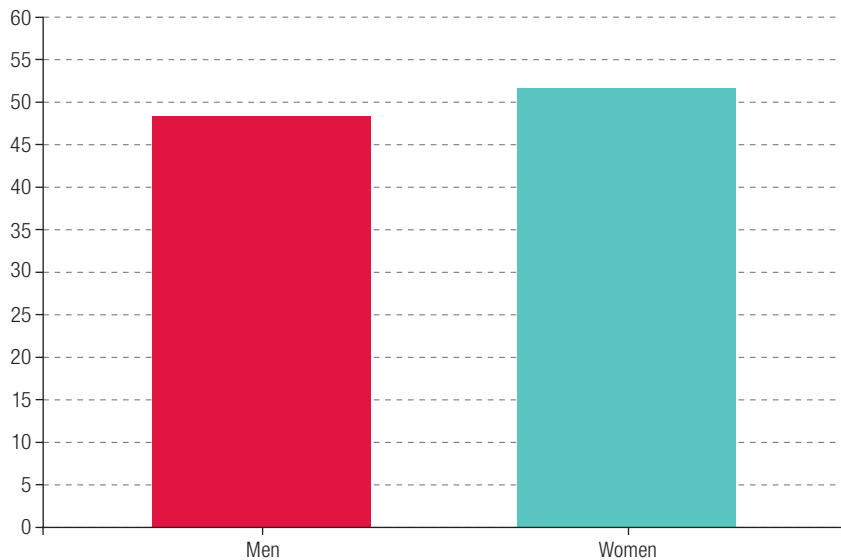
In terms of race, figure 11 illustrates how racial inequalities in Brazil would increase if health and education services were cut: the proportion of Black persons who would have to incur an increase in spending of more than 50% of their income is higher (they account for 66.2% of the affected population but only 54.6% of the total population).

Figure 10
Brazil: population affected by a hypothetical retrenchment and total population,
by sex, 2017–2018
(Percentages)

A. Affected



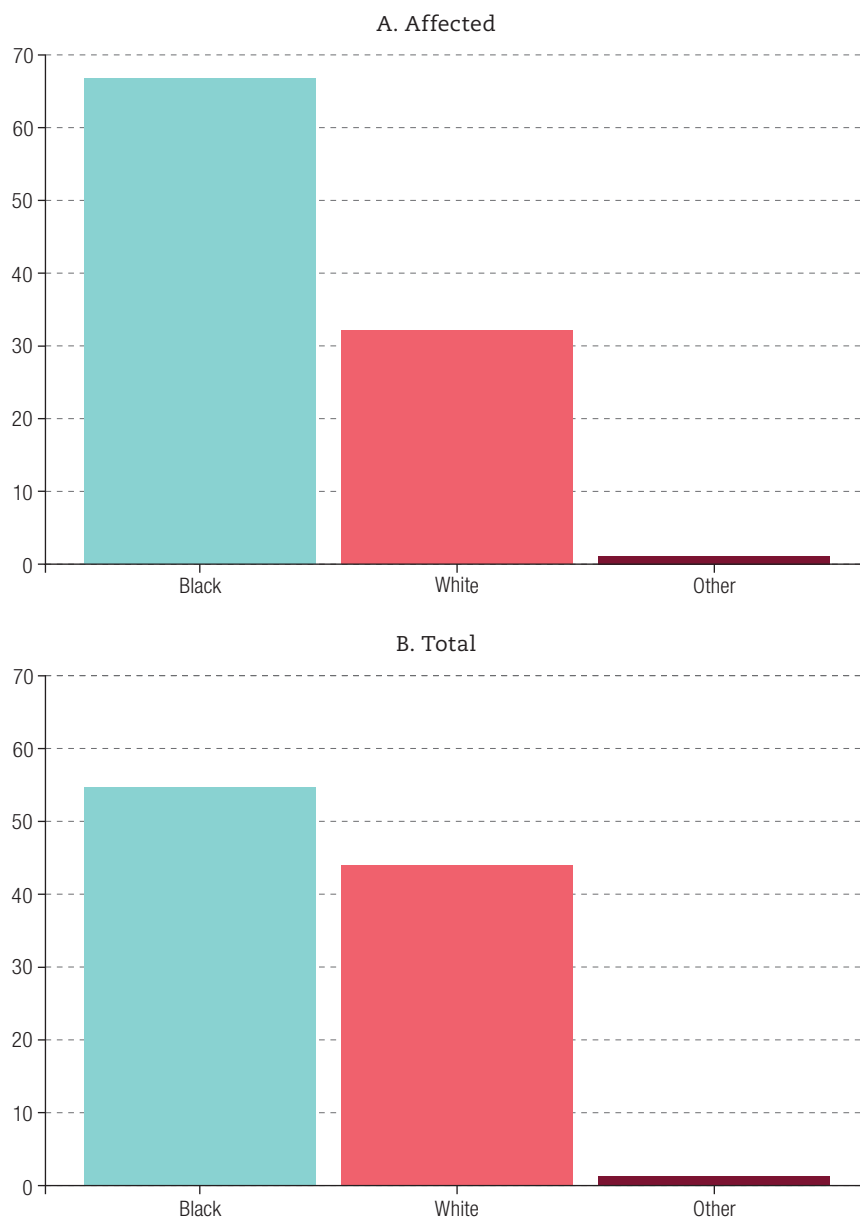
B. Total



Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Household budget survey (2017–2018), Rio de Janeiro.

Note: The affected population is defined as people whose spending would increase by more than 50% compared with their current income.

Figure 11
Brazil: population affected by a hypothetical retrenchment and total population, by race, 2017–2018
(Percentages)



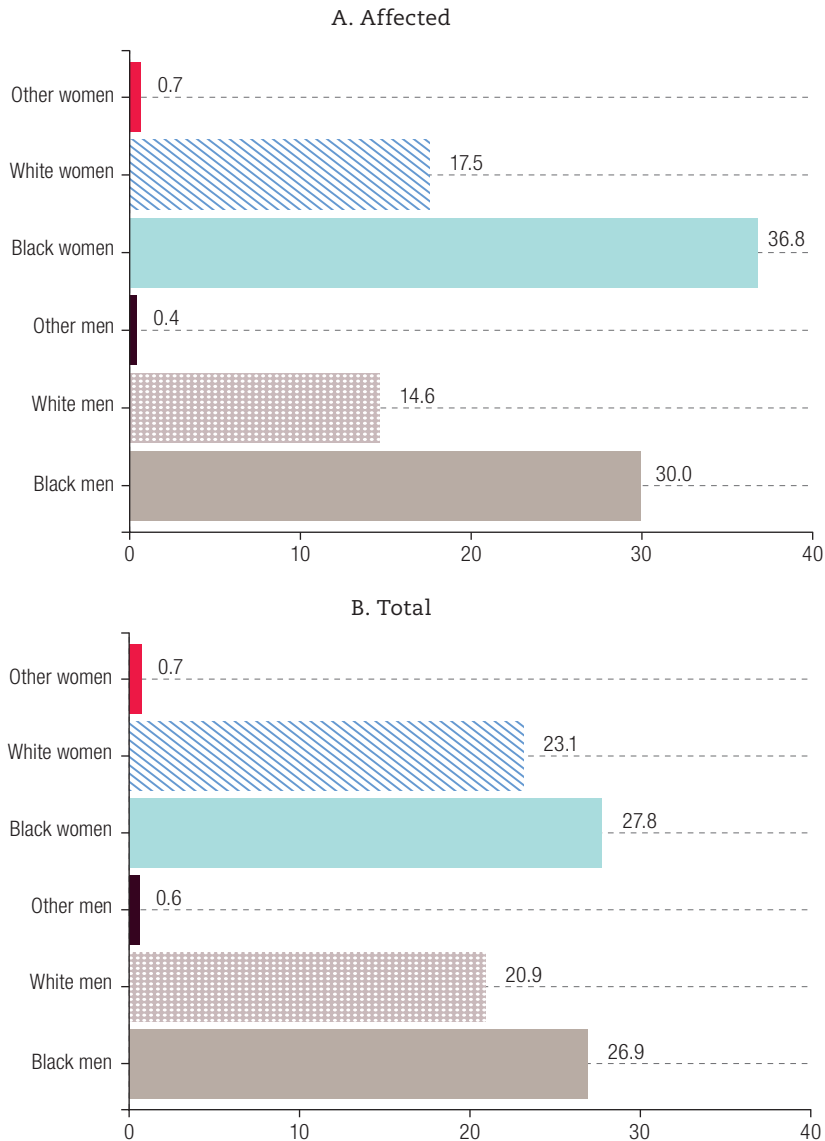
Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Household budget survey (2017–2018), Rio de Janeiro.

Note: The affected population is defined as people whose spending would increase by more than 50% compared with their current income.

Figures 10 and 11 highlight the burden that would be borne by women and the Black population if public spending were curtailed. At the intersection of these two groups is another group —Black women— that would be even more vulnerable. It is therefore impossible to dissociate vulnerability analysis (even in hypothetical terms, as done in this exercise, as the monetary impact of social spending cuts is difficult to grasp) from analysis of gender and racial inequalities in Brazil. For Brazil, a racially heterogeneous country (Seguino and Heintz, 2012), race can be an even stronger marker of poverty, inequality and vulnerability than gender, as highlighted by figures 10 and 11.

Using an intersectional approach, figure 12 highlights how Black women are especially prevalent in the affected group (35.8%), at a far higher rate than in the total population (27.6%). Black men are also overrepresented in the affected group compared with the total population.

Figure 12
Brazil: population affected by a hypothetical retrenchment and total population,
by race and sex, 2017–2018
(Percentages)



Source: Prepared by the authors on the basis of Brazilian Institute of Geography and Statistics (IBGE), Household budget survey (2017–2018), Rio de Janeiro.

Note: The affected population is defined as people whose spending would increase by more than 50% compared with their current income.

The data used for this article refer to a time before the coronavirus disease (COVID-19) pandemic. Further studies will be conducted once databases have been updated, in order to understand the impacts of the pandemic on poverty, inequality and vulnerability in relation to gender and race and the role of the public sector (Matos de Oliveira and Alloatti, 2022).

IV. Conclusions

Brazil has a long history of various types of inequality, but especially with regard to race, gender and class, which have been perpetuated and strengthened over time. In this regard, the 1988 Federal Constitution is considered an outlier in Brazilian history, as it seeks to reduce inequalities (for example, by guaranteeing access to public health and education). However, the possibility of further cuts to health and education services is always present, and even more so since 2015. This exercise, although extreme in that it posits the elimination of such expenditure, helps us to understand the class, gender and racial outcomes of such an action.

As previously argued, although the Constitution stipulates that reducing inequalities is a fundamental objective, the State has not used all the available tools to counter it (such as progressive tax reform), and more recently, social policy regression and the “shrinking” of the State have also greatly affected people who cannot afford to pay for private services.

Following the COVID-19 pandemic, the issue is even more pressing: first, owing to the increased vulnerability of the Brazilian population resulting from the socioeconomic repercussions of the pandemic; second, because the pandemic has highlighted the importance of public provision of health and education services and of prompting State coordination in times of crisis. With updated information, the exercise conducted in this study can be repeated to confirm whether the population has become even more vulnerable following this major watershed event.

The data show that for those in lower income brackets, household budgets are already overstretched (and were even before the pandemic). When public expenditure is curtailed, financial constraints mean that families do not necessarily resort to market substitutes or that they find precarious substitutes for services. Nonetheless, there is a class, gender, racial and regional component to the monetary impact of the hypothetical elimination of public health and education services, as persons living in poverty, women and the Black population are historically more vulnerable and are more dependent on public provision of goods, especially populations in the northeast of the country. The elimination of public services for this population would represent a significant blow to already overstretched household budgets, as figure 8 illustrates, possibly leading to an increase in monetary poverty, to be measured in future studies. The data discussed in this article show that women experience extreme impacts as “recipients” of public policy. Another issue of interest, however, is that women as “producers” of public policy (because they comprise the majority of the health and education workforce) would also be affected. Neither of these effects can be disregarded when discussing the public budget and the importance of social provisions for tackling historical inequalities.

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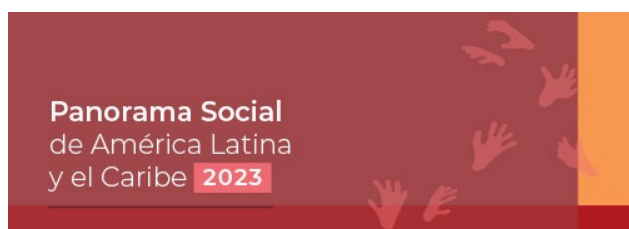
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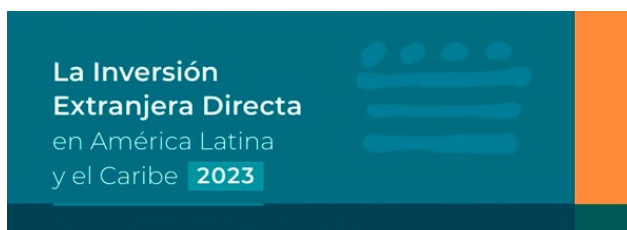
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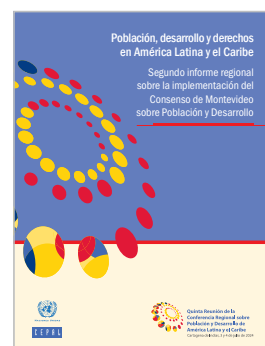
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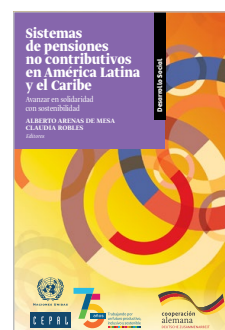


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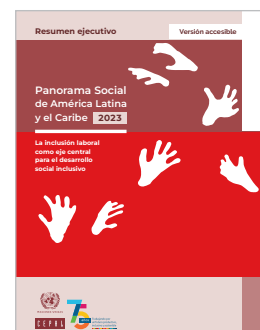
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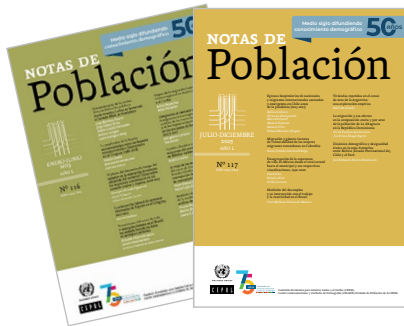
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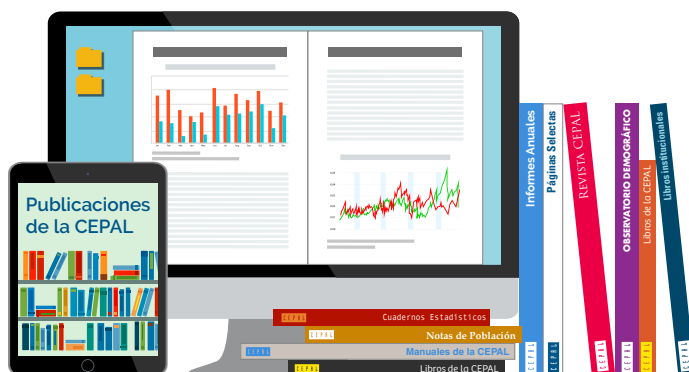


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