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Esta nueva edición especial de Ensayos Económicos expone los cinco trabajos presentados en el Workshop "Modelos macroeconómicos para economías pequeñas y abiertas" organizado por el BCRA, los días 20 y 21 de mayo de 2021.

Celebramos dicho evento bajo el convencimiento de que no existe un único modelo, universalmente válido, y partiendo de la premisa de que el debate académico debe celebrar la amplitud teórica y metodológica. Contar con una pluralidad de enfoques enriquece el análisis y las recomendaciones de política, al permitir robustecer, contrastar y contextualizar los resultados de las proyecciones y pronósticos que cotidianamente realizan los Bancos Centrales. Y bien pueden complementar el uso de estadísticas y pronósticos de alta frecuencia, especialmente en un contexto cambiante como el actual, marcado por los efectos de la pandemia de COVID-19.

Bajo esta premisa, encontrarán en esta edición especial artículos pertenecientes a diversos enfoques teóricos: una formalización de tipo súper-multiplicador, un modelo de equilibrio general dinámico y estocástico (DSGE, por sus siglas en inglés), un modelo de inspiración kaldoriana restringido por balance de pagos, uno de economía dual con heterogeneidad estructural y, finalmente, un modelo stock flujo consistente (SFC).

En el primer trabajo, Fabio Freitas, Esther Dweck y Fernando Ligiéro, de la Universidad de Río de Janeiro, examinan cómo la composición de la demanda autónoma influye en los efectos de la política fiscal sobre el desempeño de la economía. Sobre la base de un modelo de supermultiplicador aplicado a una economía pequeña y abierta, analizan la trayectoria diferencial de dos economías caracterizadas por parámetros estructurales alternativos, una con una participación elevada del gasto público en la demanda autónoma total y otra con una mayor participación de las exportaciones, pero cuyos gobiernos siguen la misma regla de política fiscal. El principal resultado de los ejercicios de simulación es que el factor determinante de la trayectoria diferencial (tanto en la tasa de crecimiento económico como en el cociente deuda/PIB) está dado por la importancia del gasto gubernamental en el gasto autónomo total.

Por su parte, Mariana García Schmidt y Benjamín García, del Banco Central de Chile, presentan el modelo de pronóstico principal de la autoridad monetaria chilena. Así, describen el XMAS, el principal modelo estructural para la toma de decisiones de política, que consiste en un DSGE nuevo keynesiano con una variedad de sectores, fricciones y shocks, y señalan los cambios recientes que se le han realizado para incorporar nuevos fenómenos económicos (por ejemplo, el impacto de la creciente inmigración). Los autores también presentan dos modelos "satélite", que se diseñan para lidiar con problemas puntuales, evitando complejizar excesivamente el modelo estructural principal.

En el siguiente trabajo, José Luis Oreiro, de la Universidad de Brasilia, junto con Luciano Dias de Carvalho, Luciano Ferreira Gabriel y Evaldo Henrique da Silva, de la Universidad Federal de Viçosa, se proponen mostrar cómo las decisiones de política monetaria pueden tener una influencia persistente en la estructura productiva de una economía pequeña y abierta. Para ello, plantean una serie de hipótesis de comportamiento que capturan los efectos de histéresis de una baja tasa de crecimiento efectiva sobre el crecimiento potencial de la economía, así como la idea de que la industria manufacturera es uno de los principales motores del crecimiento. En línea con el enfoque Neo-desarrollista, sostienen que la política monetaria —conducida bajo un esquema de metas de inflación "flexible"— puede afectar el sendero de crecimiento de largo plazo y el ritmo de progreso tecnológico, por lo que no resultaría posible separar la conducción de la política macroeconómica de las consideraciones asociadas al desarrollo de largo plazo.

En el cuarto trabajo, Arslan Razmi, de la Universidad de Amherst, presenta un modelo que formaliza una economía dual, en la que existe un sector tradicional que produce bienes no transables, y un sector moderno que produce bienes transables, basado en el modelo de dos sectores de "economía dependiente" desarrollado por Swan en la década del sesenta, aunque con un mercado laboral dual, con excedente de trabajo sub o informalmente empleado en el sector tradicional, a la Lewis. Dicho marco analítico es utilizado para formalizar cuestiones vinculadas al crecimiento de una economía abierta, tales como el conflicto distributivo, la restricción externa, el comportamiento de la cuenta capital del balance de pagos, el descubrimiento de recursos naturales, shocks de términos de intercambio, los fenómenos de enfermedad holandesa y cuellos de botella del lado de la oferta.

Por último, Gabriel Michelena, del Banco Central de la República Argentina, desarrolla un modelo stock-flujo dinámico estimado y calibrado para la economía argentina. Los modelos stock flujo consistentes están caracterizados por la utilización de matrices de contabilidad social (SAM, por sus siglas en inglés), lo que les permite realizar una desagregación de la cuenta capital y de los instrumentos financieros de diferentes sectores institucionales; y les otorga consistencia contable. El marco analítico propuesto permite realizar una serie de ejercicios contrafactuales para evaluar diferentes políticas fiscales, tributarias, monetarias y comerciales, con el objetivo de realizar proyecciones de mediano plazo sobre los principales flujos y stocks de la economía argentina.

Finalmente, quiero invitar a todos y todas a enviar sus artículos académicos para ser evaluados para su publicación en nuestra revista, y de este modo contribuir a enriquecer la discusión sobre economía y política económica en nuestro país.

Germán Feldman
Editor
Ensayos Económicos - BCRA

Índice

Autonomous Demand Composition and Fiscal Policy in a Supermultiplier Simulation Model

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Abstract

The paper aims to analyze the influence of autonomous demand composition on the impact of fiscal policy on the economic performance of an economy. To do so, we develop a supermultiplier simulation model for a small open economy. In our simulations, we use two sets of exogenous variables and parameter combinations. The main differences between these two sets are that in Country 1, the government expenditure share in total autonomous demand is relatively high, and the economy is more inward-oriented. In contrast, in Country 2, the government expenditure share is relatively low, and the economy is more outward-oriented. We then simulate the impact of the same temporary shock on GDP growth and the debt to GDP ratio in both countries of a fiscal policy that follows a stylized structural balance rule. The main result obtained from the simulation exercise points to the importance of the government share in total autonomous expenditure as the factor explaining the diverging economic performance regarding GDP growth and the debt to GDP ratio under the same fiscal policy.

JEL Classification: E12, E13, E62, H63.

Keywords: debt, fiscal policy, modeling, small open economy, supermultiplier.

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Composición de la demanda autónoma y política fiscal en un modelo de simulación con supermultiplicador

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Resumen

Este documento tiene como objetivo analizar la influencia de la composición de la demanda autónoma sobre el impacto de la política fiscal en el desempeño de una economía. Para ello, desarrollamos un modelo de simulación de supermultiplicador para una economía pequeña y abierta. En nuestras simulaciones, utilizamos dos conjuntos de variables exógenas y combinaciones de parámetros. Las principales diferencias entre estos dos conjuntos son que en el País 1, la participación del gasto público en la demanda autónoma total es relativamente alta y la economía está más orientada hacia adentro. En contraste, en el País 2, la participación del gasto público es relativamente baja y la economía está más orientada hacia el exterior. Luego, simulamos el impacto del mismo *shock* temporario de una política fiscal que sigue una regla estándar de balance estructural sobre el crecimiento del PIB y el ratio de deuda a PIB en ambos países. El principal resultado obtenido del ejercicio de simulación apunta a la importancia de la participación del gobierno en el gasto total autónomo como factor que explica el desempeño económico divergente en cuanto al crecimiento del PIB y a la relación deuda/PIB bajo la misma política fiscal.

Clasificación JEL: E12, E13, E62, H63.

Palabras clave: deuda, economía pequeña y abierta, modelación, política fiscal, supermultiplicador.

1. Introduction

The paper aims to analyze the influence of autonomous demand composition on the impact of fiscal policy on the economic performance of an economy. To do so, we will present a supermultiplier simulation model for a small open economy. We will undertake a pure demand-led growth simulation exercise that ignores, for analytical purposes only, the possible constraints to a demand-led growth pattern associated with the balance of payments, labor force employment dynamics, natural resources, and environmental issues. The simulation exercise is based on two sets of exogenous variables and parameter combinations. The main differences between these two sets are that in Country 1, the government expenditure share in total autonomous demand is relatively high, and the economy is more inward-oriented. In contrast, in Country 2, the government expenditure share is relatively low, and the economy is more outward-oriented. In our simulation exercise, we suppose the existence of an underlying economic scenario capturing a situation in which the economy is subject to a "temporary shock" involving changes in the growth rate of private autonomous expenditure, the interest rate, and functional distribution of income. We also suppose that the governments in the two countries follow the same stylized fiscal policy rule, a structural balance rule. The paper's main conclusion is that, within our analytical framework, the composition of autonomous demand has important effects on the economy's performance and, in particular, on the level and rate of growth of GDP and the debt to GDP ratio.

The structure of the paper is the following. The first section presents the supermultiplier growth model that will be used in our simulation exercise. The second section discusses the calibration of the parameters/exogenous variables of the model and the initial conditions for the endogenous variables. Next, the economic scenario and stylized fiscal policy rule used in the simulation are presented in the paper's third section. The fourth section presents and discusses the main results obtained from the simulation exercise. Finally, we present our concluding remarks highlighting the main result obtained and indicating how its robustness can be evaluated within our analytical framework.

2. A supermultiplier simulation model for a small open economy with a government sector

We develop a simple version of the supermultiplier model for the simulation analysis of the impact of fiscal policy on a small economy.[1] As a first approximation, we will explore only the pure demand-led pattern of economic growth in our simulations, leaving entirely out of the picture the main constraints to demand-led growth: the balance of payments, the labor force, and natural resources. To further simplify the model, we suppose that government activities are limited to government consumption and investment, social transfers, direct taxation, and the issuing of domestic denominated debt. The monetary authority controls the real rate of interest through the

[1] The specific version here developed has Freitas and Christianes (2020) and Haluska *et al*. (2019) as its main references in the literature.

manipulation of the nominal interest rate. Income distribution is exogenously determined, reflecting the influence of class conflict mediated by the institutional and social framework. Moreover, we also assume that the only production method in use requires a fixed combination of a homogeneous labor input with homogeneous fixed capital to produce a single product. Constant returns to scale prevail, and there is no technological progress. Finally, the model is specified in real terms, in the sense that all relevant variables of the model are real magnitudes and in discrete time.[2]

Let us start by supposing that an equilibrium between aggregate supply and demand, which in our open economy with a government setting, implies that:

$$Y_t + M_t = C_t + I_t + G_t + X_t \tag{1}$$

where Y is the gross domestic product (GDP), M imports, C household consumption, I aggregate investment, G government consumption, and X exports.

We suppose that total imports are a function of aggregate demand and, for simplicity, we also assume a uniform import content coefficient for all aggregate demand components. Therefore, we have:

$$M_t = m(C_t + I_t + G_t + X_t) \tag{2}$$

where m is the import content coefficient, with $0 \leq m \leq 1$.[3]

Household consumption depends on three sources: the purchasing power introduced in the economy by capitalist production decision to mobilize the labor force, as captured by the wage bill; the purchasing power introduced in the economy through government social transfers; and the purchasing power introduced in the economy by the consumption expenditures financed by credit or by previously accumulated wealth. Consumption financed by wages is an induced expenditure since it depends on current production decisions. As a first approximation, we suppose that the marginal propensity to consume out of wages is equal to one and, therefore, consumption out of wages is equal to the after-tax wage bill. Thus, given the wage share on total income (denoted ω below) and tax rate on wages (denoted t_w below), consumption out wages is proportional to GDP. On the other hand, consumption out of social transfers is an autonomous source of demand in the economy, and we assume, as a first approximation, that all social transfers are spent. Finally, consumption financed by credit and accumulated wealth (denoted C^A below) is also an autonomous source of demand.[4] Therefore, aggregate consumption is given by:

[2] Throughout the article we denote x_t as the value of the variable x at the finite time period t.
[3] See Miyazawa (1976, chap. 3) and Gandolfo (2002, chap. 8, sec. 8.4 and appendix D, sec. D.3) for this kind of formulation of the import function. Notice that the import content coefficient has limits to its variations, which excludes the possibility of continual increasing or decreasing. Note also that it includes the derived demand for imported intermediate inputs.
[4] As a first approximation, rentier and capitalist consumption are completely autonomous in this formulation, that is, the marginal propensity to consume out of profits and government debt repayments (interest and principal) is zero.

$$C_t = (1 - t_w)\omega Y_t + Tr_t + C_t^A \tag{3}$$

where Tr_t is the value of social transfers as for period t.

On the other hand, total investment has four components, of which three of them are supposed to be autonomous: public investment, I^G; residential investment by households, I^R; R&D expenditures by capitalist firms, I^{AF}. The last component is the induced investment by capitalist firms, I_t^{IF}. We assume that the capital stock adjustment principle explains the latter. According to this principle, capitalist competition influences the investment process by bringing about a tendency towards the adjustment of productive capacity to the production flows required to meet demand at a price that covers production expenses and allows, at least, the obtainment of a minimum required profitability. Since capacity adjustment is not instantaneous due to technical and economic indivisibilities and firms do not want to lose their market shares to incumbent firms and potential entrants, they maintain margins of spare capacity to allow the adjustment of production to a fluctuating demand. On the other hand, under the pressure of competition, firms also do not want to keep accumulating costly unneeded spare capacity when the actual degree of capacity utilization remains below the profitable normal level. In this case, a reduction in the pace of investment in relation to demand increases capacity utilization and the realized rate of profit without putting in danger the firm's market share. Thus, we arrive at the notion of a planned margin of spare capacity that corresponds to a normal capacity utilization rate. Following Ciccone (1986; 1987), we interpret the normal or planned rate of capacity utilization as determined, among other things, by the historically 'normal' ratio of peak to average demand. This latter ratio is assumed to be unaffected by current oscillations of demand since it is presumably based on the observation of the actual cyclical and seasonal patterns of the market over a long period. To represent this kind of investment behavior, we use the following investment function close to the specification suggested by Serrano (1995a; 1995b) and Cesaratto *et al*. (2003):

$$I_t^{IF} = v\,(\delta + g_t^e)Y_t \tag{4}$$

where v is the normal capital-output ratio, δ is the capital replacement coefficient, and g_t^e is the expected GDP growth rate at period t. We further assume that expectations are formed according to an adaptive pattern, so that:

$$g_t^e = (1 - x)g_{t-1}^e + xg_{t-1} \tag{5}$$

where x is the expectation adjustment parameter, with $0 \leq x \leq 1$.

From the assumptions above, we obtain the equilibrium level of GDP of the economy as follows:

$$Y_t = \left\{\frac{1 - m}{1 - (1 - m)[(1 - t_w)\omega + v\,(\delta + (1 - x)g_{t-1}^e + xg_{t-1})]}\right\} Z_t \tag{6}$$

where the term in braces is the supermultiplier incorporating both consumption and investment inducement effects and $Z_t = G_t + I_t^G + Tr_t + I_t^R + I_t^{AF} + X_t + C_t^A$ is the autonomous component of aggregate demand. The rate of growth of autonomous demand is the weighted average of the growth rates of its components, so that:

$$g_{Zt} = \left(\frac{G_{t-1}}{Z_{t-1}}\right) g_{Gt} + \left(\frac{I_{t-1}^G}{Z_{t-1}}\right) g_{I^G t} + \left(\frac{Tr_{t-1}}{Z_{t-1}}\right) g_{Trt} + \left(\frac{I_{t-1}^R}{Z_{t-1}}\right) g_{I^R t} + \left(\frac{I_{t-1}^{AF}}{Z_{t-1}}\right) g_{I^{AF} t} + \left(\frac{C_{t-1}^A}{Z_{t-1}}\right) g_{C^A t} + \left(\frac{X_{t-1}}{Z_{t-1}}\right) g_{Xt} \tag{7}$$

The growth rates of the various autonomous demand components will be discussed below in connection with the definition of the fiscal policy rule and economic scenarios for the simulation exercises. From (6) and (7), we obtain a difference equation for the rate of growth of GDP according to the model:

$$g_t = g_{Zt} + \frac{(1-m)v\,(1+g_{Zt})x(g_{t-1} - g_{t-1}^e)}{1-(1-m)[(1-t_w)\omega + v\,(\delta + (1-x)g_{t-1}^e + xg_{t-1})]} \tag{8}$$

The GDP growth rate depends on the rate of growth of autonomous demand and on the change in the supermultiplier caused by the revisions of growth expectations that affect the propensity to invest (i.e., $v\,(\delta + g_t^e)$).[5]

Additionally, when exogenous changes of some variables present in the supermultiplier occur, there is a temporary change in GDP growth rate and, therefore, a level effect on GDP. In our simulations, we will restrict our analysis to changes of the wage share on total income (denoted ω_t below) and of the income tax rate on wage income (t_{wt}). These changes are captured on the RHS of equation (8). For each specific source of change, we have an additional term like the second one on the RHS of equation (8).

Regarding the fiscal policy indicators, we will discuss the behavior of the primary surplus to GDP ratio and debt to GDP ratio. The primary surplus to GDP ratio is defined as follows:

$$\frac{\beta_t}{Y_t} = \frac{T_t - G_t - I_t^G - Tr_t}{Y_t} = \frac{t_w\omega Y_t + t_K(1-\omega)Y_t + t_r r B_{t-1} - G_t - I_t^G - Tr_t}{Y_t} \tag{9}$$

[5] Equations (5) and (8) form together a 2x2 system of difference equations in g and g^e. Under the assumption that all autonomous demand components grow at the same constant rate g_Z the system has a steady-state equilibrium in which $g^* = g^{e*} = g_Z$ and this equilibrium is locally dynamically stable if the disequilibrium propensity to spend has a value lower than one in the neighborhood of the equilibrium, that is if $(1-m)[(1-t_w)\omega + v(g_{zt} + \delta) + vx + vxg_{zt}) < 1$. See Serrano *et al*. (2019, Appendix B) for a formal demonstration of these results in the case of a closed economy without government.

where β is the primary surplus, t_K is the tax rate on profits, t_r is the tax rate on interest received by public debt owners, r is the real interest rate, B is the public debt stock. Moreover, we assume, for simplicity, that $t_w = t_K = t_r$.

On the other hand, the following difference equation gives us the dynamic behavior of the public debt to GDP ratio (denoted b below):

$$b_t = -\frac{\beta_t}{Y_t} + \left(\frac{1+r}{1+g_t}\right) b_{t-1}$$

or

$$b_t = \frac{G_{t-1}(1+g_{Gt}) + I_{t-1}^G\left(1+g_{I^G t}\right) + Tr_{t-1}(1+g_{Trt})}{Y_{t-1}(1+g_t)} - t_w\omega - t_K(1-\omega) + \left(\frac{1+(1-t_r)r}{1+g_t}\right) b_{t-1} \quad (10)$$

Note that if a transformed Domar condition $g_t > (1-t_r)r$ holds, it is possible to maintain a primary deficit to GDP ratio (excluding interest tax revenues) without an increasing or decreasing debt to GDP ratio. Conversely, if $g_t < (1-t_r)r$, a stationary debt to GDP ratio requires the maintenance of a sufficiently high primary surplus to GDP ratio.[6]

3. Model calibration and initial values

The calibration of the parameters/exogenous variables of the model and the definition of the initial values for endogenous variables are chosen to reflect two different kinds of open economies. In Country 1, the government expenditure share in total autonomous demand is relatively high, and the economy is more inward-oriented. In contrast, in Country 2, the government expenditure share is relatively low, and the economy is more outward-oriented.

In the case of Country 1, the model calibration and initial values were set to reflect, whenever possible, the Brazilian economy.[7] On the other hand, in the case of Country 2, the calibration and initial values were set to the same values as Country 1, whenever possible, but changed to reflect a much smaller government sector and a lot larger foreign trade relative to the size of the economy. In both countries, the initial level of GDP is set at 100 to facilitate comparison between both countries and, hence, initial levels of autonomous expenditure represent percentages of GDP. Despite the differences between both economies, parameters/exogenous variables and

[6] In particular, assuming a given primary surplus to GDP ratio (excluding the tax revenues on interest) β' and that all autonomous demand components grow at the same given rate g_Z, the steady-state equilibrium for equation (10) above is $b^* = -(\beta'/Y)^*/(g_Z - (1-t_r)r)/(1+g_Z)$. Under these assumptions this equilibrium is stable if the (Domar) condition $g_Z > (1-t_r)r$ holds.

[7] The parameters/exogenous variables and initial values for endogenous variables were based on data from the Complete Tables of the Quarterly National Accounts System up to 2019 and yearly data of the Complete Tables of the National Accounts System up to 2018 (IBGE 2021a, IBGE 2021b).

initial values of the endogenous variables (presented in Table 1 and Table 2 below) are chosen so that both countries have precisely the same initial level of autonomous expenditure in order to focus the analysis on the role of the autonomous demand composition.

Table 1 | Calibration of parameters/exogenous variables for the simulation exercise

Parameter	Value		Description
	Country 1	Country 2	
m	0.15	0.31	Propensity to import.
x	0.10		Sensitivity of fixed private investment to the difference between current and expected demand.
ω	0.57		Pre-tax labor share in income.
v	1.65		"Normal" capital to output ratio.
δ	6.6%		Annual replacement coefficient.

Source: Own calculation based on IBGE (2021a, 2021b), Souza and Cornelio (2020), and Haluska et al. (2019)

Although the calibration and initial variables for Country 1 were set in reference to real Brazilian data whenever possible, given the high degree of abstraction of the model regarding taxation, the rate of direct taxation is set in a somewhat arbitrary fashion, being much higher than occurs in reality. Also, since some of the more interesting results of the model are apparent only when the economy is close to fulfilling the transformed Domar condition for a balanced debt to GDP ratio, taxation was set so that there is a primary surplus of 1% of GDP at $t = 1$. Since the real interest rate begins at 4% a year, that means, for example, that a yearly growth rate of 3% of GDP leads to a falling ratio of debt to GDP.[8]

Initial real interest rates of 4% per year are close to rates for 10-year government debt currently in Brazil, which according to ANBIMA (2021), stood at 3.9603% for IPCA (the official consumer price index) inflation-indexed bonds on April 29th, 2021. The real rate of interest applicable to gross debt is considerably lower, mainly because government bonds used in monetary policy repo transactions by the Central Bank constitute a large share of this debt, with nominal rates for gross debt at 5.8% a year for an annual inflation rate of 6.10% in March 2021 (BCB, 2021; IBGE, 2021c). Given these numbers and the history of Brazilian real interest rates, the simulation involves real interest rates between 4% and 6 %, as will be commented below, which seem plausible for the Brazilian Economy.

[8] The exact rate above which GDP must grow in order to lower the debt to GDP ratio also depends on the initial debt to GDP ratio as can be seen in equation (10).

Table 2 | Initial values of endogenous variables for the simulation exercise

Variable	Initial Value		Description
	Country 1	Country 2	
$t_{wt=1}$	0.40	0.22	Rate of direct taxation on labor income in *t* = 1.
$t_{Kt=1}$	0.40	0.22	Rate of direct taxation on capital income in *t* = 1.
$t_{rt=1}$	0.40	0.22	Rate of direct taxation on rentier income in *t* = 1.
$r_{t=1}$	4%		Real interest rate in *t* = 1.
$b_{t=1}$	90%		Level of the debt to GDP ratio in *t* = 1
$\frac{\beta}{Y}$	1%		Primary surplus β as a % of GDP Y in *t* = 1.
$g_{t=1}$	2.0%		GDP growth rate in *t* = 1.
$g^e_{t=1}$	2.5%		Expected GDP growth rate in *t* = 1.
$g^Z_{t=1}$	2.0%		Autonomous expenditure growth rate in *t* = 1.
$Y_{t=1}$	100		Level of GDP normalized to 100 in *t* = 1.
$X_{t=1}$	14	34	Level of exports of goods and services in *t* = 1.
$G_{t=1}$	20	10	Level of government transfers in *t* = 1.
$Tr_{t=1}$	18.5	9.5	Level of government transfers excluding interest in *t* = 1.
$I^G_{t=1}$	2	1	Level of government investment in *t* = 1.
$ZG_{t=1}$	40.5	20.5	Level of government autonomous expenditure in *t* = 1.
$I^R_{t=1}$	4.5	4.5	Level of residential investment in *t* = 1.
$I^{AF}_{t=1}$	3	3	Level of autonomous firm investment in *t* = 1.
$C^A_{t=1}$	6.4	6.4	Level of autonomous consumption in *t* = 1.
$Z_{t=1}$	68.4	68.4	Level of autonomous expenditure in *t* = 1.
$ZG_{t=1}/Z_{t=1}$	59.2%	30.0%	Share of government autonomous expenditure in total autonomous expenditure in *t* = 1.

Source: own calculation based on IBGE (2021a, 2021b) and BCB (2021).

Regarding the parameter that reflects the adjustment of expected demand to past growth that is used to determine fixed-capital private investment, we suppose that $x = 0.10$, which Haluska *et al*. (2019, p. 30, note 16) point as a possible benchmark in the existing literature. This value is well above $x = 0.07$, the value obtained in the econometric estimation in the same paper (Ibid., pp. 27-32) for the United States from 1985 to 2017. These values for the parameter x are sufficiently low to avoid the likelihood of unstable behavior of the model, even for relatively high growth rates of the economy.

For the exogenous variable v, the desired or "normal" capital-output ratio, we use the estimates for the capital stock of the Brazilian economy, excluding the stock of residential capital obtained by Souza and Cornelio (2020, pp. 44-45). Thus, considering the average value of v between 1998-2017 as a proxy, we use $v = 1.65$ in our simulations. The latter value is higher than the one ($v = 1.07$) obtained by Haluska *et al*. (2019, p. 30) for the U. S. economy. However, it is important to note that even if our estimate is somewhat inaccurate, reasonable calibrations of this parameter do not significantly change the simulation results.

As a proxy for δ, which is the capital replacement coefficient, we utilize the depreciation rate of fixed capital. Once more, we use the estimates of Souza e Cornelio (2020, pp. 44-45) for the Brazilian Economy, in which the average rate of depreciation has grown in recent years because of the subitem "other" capital stock, that includes intellectual property products, which constitute a small but growing share of the capital stock.[9] With this observation in mind, we considered only the average depreciation from 2013 to 2017, obtaining $\delta = 6.6\%$ as a proxy. This result is very close to the estimate obtained for the U. S. economy by Haluska *et al*. (2019. p. 30). Just as in the calibration of v, even if our estimate is somewhat inaccurate, reasonable calibrations of this parameter do not significantly change the simulation results.

Given the parameters and initial conditions regarding the primary surplus and real interest rate, the crucial initial condition is the one capturing the composition of autonomous demand. Both countries have the same initial level of total autonomous expenditure. Still, as illustrated in the last line of Table 2, this is set so that Country 1 has 59.2% of autonomous expenditure being government expenditure, and in Country 2 the same variable is 30.0% percent. This is the crucial supposition that will explain the different results obtained in the simulations for both countries, which otherwise share very similar conditions.

4. Economic simulation scenario and stylized fiscal policy rule

We illustrate some features of the model by simulating a scenario with a "temporary shock" involving a change to the growth rate of private autonomous expenditure, interest rates, and the functional distribution of income. These variables go through marked changes that last for a few years and then return to their previous magnitudes. A structural balance fiscal policy rule has been applied to this scenario, seeking to lower the debt to GDP ratio starting in year $t = 2$.

The scenario was set to reflect the example of a country in the periphery suffering a temporary shock that lasts for a few years, which initially affects exports and then leads to higher interest rates, negative growth rates for other autonomous private expenditures, and a change in the functional distribution that favors capital over labor. The exogenously determined growth rates of exports and private autonomous demand components, the interest rate, and the government share of total autonomous demand in the scenario are presented in Appendix 1.

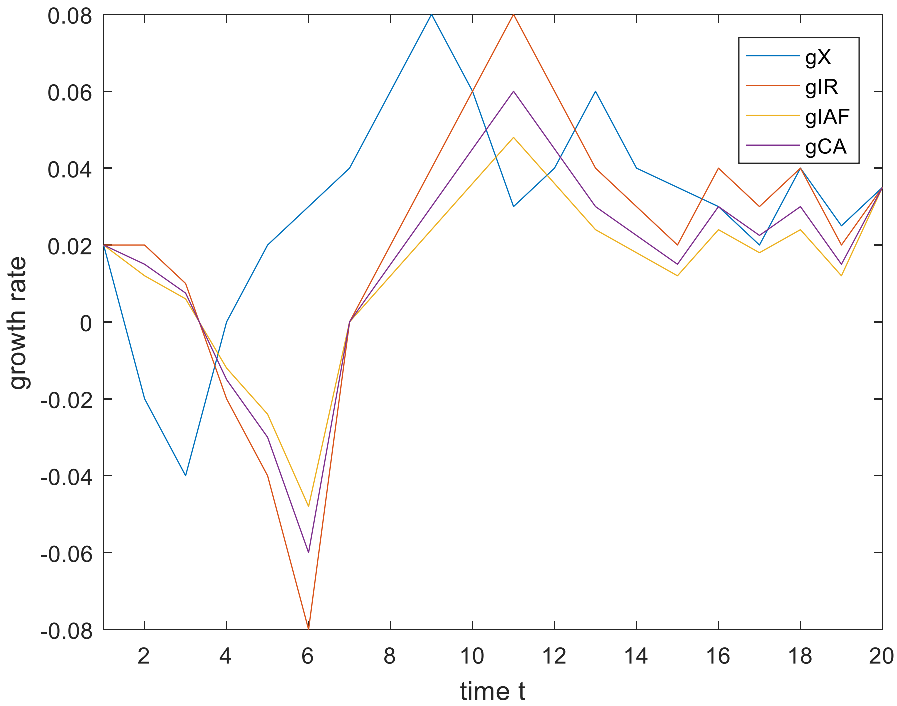
The shock to exports, which were growing at $gX = 2\%$ at $t = 1$, leads to negative growth rates in $t = 2$ and $t = 3$ and exports staying flat in $t = 4$ with zero growth. Exports then recover so that exports grow at an approximately 3% per year geometric average rate for the entire simulation period of twenty years. Real interest rates increase, starting in $t = 3$, until they reach 6% in $t = 6$, then fall back starting in $t = 7$ until they reach 4% a year in $t = 10$ and remain at this level until the end of the simulation period of twenty years. The functional distribution of income gradually becomes more favorable to capitalists in relation to workers starting in $t = 3$ with $\omega = 57\,\%$ in $t = 1$ changing to $\omega = 55\%$ in $t = 6$, then gradually increasing back, beginning in $t = 7$, until it

[9] In our calculations of the depreciation rate, we did not take into account the stock of residential capital.

stabilizes when reaching $\omega = 57\ \%$ in $t = 10$ and after that remaining in this level until the end of the simulation period. Other private autonomous expenditure growth rates (excluding exports) are set exogenously so that they are inversely related to real interest rates, but with residential investment being more sensitive than autonomous consumption and this last expenditure being more sensitive than autonomous firm investment.

Graph 1 below illustrates the behavior of the growth rate of autonomous expenditure for the entire period, with gX, gIR, $gIAF$ and gCA corresponding to the growth of exports, residential investment, autonomous firm expenditure, and autonomous consumption, respectively.

Graph 1 | Growth rates of private autonomous demand components



Source: own calculations.

Regarding the stylized fiscal policy rule, the structural balance rule requires, initially, a primary structural surplus to GDP target ratio to set the rule. This target is set at 2.5% of potential GDP. Since the initial primary balance is 1% and is supposed to be equal to the initial primary balance at potential GDP, there must be a fiscal adjustment involving 1.5% of GDP. The structural balance rule does not prescribe how this adjustment must be conducted, something that in practice would be up to policymakers to decide. We suppose this adjustment occurs with 2/3 of the adjustment falling on projected spending and 1/3 on raising revenue. Table 3 below summarizes this procedure.

Table 3 | Structural primary surplus target and fiscal adjustment

% of GDP				
Primary Balance at *t*=1	Structural Primary Surplus Target $(\frac{\beta}{Y_t^e})$	Total fiscal Adjustment	Adjustment Apportionment	
			Δ spending (2/3)	Δ revenue (1/3)
1.0%	2.5%	1.5%	1.0%	0.5%

Now, it is necessary to proceed with the adjustment by altering projected spending and revenue (supposing that spending growth was the same as expected GDP growth and considering the revenue expected at this growth rate). We have that $\Delta\ spending$ is expressed as % of GDP and $\Delta\ spending^{adj}$ is merely a variable used to transform spending from % of GDP to a factor that adjusts government spending growth:

$$original\ projected\ spending = ZG_t^e = (I_t^G + G_t + Tr_t)\ (1 + g_t^e) \Longrightarrow$$

$$new\ spending\ growth = (I_t^G + G_t + Tr_t)\ (1 + g_t^e - \Delta\ spending_t^{adj}) \Longrightarrow$$

$$\Delta\ spending^{adj} = \left[\frac{(Y_{t-1})(1 + g_t^e)}{G_{t-1} + IG_{t-1} + Tr_{t-1}}\right]\Delta\ spending \qquad (11)$$

Equation (11) shows that the adjustment in the rate of spending growth is the same as the projected spending cut as a percentage of projected GDP multiplied by the term in brackets.[10] Regarding the necessary adjustment in projected revenue, we have:

$$original\ projected\ revenue = T_t^e = (Y_{t-1})(1 + g_t^e)[t_{wt}\omega + t_{Kt}(1 - \omega)] + t_r r B_{t-1}$$

However, since we supposed that $t_{wt} = t_{Kt} = t_{rt}$, then:

$$original\ projected\ revenue = T_t^e = (Y_{t-1})(1 + g_t^e)[t_{wt}\omega + t_{wt}(1 - \omega)] + t_{wt} r B_{t-1}$$

$$\Longrightarrow T_t^e = \{(Y_{t-1})(1 + g_t^e)[\omega + (1 - \omega)] + rB_{t-1}\}t_{wt} \Longrightarrow$$

[10] Since $\Delta\,\mathrm{spending}^{\mathrm{adj}}\left[\frac{G_{t-1}+IG_{t-1}+Tr_{t-1}}{(Y_{t-1})(1+g_t^e)}\right] = \Delta\,\mathrm{spending}$. In our example, we have $\Delta\,\mathrm{spending} = 1\%\ \mathrm{of\ projected\ GDP} = 1\% * (Y_{t-1})(1 + g_t^e)$, that needs to be transformed into a deeper cut in spending than 1%, since government spending is only a fraction of GDP. Since the term in brackets is smaller than 1, that is $\left[\frac{G_{t-1}+IG_{t-1}+Tr_{t-1}}{(Y_{t-1})(1+g_t^e)}\right] < 1$, then when $\Delta\,\mathrm{spending}$ is divided by the term in brackets we have $\Delta\,\mathrm{spending}^{\mathrm{adj}}$, which is necessarily larger than 1%, that is, a 1% adjustment of GDP in spending implies a much larger adjustment in the growth percentage of spending.

$T_t^e = \{(Y_{t-1})(1+g_t^e) + rB_{t-1}\}t_{wt}$

$original\ projected\ revenue\ \%\ of\ GDP = t_t^e \Longrightarrow$

$t_t^e = [1 + \frac{rb_{t-1}}{1+g_t^e}]t_{wt} \Longrightarrow$

$original\ projected\ revenue +\ new\ required\ revenue\ \%\ of\ GDP =$

$t_t^e + \Delta\ \text{revenue} =$

$[1 + \frac{rb_{t-1}}{1+g_t^e}]t_{wt}^{ajustment}$

$\Longrightarrow t_{wt}^{adjustment} = \frac{t_t^e + \Delta\ \text{revenue}}{1+\frac{rb_{t-1}}{1+g_t^e}} \Longrightarrow$

$$t_{wt}^{adjustment} = t_{wt} + \frac{\Delta\ revenue}{1+\frac{rb_{t-1}}{1+g_t^e}} \qquad (12)$$

Equation (12) shows that the adjustment in the income tax rate applicable to workers income, which out of simplicity we supposed was equal to the income tax rate applicable to capitalists and rentiers ($t_w = t_K = t_r$), is the original worker tax rate, adjusted by the increase in projected revenue required by the fiscal rule as a percentage of GDP, divided by the term $1 + \frac{rb_{t-1}}{1+g_t^e} > 1$. This adjustment occurs, so a required increase in revenue as a percentage of GDP ($\Delta\ revenue$) is expressed as an adjustment in the tax rate $t_{wt} = t_{Kt} = t_{rt}$.[11]

The above formulation could be used for different types of fiscal rules involving different references regarding GDP growth. But for the structural balance rule here used, this should be the expected growth rate of potential GDP. To do this, a simple rule is adopted that uses the same rate of expected GDP growth as the private fixed investment adaptive expectation rule:

$$gstruct_t^e = g_t^e, \qquad (13)$$

with:

$$g_t^e = (1-x)g_{t-1}^e + xg_{t-1} \qquad (14)$$

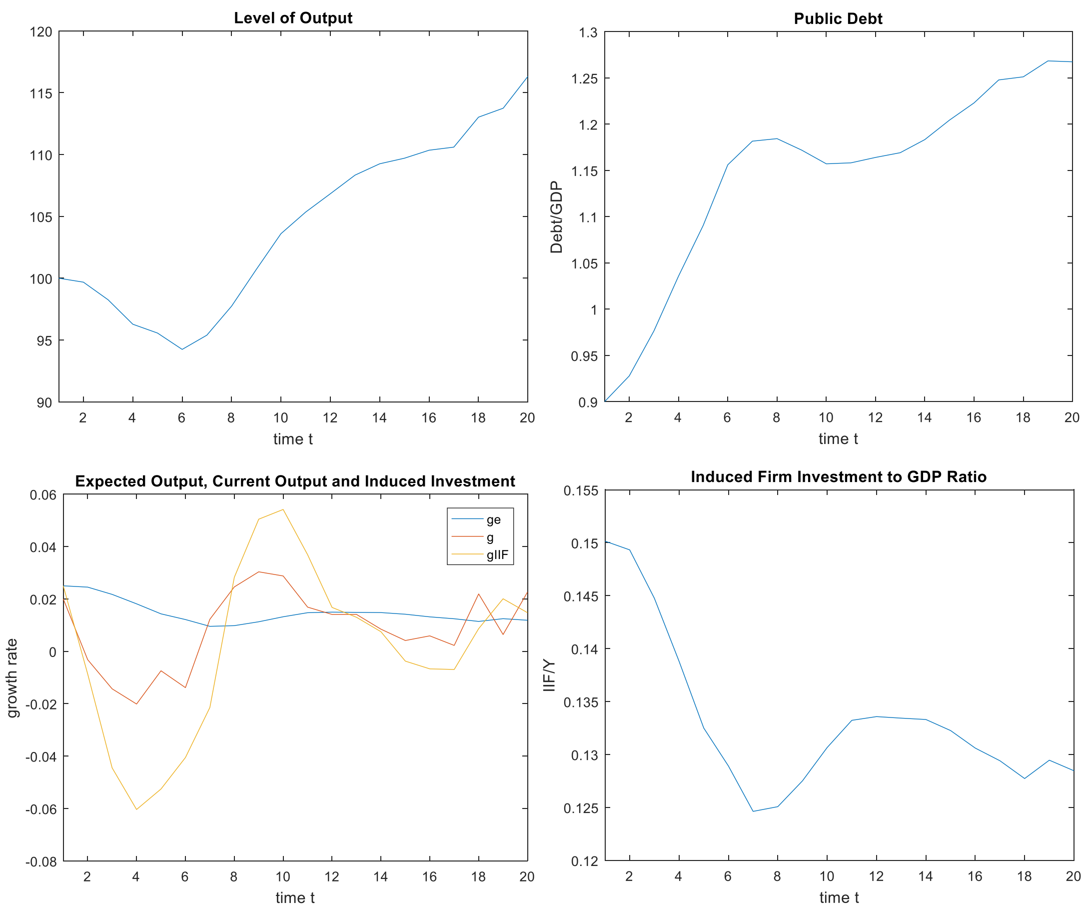
[11] Differently from the adjustment in spending, since the income tax rate is applied to GDP as a whole as well as to the stock of past debt, the increase in the tax rate is smaller in percentage points than the required revenue adjustment in percentage of GDP. In our example, the $\Delta\ \text{revenue} = 0.5\ \%\ \text{of GDP}$, will result in an adjustment of the tax rate (which is the same for all types of income for simplicity) of less than 0.005.

This type of rule means past GDP growth is used to estimate current GDP growth, but the adjustment to changing GDP growth is slow since $x = 0.10$. Hence, if the primary structural surplus is equal to or higher than 2.5% of potential GDP in a specific year t, government spending is set to grow in $t + 1$ at potential GDP ($gZGt = gstruct_t^e$) and direct taxation rates remain at the same level as in year t.

5. Some simulation results

Starting with Country 1, Graph 2 shows that the attempts to bring down the debt to GDP ratio by increasing the structural balance rule during the external shock are ineffective and lead to a significant GDP loss. Only when the economy grows again does the debt to GDP ratio stabilize. Although the structural balance is greatly increased, as shown in Graph 3 below, the current nominal balance remains low until the economy grows again. Graph 2 also illustrates how the growth rate of induced investment has a marked cyclical behavior, exacerbating changes in output growth as investment adjusts to changes in the expected growth rate. In turn, this affects the induced firm investment to GDP ratio, which suffers a precipitous decrease in the first few periods, recovering only partially when the growth of output resumes.

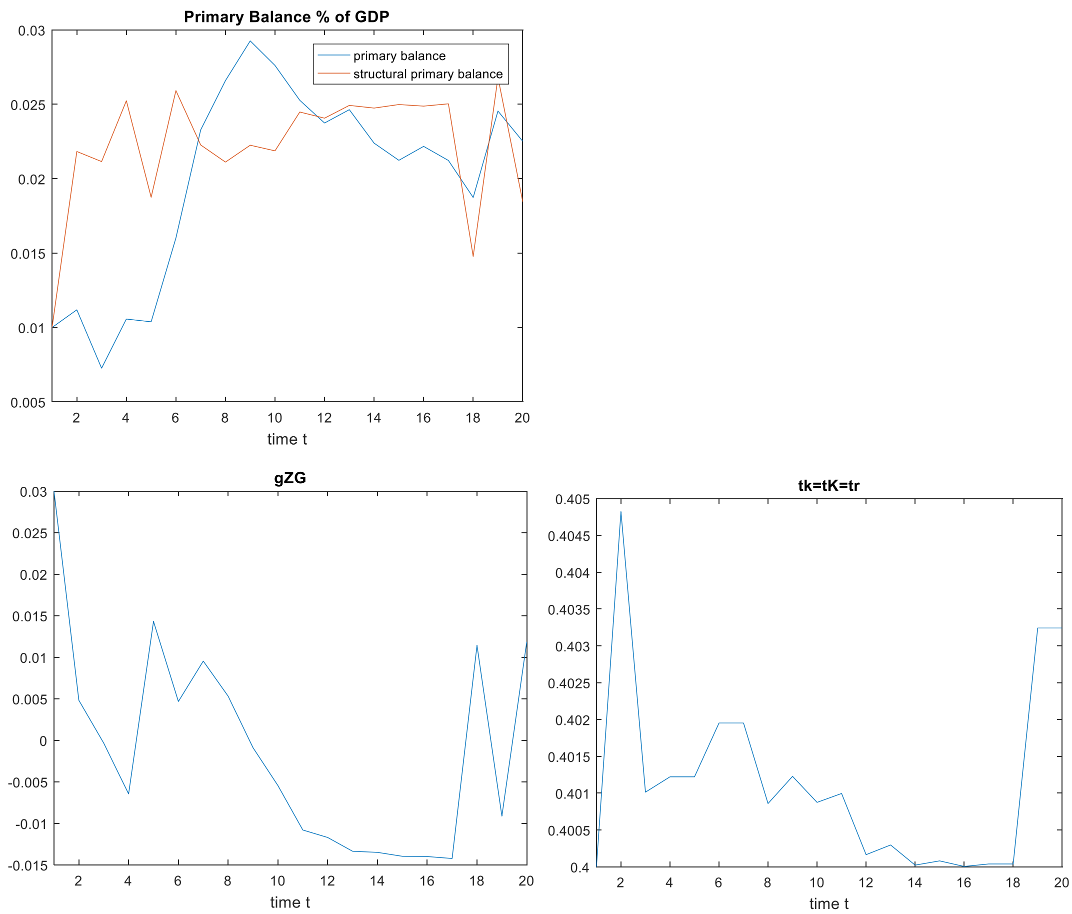
Graph 2 | Output, Induced Investment, and Public Debt – Country 1 (Brazil)



Source: own calculations.

The fiscal policy rule adopted is in great part responsible for the result illustrated in Graph 3 below. After an initial cut in government spending growth gZG in $t = 2$ to $t = 4$ and an increase in initial direct tax rates, the structural balance of 2.5% is achieved in year 4, and spending growth is increased to expected potential growth in $t = 5$, which is estimated to be significantly lower than at the beginning of the simulation. Structural balance is below the 2.5% target in $t = 5$, and austerity resumes in $t = 6$, achieving a structural balance above the target in this year. Government spending once again grows at the potential at $t = 7$, but this is lower than before. However, when the structural balance adjustment process starts, it significantly lowers government spending for several years, turning the latter growth rate to a negative value. This eventually leads to even lower GDP growth and raises the debt to GDP ratio instead of lowering it, which leads to a self-defeating austerity process. At the end of the simulation, government spending growth and taxation alternates between austerity and return to spending growth at potential GDP and lower rates, respectively, as there are attempts to achieve the structural primary surplus target of 2.5% of GDP.

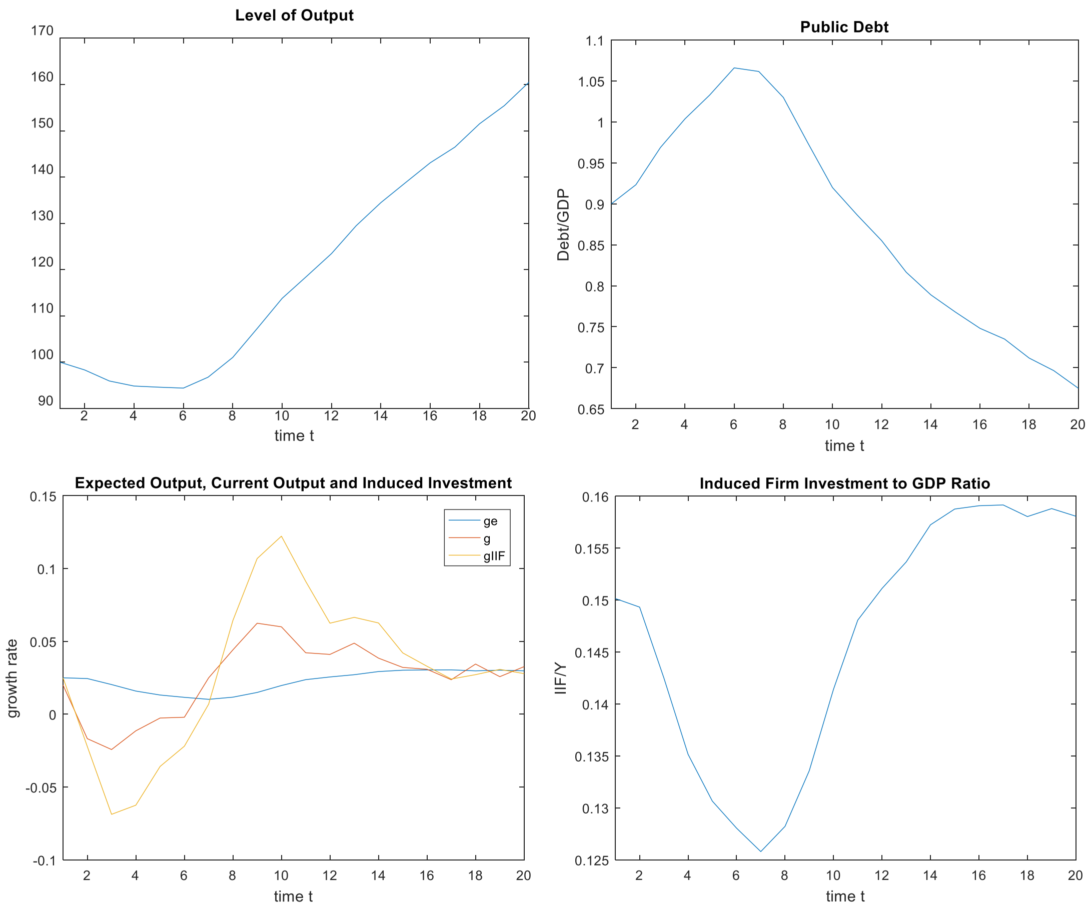
Graph 3 | Fiscal Policy – Country 1 (Brazil)



Source: own calculations.

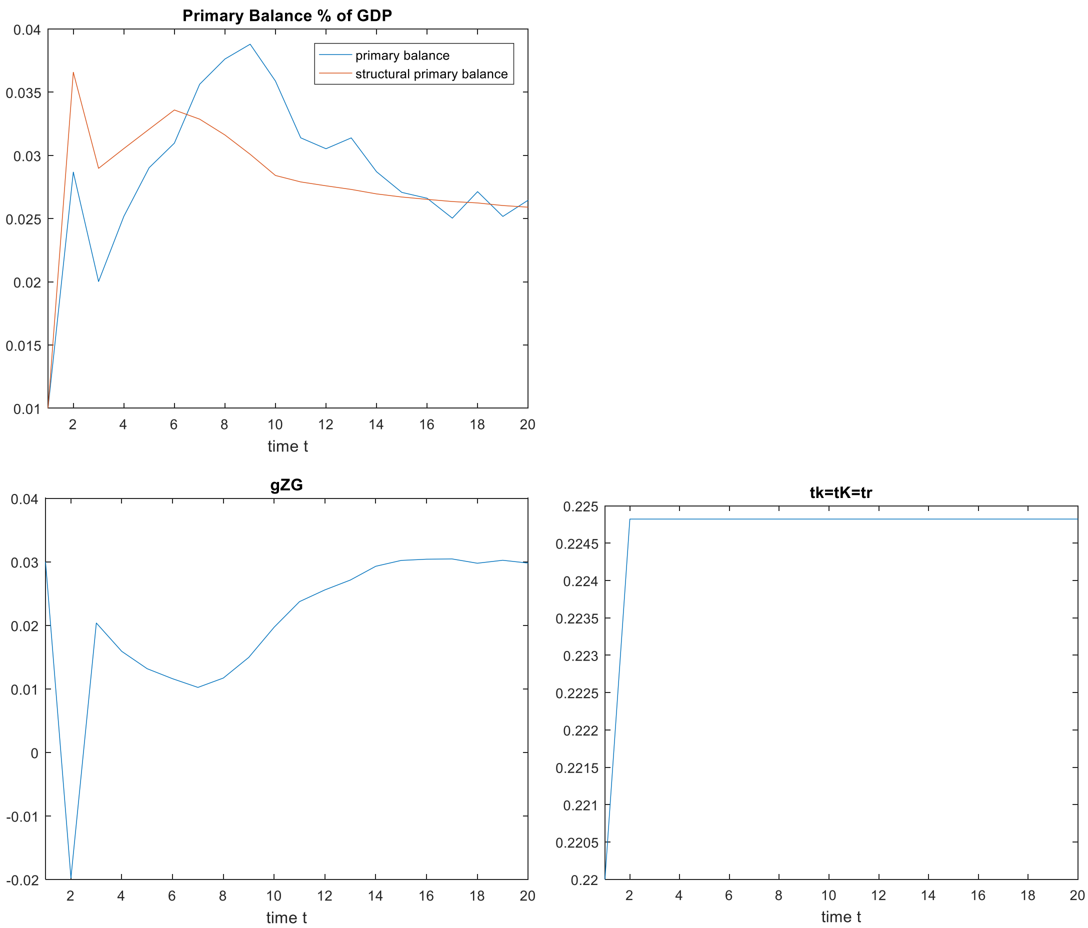
In Graph 4 and Graph 5 below, we see the performance of Country 2. Although the initial shock has a severe effect on the country in the first few years with a significant adverse impact on GDP and the debt to GDP ratio, once growth resumes, the country resumes a path of steady growth and a lowering of the debt to GDP ratio. Even if initially, in the first few periods, just as in the case of Country 1, induced firm investment falls substantially, afterward it behaves somewhat differently, not only recovering its former level but settling at a higher ratio in relation to GDP, as it adapts to a higher trend in the growth rate of the economy. These entirely different results occur with the same structural balance rule.

Graph 4 | Output, Induced Investment, and Public Debt – Country 2 (export-led)



Source: own calculations.

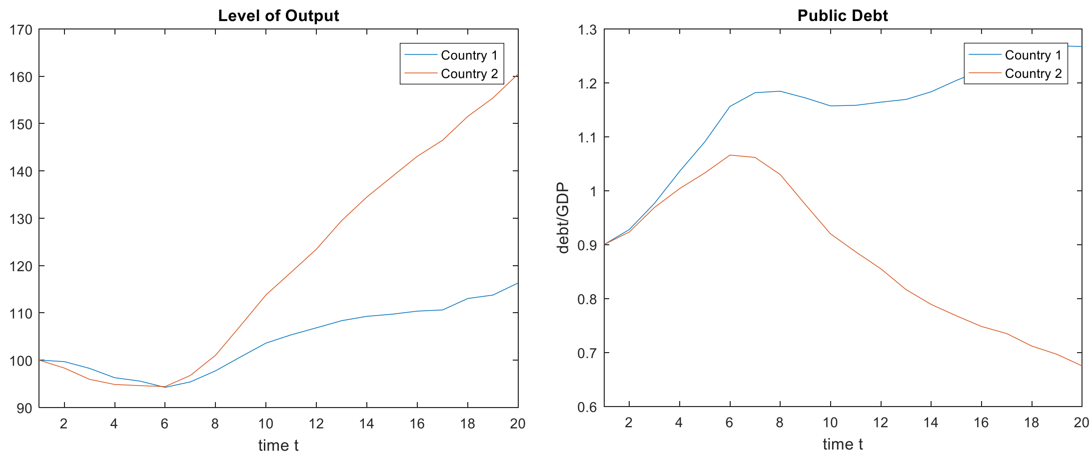
Graph 5 | Fiscal Policy – Country 2 (export-led)



Source: own calculations.

The difference in performance between countries can be better visualized in Graph 6 and Table 4 below. Although both countries experience the shock with a severe contraction, that is accentuated by a fiscal policy that seeks to increase the primary structural balance to 2.5% of GDP from an initial level of 1.0% of GDP that lasts to $t = 6$, the recovery experienced by the export-led country starting at $t = 7$ is a lot more intense.

Graph 6 | Comparing Output and Public Debt in both countries



Source: own calculations.

Table 4 | Comparing Output and Debt to GDP Levels at t=20

	At *t*=20	
	Country 1 (Brazil)	**Country 2 (Export led)**
Level of GDP	116.32	160.51
Debt/GDP (t=20)	126.74%	67.4%

Source: own calculations.

Regarding the debt to GDP ratio, both countries experience a steep rise because of the increase in the real interest rate, but this is more intense in Country 1 than in Country 2. Once GDP growth resumes in both countries (and real interest rates decrease), the ratio stabilizes and, after that, falls, but much more intensely in Country 2. But then, after a few years, the structural balance rule leads to two very different results: a continuously diminishing debt to GDP ratio in Country 2 and a self-defeating fiscal adjustment in Country 1 as debt to GDP rises with continued austerity.

This last result occurs because, in the demand-led growth setting of our model, the structural balance rule has a perverse effect on the growth of potential GDP as it is influenced by the trend rate of observed GDP growth. This feature, combined with the assumption of a relatively high government share of total autonomous demand in Country 1, makes the growth rates of total autonomous demand and GDP very sensitive to government spending growth rate changes. The latter situation leads to more austerity, reinforcing the process and opening space for the self-defeating policy scenario. On the other hand, in the case of Country 2, the relatively low share of government spending in total autonomous demand makes the growth rates of total autonomous demand and GDP less sensitive to changes in the rate of growth of government spending, which facilitates the fiscal adjustment promoted by the structural balance rule. Moreover, note that even when the primary structural balance of 2.5% of GDP is achieved and government spending growth resumes, this occurs at a much lower estimated growth for potential GDP, continuing to reinforce this perverse dynamic process. Indeed, although the latter occurs in both countries, in Country 2 this behavior is restricted to the first part of the simulation, while in Country 1 it persists throughout the entire period of 20 years.[12]

A possible critique of the stylized fiscal rule used above is that it is common practice for fiscal rules, including structural balance rules, to have escape clauses to deal with severe shocks, meaning the rule is too unrealistic to be of use. This choice of stylized rules was intentional, since it illustrates how this type of rule, like most fiscal rules, does not work adequately and has to constantly utilize its escape clause so that it does not lead to perverse results. In an IMF Staff Discussion Note, Eyraud *et al*. (2018, p. 11) point that in the three decades before 2018 fiscal rules were only adhered to approximately 50% of the time, if not considered the use of escape clauses. We argue that this tendency for fiscal rules to be broken or to utilize escape clauses is largely a result of their inadequate design that is illustrated by this need to resort constantly to escape clauses.

6. Concluding remarks

The paper argues that the composition of autonomous expenditure is an important element in explaining the causes of the differing fiscal performances under the same fiscal policy rule. We developed a supermultiplier growth model to show that this performance can differ significantly between countries depending on the government share of total autonomous demand. We suggest that in countries with a relatively high share of government expenditures in total autonomous spending, the results of fiscal rules can lead to significantly lower GDP growth and self-defeating austerity, raising instead of lowering the debt to GDP ratio. In contrast, in countries with relatively low autonomous demand shares of government spending, the same fiscal rule can have a less perverse effect on GDP growth and lead to the intended result of lowering the debt to GDP ratio.

As always is the case with simulation exercises, it is important to evaluate the robustness of our results with respect to different specifications of the model, alternative fiscal policy rules, and economic scenarios. In particular, it would be interesting to go beyond the pure demand-led growth exercise done in this paper. For instance, this could be realized by explicitly incorporating the idea of balance-of-payments constraint along the lines suggested by the literature on the Kaldor-Thirlwall model and considering the influences of external imbalances on aggregate demand growth particularly through the economic policy channel. Another interesting change in the model in the same direction would be the explicit incorporation of labor market dynamics and its repercussions on aggregate demand growth, especially through its effects on income distribution and inflation and the impact of these variables on economic policies. Finally, a significant improvement would be the explicit introduction of natural resources and environmental issues in the model and the investigation of their repercussions on aggregate demand dynamics and economic policies.

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[12] One important observation is that the structural balance rule, just as any fiscal balance rule, allows the choice to achieve the result through raising revenue or reducing spending growth in whatever proportion policymakers deem best or possible. It is important to emphasize that this choice leads to significantly different results for the simulations under the same rule. In this respect, see Ligiéro (2021, chap. 3) for simulations with the model illustrating this point.

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Appendix 1 – Exogenous variables for temporary shock scenario

T	*gX*	*gIR*	*gIAF*	*gCA*	*r*	*ω*
1	2.00%	2.00%	2.00%	2.00%	4.00%	57.0%
2	-2.00%	2.00%	1.20%	1.50%	4.00%	57.0%
3	-4.00%	1.00%	0.60%	0.75%	4.50%	56.5%
4	0.00%	-2.00%	-1.20%	-1.50%	5.00%	56.0%
5	2.00%	-4.00%	-2.40%	-3.00%	5.50%	55.5%
6	3.00%	-8.00%	-4.80%	-6.00%	6.00%	55.0%
7	4.00%	0.00%	0.00%	0.00%	5.50%	55.5%
8	6.00%	2.00%	1.20%	1.50%	5.00%	56.0%
9	8.00%	4.00%	2.40%	3.00%	4.50%	56.5%
10	6.00%	6.00%	3.60%	4.50%	4.00%	57.0%
11	3.00%	8.00%	4.80%	6.00%	4.00%	57.0%
12	4.00%	6.00%	3.60%	4.50%	4.00%	57.0%
13	6.00%	4.00%	2.40%	3.00%	4.00%	57.0%
14	4.00%	3.00%	1.80%	2.25%	4.00%	57.0%
15	3.50%	2.00%	1.20%	1.50%	4.00%	57.0%
16	3.00%	4.00%	2.40%	3.00%	4.00%	57.0%
17	2.00%	3.00%	1.80%	2.25%	4.00%	57.0%
18	4.00%	4.00%	2.40%	3.00%	4.00%	57.0%
19	2.50%	2.00%	1.20%	1.50%	4.00%	57.0%
20	3.50%	3.50%	3.50%	3.50%	4.00%	57.0%

Evolución y uso de modelos estructurales en el Banco Central de Chile

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Resumen

El Banco Central de Chile (BCC) usa varios modelos para analizar la economía chilena y ayudar a los miembros del consejo en su toma de decisiones. Su modelo estructural principal se llama XMAS y es un modelo dinámico y estocástico de equilibrio general Neo-Keynesiano con una amplia variedad de sectores, rigideces y *shocks*. Este modelo se usa de forma recurrente como parte del marco de política monetaria. Como la economía está sujeta a una continua evolución, la necesidad de nuevas herramientas para responder preguntas también evoluciona continuamente. Así, para responder nuevas preguntas, el BCC sigue una estrategia de incorporar en el XMAS sólo cambios que sean necesarios, y de crear nuevos modelos, llamados satélites, para otros cambios. Este documento presenta las características principales del XMAS y muestra ejemplos de cambios realizados en este modelo en el pasado, así como también modelos satélites.

Clasificación JEL: E12, E32, E52, E58.

Palabras clave: Chile, modelos EGDE, modelos satélite.

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Evolution and Use of Structural Models in the Central Bank of Chile

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Abstract

The Central Bank of Chile (BCC) uses various models to analyze the Chilean economy and to assist board members in their decision-making. Its main structural model is called XMAS and it is a Neo-Keynesian dynamic and stochastic general equilibrium model with a wide variety of sectors, rigidities, and shocks. This model is usually used as part of the monetary policy framework. As the economy is continually evolving, the need for new tools to answer new questions is evolving as well. Thus, to answer new questions, the BCC follows a strategy of incorporating into the XMAS only the necessary changes and creating new models, called satellites, for other issues. This document shows the main features of the XMAS and shows examples of changes made to this model in the past, as well as satellite models.

JEL Classification: E12, E32, E52, E58.

Keywords: Chile, DSGE models, satellite models.

1. Introducción

El Banco Central de Chile (BCC), como muchos otros bancos centrales, utiliza varios modelos para analizar las condiciones de la economía y poder ayudar a los miembros del Consejo en sus decisiones de política monetaria. Estos modelos ayudan a comprender los mecanismos inherentes en la economía y, en especial, los mecanismos de transmisión de la política monetaria. Ayudan también a proyectar la inflación y otras variables importantes y a evaluar cómo respondería la economía a diferentes eventos y trayectorias de la tasa de política monetaria. Debido a que un solo modelo no puede ayudar a responder todas las preguntas de interés, el análisis realizado en el BCC generalmente depende de un grupo de modelos, que van desde modelos empíricos simples hasta modelos dinámicos y estocásticos de equilibrio general (DSGE, por sus siglas en inglés) de gran tamaño.

El BCC actualizó recientemente su marco de política monetaria (Banco Central de Chile, 2019) y, como complemento, publicó un libro que documenta los modelos macroeconómicos y su uso en el BCC (Banco Central de Chile, 2020). Ese libro es una actualización y una mejora sustancial de un documento anterior. Es parte de un esfuerzo hecho por el Banco para aumentar y mejorar su transparencia y comunicación con el resto de la economía, ayudando a comprender mejor cómo hace su política. Este documento se basa principalmente en ese libro de modelos y los trabajos ahí citados, que contienen todas las ecuaciones y otros detalles de los modelos.

El principal modelo DSGE utilizado en el BCC se llama XMAS y se usa recurrentemente para el análisis de política monetaria. Este es un modelo con un gran número de rigideces nominales y reales y un gran número de *shocks*. Sus principales agentes son hogares, empresas, las autoridades fiscal y monetaria, y el sector externo. Tiene una amplia variedad de bienes, incluyendo un bien minero que se exporta íntegramente, otros exportables, bienes importables y también bienes de producción local. Su mercado laboral presenta fricciones de búsqueda y emparejamiento. Finalmente, hay un grupo de parámetros que se calibra y otro que se estima utilizando un conjunto de importantes series macroeconómicas.

El BCC también tiene otros modelos DSGE, generalmente más pequeños, llamados modelos satélites. Estos se utilizan principalmente para preguntas que el XMAS no está diseñado para responder o en las que se necesita mayor detalle en su respuesta. En el BCC, hay un departamento especializado con una agenda de investigación en constante evolución, que se centra en desarrollar nuevos modelos o mejorar las características de los modelos existentes. La inclusión de nuevos proyectos a la agenda de modelización se decide según lo que se considere necesario para mejorar el análisis económico, ahora o en el futuro.

Ejemplos de mejoras de modelos existentes incluyen la incorporación de *shocks* migratorios y el modelamiento explícito del co-movimiento de los precios externos de Chile al XMAS. Cuando se creó el XMAS, la inmigración en Chile no era muy importante y, por eso, el supuesto de una población o fuerza laboral constante era acertado. Luego, a partir del 2015-2016, Chile empezó a recibir un gran número de inmigrantes y la necesidad de estudiar su efecto e incluirlo en los análisis recurrentes se volvió muy importante. El segundo ejemplo es la incorporación explícita del co-movimiento de precios externos, que ocurrió alrededor de 2016. Este implicó cambiar el modelo de precios externos, que asumía independencia completa entre ellos, a permitir un factor común que mueve todos los precios al mismo tiempo. De esta forma, todos los precios externos del XMAS son función del factor común y de un *shock* idiosincrásico, estimando con los datos relevantes sus respectivos pesos. Cabe destacar que el supuesto de independencia de los precios es una posibilidad en la nueva formulación, llevando a que, si los precios fueran de verdad independientes, la estimación conduciría a una importancia baja del factor común, lo que no es el caso.

En otras ocasiones, las preguntas de investigación se responden desarrollando nuevos modelos. Esto se debe a que, aunque las preguntas o nuevos desarrollos sean significativos, necesarios de estudio o recurrentes, no siempre deben abordarse dentro de los modelos principales. Agregar una característica a un modelo, aunque puede aumentar su realismo, generalmente también aumenta su complejidad. Si bien lo primero es algo deseable, lo segundo no lo es, ya que puede empeorar su manejo y la precisión de sus proyecciones. Es necesario un análisis cuidadoso de los beneficios y costos de incluir una característica en uno de los modelos principales o si se hace un modelo satélite. Ejemplos recientes incluyen, entre otros, un modelo DSGE con bienes transables y no transables construido para estudiar el efecto inflacionario de los movimientos del tipo de cambio nominal en diferentes sectores de la economía, y un modelo de generaciones traslapadas (OLG, por sus siglas en inglés) construido para estudiar el impacto de posibles cambios en el sistema chileno de pensiones.

El documento continúa de la siguiente manera. La siguiente sección describe el XMAS con sus principales supuestos y mecanismos. La sección 3 analiza uno de los cambios recientes introducidos en el modelo XMAS, que corresponde a la migración. La sección 4 muestra dos modelos satélites, uno que responde a una pregunta con más detalle que el XMAS, el modelo transable/no-transable, y otro que responde a preguntas específicas que el XMAS no fue diseñado para abordar, el modelo OLG. Finalmente, la sección 5 concluye.

2. El XMAS: modelo extendido para análisis y simulación

El principal modelo estructural del BCC se llama XMAS, lo que significa modelo extendido para análisis y simulación por sus siglas en inglés (Extended Model for Analysis and Simulation) y es la extensión del modelo anterior del Banco, el MAS, cuyas siglas en inglés corresponden a modelo para análisis y simulación (Model for Analysis and Simulation). El MAS fue desarrollado por Medina y Soto (2007) y fue el primer gran modelo DSGE desarrollado en el BCC para el análisis y proyecciones de política. Este modelo se usó desde su creación y fue continuamente modificado, hasta que en 2016 se empezó una modificación formal a cargo de un grupo de economistas del BCC que terminó en el trabajo de García *et al*. (2019).[1]

La versión actual de XMAS comparte una estructura similar con modelos de otros bancos centrales con metas de inflación. Estos modelos se caracterizan generalmente como Neo-Keynesianos con rigideces nominales para generar no neutralidad monetaria; capital y trabajo como insumos

[1] Medina y Soto (2007) tiene una descripción completa del MAS y García *et al.* (2019) tiene una sección que compara la dinámica del MAS y XMAS explicando los efectos de los cambios más importantes.

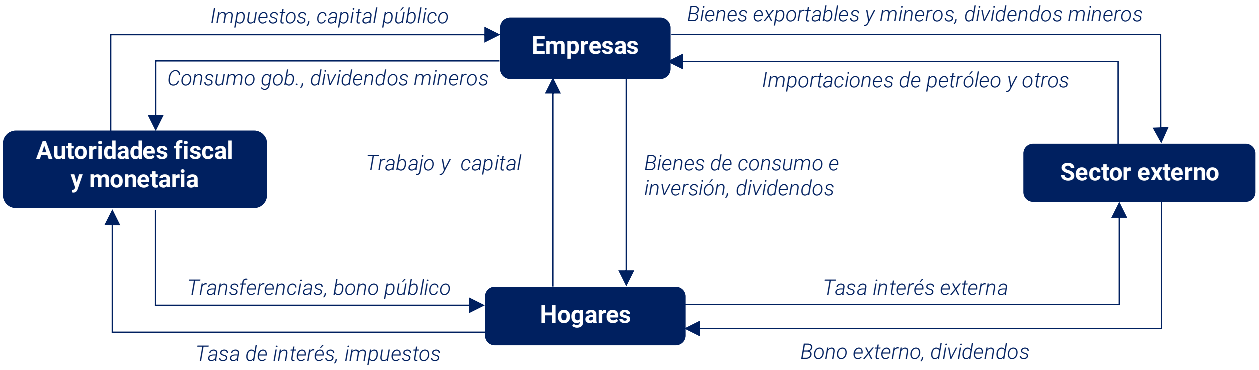
de producción; diferentes bienes que se exportan, importan o venden localmente; y políticas monetarias y fiscales, entre otras características. También tiene algunas características específicas de la economía chilena, como un sector minero y una regla estructural para el gasto fiscal.

El XMAS se puede describir en breve como un modelo DSGE de economía pequeña y abierta, con rigideces nominales y reales, hogares ricardianos y no ricardianos. Los bienes nacionales se producen con capital y trabajo, hay formación de hábitos en el consumo, costo de ajuste en la inversión, empresas que enfrentan un problema de precios tipo Calvo (Calvo, 1983) con indexación parcial y un traspaso imperfecto del tipo de cambio a precios de importación en el corto plazo debido a rigideces de precios en moneda local. El mercado laboral tiene desempleo involuntario debido a fricciones de búsqueda y emparejamiento con separaciones endógenas. La economía exporta un bien de producción local y un *commodity*. El modelo incluye varios *shocks* internos y externos, como preferencias, tecnología, PIB externo y precios internacionales, entre muchos otros. Los parámetros del modelo se fijan en parte a través de calibración y en parte a través de estimación utilizando técnicas bayesianas.

El XMAS, como cualquier modelo, tiene limitaciones importantes. Por ejemplo, presenta fricciones financieras muy limitadas, expectativas racionales como su supuesto de formación de expectativas y heterogeneidad limitada de agentes. Muchas de sus limitaciones ya son abordadas en otros modelos del BCC y otras son parte de la agenda futura de modelación.

A continuación, describiremos la estructura del XMAS y los problemas que enfrentan sus agentes.[2] Como se muestra en el Esquema 1, el XMAS tiene cuatro bloques principales interconectados: hogares, empresas, las autoridades fiscal y monetaria, y el sector externo. Todos los agentes están conectados, directa o indirectamente, entre sí. Los hogares compran bienes y reciben dividendos de las empresas y les ofrecen su trabajo y capital. Pagan impuestos y reciben transferencias de la autoridad fiscal y pueden comprar un bono público, cuya tasa de interés es la fijada por la autoridad monetaria. También pueden comprar un bono extranjero, por el que reciben una tasa de interés externa, y obtienen dividendos de empresas externas.

Esquema 1 | Principales agentes del XMAS



[2] Para mayores detalles, como todas las ecuaciones, ver García *et al.* (2019) y para los códigos de replicación y detalles de estimación, ver el repositorio en línea de Banco Central de Chile (2020).

Las empresas, además de la conexión con los hogares, pagan impuestos, usan capital público, venden sus bienes al gobierno y dan dividendos mineros. Por último, venden sus bienes mineros y exportables al sector externo y compran importaciones, las cuales son petróleo y no-petróleo. Las empresas mineras son parcialmente propiedad de extranjeros.

2.1. Hogares

Hay dos tipos de hogares, restringidos y no restringidos, y todos tienen la misma función de utilidad. Los miembros de los hogares pueden estar empleados o desempleados. Derivan utilidad del consumo de bienes públicos y privados (con hábitos) y del ocio, definido como horas no trabajadas. Como Merz (1995), los miembros de cada hogar comparten riesgos.

Los hogares no ricardianos o restringidos solo enfrentan el problema de consumir sus ingresos netos de impuestos y transferencias. Dentro de sus ingresos se encuentran los salarios de los trabajadores empleados, el seguro de desempleo de los desempleados y transferencias de monto fijo del gobierno. Por otro lado, los gastos de los hogares incluyen el pago de impuestos al consumo y a los ingresos laborales, que incluye un impuesto salarial general y una contribución al fondo del seguro de desempleo; e impuestos de suma alzada que puede poner la autoridad fiscal.

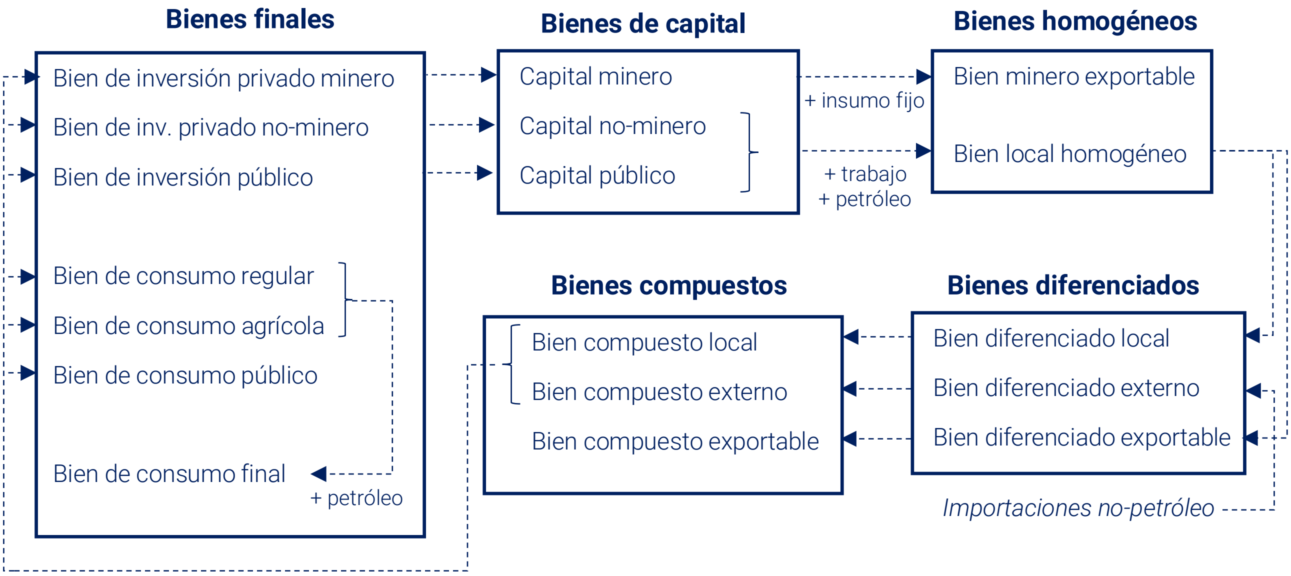
En cambio, los hogares ricardianos o no restringidos tienen variables de decisión adicionales. Ellos también reciben pagos provenientes de ser dueños de las empresas (nacionales y externas), del arriendo de los bienes de capital y de activos financieros. Por otra parte, sus gastos incluyen inversión en bienes de capital (con costos de ajuste), compra de bonos locales y externos y el pago de impuestos sobre dividendos e ingresos de capital.

2.2. Empresas

Hay cinco tipos de bienes producidos en un sistema circular: bienes de capital, bienes homogéneos, bienes diferenciados, bienes compuestos y bienes finales. La estructura insumo-producto que vincula los diferentes tipos de bienes se resume en el Esquema 2.

Primero, hay tres bienes de capital, minero, no minero (ambos privados) y público. Cada uno se produce utilizando bienes de inversión específicos de cada sector. Las empresas productoras son perfectamente competitivas. Las decisiones de inversión óptimas son tomadas por distintos actores: la empresa minera toma la decisión de inversión minera, los hogares de inversión no minera, y el gobierno de inversión pública. La decisión óptima de inversión minera depende de sus costos, que son una restricción *time-to-build* y las tasas de interés actuales y esperadas, y los beneficios esperados. La decisión óptima de inversión no minera depende de sus costos alternativos y directos, incluidos los costos de ajuste de capital para evitar fluctuaciones excesivas de inversión, las tasas de interés y la utilidad marginal del consumo, y los beneficios derivados de la tasa de alquiler de capital esperada futura. Finalmente, la inversión pública fluctúa estocásticamente alrededor de un nivel determinado por la regla de balance estructural del gasto público.

Esquema 2 | Estructura productiva del XMAS



En segundo lugar, está la producción de bienes homogéneos realizada por empresas representativas con competencia perfecta. Como se muestra en el Esquema 2, se producen dos bienes: un bien minero exportable y un bien local homogéneo. El bien minero exportable se fabrica utilizando capital específico del sector, así como también un insumo fijo. El bien local homogéneo se produce utilizando capital privado no minero, capital público, trabajo y petróleo. Ambos sectores están sujetos a *shocks* de productividad idiosincrásicos.

En tercer lugar, tenemos la producción de bienes diferenciados que, como se muestra en el Esquema 2, son de tres tipos: bienes diferenciados locales, bienes diferenciados externos y bienes diferenciados exportables. Los productores de bienes diferenciados actúan bajo competencia monopolística y están sujetos a rigideces de precios, pudiendo escoger sólo de forma aleatoria precios óptimamente, siguiendo a Calvo (1983). Las empresas que no pueden elegir precios de manera óptima actualizan sus precios utilizando un promedio ponderado de la inflación pasada y la meta de inflación del banco central. La indexación a la inflación pasada genera efectos adicionales en la dinámica de precios. La tecnología de estas empresas requiere una unidad del bien homogéneo para producir una unidad del bien diferenciado. Los bienes locales y exportables diferenciados se producen utilizando bienes locales homogéneos. Por el contrario, el bien externo diferenciado se produce con importaciones no-petróleo.

En cuarto lugar, viene la producción de bienes compuestos. Estos bienes son fabricados por empresas representativas bajo competencia perfecta que combinan diferentes variedades de bienes diferenciados en un compuesto. Hay tres tipos de bienes compuestos: bienes locales, bienes externos y bienes exportables. Los dos primeros se venden localmente, mientras que el tercero se exporta íntegramente.

En quinto y último lugar, tenemos la producción de bienes finales, que es realizada por empresas representativas perfectamente competitivas. Como se muestra en el Esquema 2, estos bienes se pueden separar entre bienes de inversión y bienes de consumo. Los bienes de inversión además se separan en bienes de inversión privada minera, de inversión privada no-minera y de inversión pública. Los bienes de consumo se separan en consumo regular, consumo agrícola (alimentos), consumo de gobierno y bienes de consumo final. Este último es una mezcla de los bienes de consumo regular y agrícola con petróleo. Todos los bienes de inversión y todos los de consumo, menos los bienes de consumo final se fabrican combinando bienes compuestos locales y externos. La producción del bien agrícola está sujeta a un *shock* de productividad idiosincrásico adicional para dar cuenta de la mayor volatilidad de ese sector.

2.3. Autoridades fiscal y monetaria

El gobierno sigue una regla de balance estructural en la que sus ingresos a largo plazo determinan los gastos. Estos gastos incluyen el consumo del gobierno, la inversión pública y las transferencias a los hogares. Los ingresos del gobierno provienen de los impuestos, la propiedad de empresas mineras y la emisión de nueva deuda pública. Además, utilizando una combinación de subsidios e impuestos variables, el gobierno reduce la volatilidad del precio interno del petróleo, de acuerdo con el marco MEPCO.[3]

El banco central, por su parte, sigue una regla de Taylor, que depende de la desviación de una medida de inflación (una suma ponderada de la inflación total y subyacente, actual y esperada) de la meta; y la desviación del crecimiento de su nivel a largo plazo. La regla también incluye un rezago de la tasa anterior y un *shock*, el cual tiene correlación serial positiva siguiendo a Arias y García-Schmidt (2018).

2.4. Sector externo

El sector externo corresponde al resto del mundo. Los agentes de este bloque fijan precios internacionales, venden importaciones de petróleo y no-petróleo, compran el bien compuesto exportable y el bien minero, ofrecen bonos externos y reciben rentas por la propiedad parcial del sector minero.

Los precios externos se modelan dependiendo de un *shock* común y uno específico a cada precio. El factor común, así, afecta con distintos pesos a los precios del petróleo, el bien minero, el bien importable no-petróleo y el índice de precios del resto del mundo.

La depreciación nominal está determinada por una condición de paridad de tasas de interés descubierta que surge de la igualación del rendimiento esperado que los hogares ricardianos pueden obtener ahorrando en bonos locales y externos. Esta condición de paridad iguala la tasa devengada por los bonos en moneda nacional, dada por la tasa de política monetaria, y los bonos en moneda

[3] MEPCO (Mecanismo de Estabilización de Precios de Combustibles) es un mecanismo que evita fluctuaciones excesivas del precio local de los combustibles pese a haber fluctuaciones excesivas internacionalmente.

extranjera. Los bonos en moneda extranjera pagan la tasa de interés mundial libre de riesgo ajustada por las primas de riesgo observadas (deuda local como % del PIB) y no observadas.

2.5. Mercado del trabajo

El mercado laboral se modela con fricciones de búsqueda y emparejamiento como en Mortensen y Pissarides (1994), permitiendo separaciones tanto exógenas como endógenas, como en Cooley y Quadrini (1999) y den Haan *et al.* (2000). Siguiendo a Boscá *et al.* (2011), un sindicato negocia un contrato laboral único, por lo que las empresas son indiferentes entre los distintos trabajadores. Por lo tanto, todos los trabajadores reciben el mismo salario, trabajan la misma cantidad de horas y tienen la misma probabilidad de estar empleados.

En cada período, una fracción de las relaciones laborales se destruye de forma exógena. Las relaciones que sobreviven pueden separarse endógenamente dependiendo del costo de operación estocástico idiosincrásico del trabajador. Una tecnología de *matching* determina las nuevas contrataciones del período en función de los trabajadores desempleados que buscan empleo y las vacantes disponibles. Las empresas, que son maximizadoras de utilidad, determinan de manera óptima el número de vacantes disponibles y las terminaciones de relaciones laborales en cada período. El salario ganado por los trabajadores empleados y el esfuerzo laboral son el resultado de un proceso de negociación entre las empresas y el sindicato.

2.6. Shocks y mecanismos de transmisión

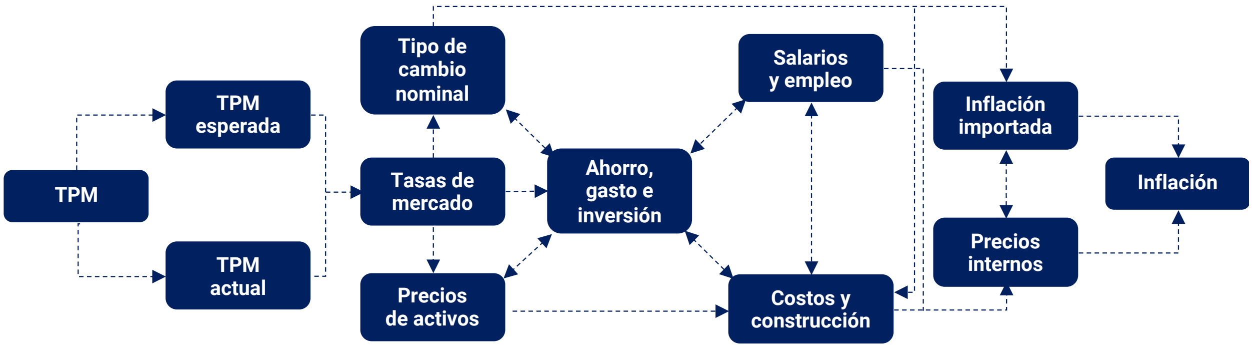
Hay 23 *shocks* en esta economía:

- *Shocks locales (14):* a las preferencias intertemporales de los hogares; a la desutilidad laboral; a la productividad marginal de la inversión (minera y no minera); a la productividad en la producción del bien minero exportable, del bien local homogéneo y del bien agrícola; a la productividad permanente; al consumo del gobierno; a la inversión pública; a las transferencias gubernamentales; a la tasa exógena de destrucción de empleo; al precio del petróleo local; y un *shock* de política monetaria.

- *Shocks externos (9):* a la tasa de interés internacional libre de riesgo; al premio de riesgo país; al premio no observado de la condición de paridad de tasas descubierta; a la demanda externa del bien compuesto exportable; al factor común de los precios internacionales y a cada precio externo por separado (petróleo, importaciones no-petróleo, bien minero e índice de precios externos).

Cada *shock* afecta a la economía de diversas formas a través de canales directos e indirectos, dada la interacción de cada detalle del modelo. A modo de ejemplo, y con la ayuda del Esquema 3, revisaremos los efectos inflacionarios y el mecanismo de transmisión de un *shock* monetario.

Esquema 3 | Canales de transmisión de la política monetaria en el XMAS



Nota: TPM se refiere a la tasa de política monetaria.

Un *shock* de política monetaria afecta las tasas de política monetaria actuales y esperadas. Ambos cambios afectan las tasas de mercado y los precios de los activos. En una economía como Chile, abierta al mercado internacional de capitales, los cambios en el diferencial de tasas de interés locales y externas afectan al tipo de cambio, tanto actual como esperado. Las expectativas de depreciación nominal se ajustan en el monto requerido para igualar el rendimiento esperado de los bonos denominados en moneda local y externa. En este contexto, los aumentos en las tasas de política monetaria se asocian a una apreciación del tipo de cambio nominal, mientras que las disminuciones a una depreciación. Los movimientos del tipo de cambio nominal afectan la inflación tanto directa como indirectamente. Directamente a través de la inflación importada y costos de producción, e indirectamente a través de su efecto sobre los precios relativos y, por lo tanto, las decisiones de ahorro, gasto e inversión.

Otro canal por el cual un cambio de política monetaria afecta a la inflación es a través de cambios en las decisiones de ahorro, gasto e inversión. Un aumento de las tasas de interés, incrementa el rendimiento de los ahorros, lo que hace que los hogares ricardianos pospongan su gasto e inversión. Una disminución de la tasa de interés, en cambio, hace que los hogares consuman e inviertan más hoy, reduciendo así sus ahorros.

Debido a que los precios relativos cambian la decisión marginal de trabajar, los canales de transmisión mencionados anteriormente también afectan los salarios y el empleo. A su vez, los cambios en el mercado laboral afectan los costos de producción de las empresas y, por lo tanto, sus decisiones de precios.

Todos estos canales se suman y se refuerzan entre sí, por lo que el efecto final será una combinación de efectos directos, indirectos y de equilibrio general.

2.7. Datos y estimación

Los parámetros del modelo se obtienen mediante una combinación de calibración y estimación. Los parámetros calibrados se obtienen de acuerdo con la literatura relacionada y algunos también se fijan como promedios u otros momentos relevantes de largo plazo de los datos.

Para estimar los parámetros restantes, se usan 24 series trimestrales locales y externas entre 2001 y 2017, período en el que el BCC ha seguido un régimen de metas de inflación con una tasa de interés nominal como instrumento de política. Entre las series locales están, por ejemplo, componentes del PIB, precios, salarios, empleo, consumo del gobierno, tasas de interés y tipo de cambio nominal. Por otro lado, entre las series externas, se encuentran precios externos (del bien minero, del petróleo y de la inflación extranjera), la tasa de interés externa y el PIB de los socios comerciales.

2.8. Uso del modelo

En el BCC, el modelo XMAS está en el centro del proceso de proyecciones de mediano plazo, junto con el modelo semi-estructural MSEP, descrito en Arroyo *et al.* (2020). Dado un conjunto de observables, que normalmente incluyen datos reales, proyecciones de corto plazo de modelos econométricos para variables nacionales, y proyecciones de corto y mediano plazo de modelos econométricos y estructurales para el resto de la economía mundial, el modelo XMAS produce proyecciones consistentes para todas sus variables endógenas. Estas trayectorias proyectadas son uno de los principales insumos para la elaboración del escenario central de proyección que se realiza 4 veces al año para el análisis de política y como parte del IPoM (Informe de Política Monetaria del BCC).

Es importante señalar que la elaboración del escenario central de proyección se realiza en un proceso que tiene muchos pasos y dura varias semanas.[4] De forma general, se puede separar en tres bloques: la proyección de variables externas, la proyección de variables locales de corto plazo y, finalmente, la proyección de variables locales de mediano plazo, que utiliza como insumos las dos primeras partes y es para la que se usa el XMAS. Cada paso del proceso incluye no solo modelos y datos, sino también juicio. A veces, el juicio es necesario por falta de datos y otras veces complementa información de datos disponibles. Esto es muy importante para asegurarse que las proyecciones tengan sentido y tengan la mejor cantidad y calidad de información disponible. Es de suma importancia tener la flexibilidad para incluir juicio debidamente justificado, porque esta inclusión genera mejores proyecciones y ayuda en el análisis.

La naturaleza del XMAS también permite su utilización en otros dos casos. Primero, el modelo puede descomponer las trayectorias históricas y proyectadas de los *shocks* subyacentes que están detrás de los movimientos de las variables endógenas. Esta característica permite que el modelo se utilice no solo para obtener proyecciones de las variables de interés, sino también para tener una idea de los *shocks* que impulsaron los movimientos. Es importante contrastar esta información con la visión del *staff* y del Consejo para entender todos los mecanismos y poder explicar los movimientos de forma coherente.

En segundo lugar, la naturaleza estructural del modelo lo convierte en una herramienta ideal para el análisis de escenarios hipotéticos, lo que resulta de mucha utilidad para evaluaciones de riesgo y sensibilidad. Los análisis de sensibilidad también son una parte principal de la discusión de polí-

[4] El capítulo 2 de Banco Central de Chile (2020) tiene una descripción detallada del proceso y el capítulo 3 y 4 describen los modelos usados en él.

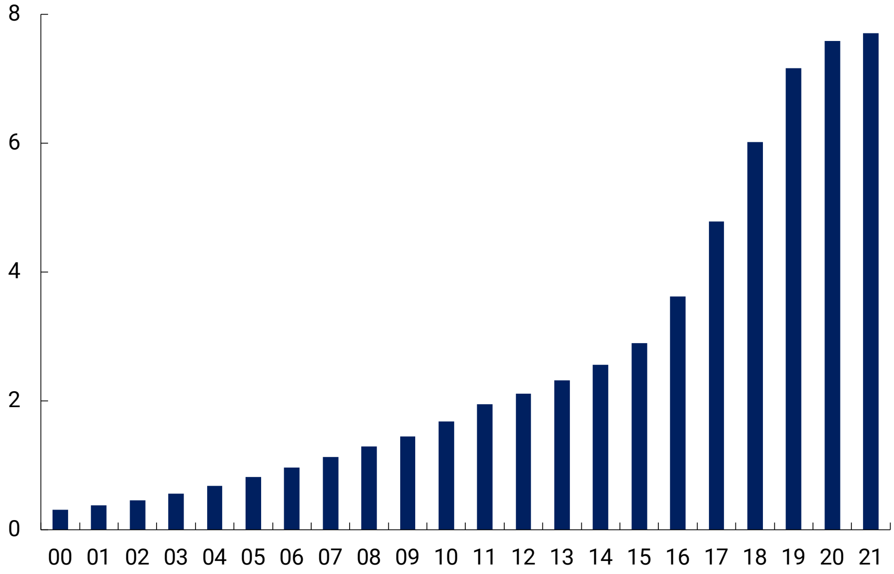
tica monetaria y del IPoM porque muestran las implicancias cuantitativas de la ocurrencia de algunos *shocks* que, pese a no estar en el escenario central, si pueden ocurrir. Es muy importante para el manejo de riesgos tener una idea de cómo posibles *shocks* afectarán a la economía.

3. Introduciendo migración en el XMAS

Chile no era un país que solía recibir muchos inmigrantes, a diferencia de Estados Unidos o muchos países de Europa. Como muestra la Gráfico 1, en 2007, cuando se desarrolló el modelo MAS, la proporción de extranjeros como porcentaje de la población total era sólo alrededor del 1%. Incluso en 2015, cuando comenzó el desarrollo del XMAS, los inmigrantes representaban menos del 3% de la población. Sin embargo, a partir de 2016 se produjo un aumento significativo de los flujos migratorios. Estimaciones recientes para 2021 muestran que la fracción de extranjeros es alrededor del 7,5% de la población total.

La magnitud de los nuevos inmigrantes fue sustancial y no se espera que desaparezca. Por lo tanto, es muy importante analizar los efectos de un *shock* migratorio en la economía y en el XMAS. García y Guerra-Salas (2020) encontraron una manera limpia y directa de incluir tal *shock* en el XMAS, y analizaron distintos supuestos asociados al actuar de los inmigrantes, que de hecho cambian su dirección inflacionaria. Esta sección ofrece una visión general de cómo se incluyó dicho cambio y las principales conclusiones.

Gráfico 1 | Estimación del número de extranjeros como porcentaje de la población total



Fuente: Instituto Nacional de Estadísticas (INE).

3.1. El modelo

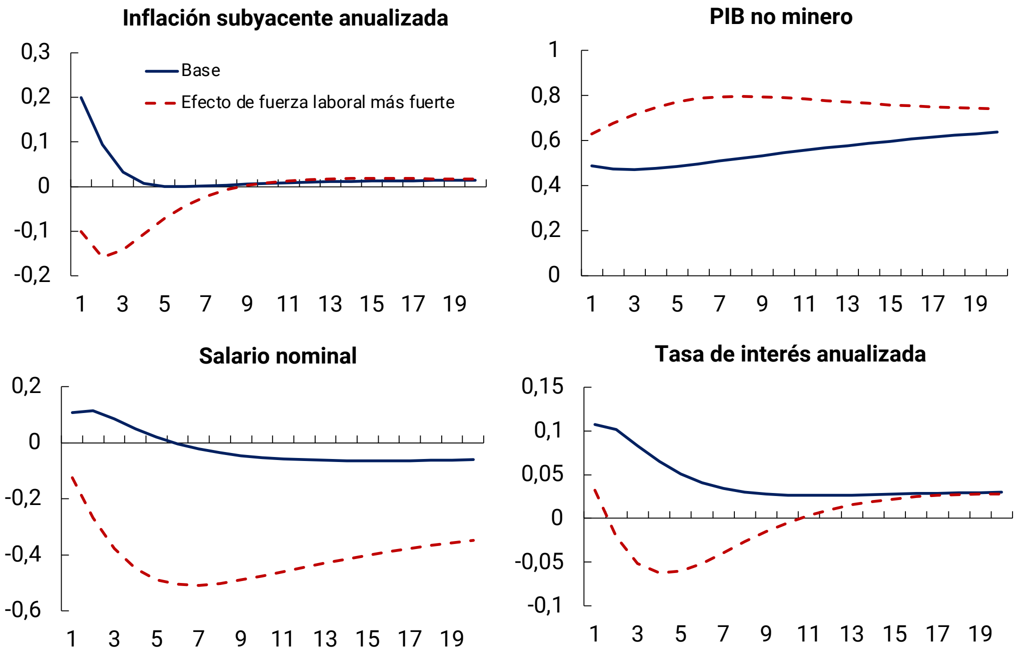
Como explican García y Guerra-Salas (2020), el efecto *a priori* de un *shock* migratorio en la inflación es ambiguo. Por un lado, al aumentar la población, aumenta el consumo agregado, creando un canal de demanda que aumenta la inflación. Por otro lado, más personas ingresan al mercado laboral, lo que lo debilita, creando un canal de oferta laboral que contiene el crecimiento salarial y genera presiones desinflacionarias.

El principal cambio en el modelo es permitir una variación exógena en el tamaño de la fuerza laboral. El *shock* migratorio es así un aumento exógeno y cuasi-permanente en la fuerza laboral (el tamaño del hogar). Se asume que los inmigrantes llegan desempleados y deben buscar trabajo.

La especificación base asume que los inmigrantes no experimentan un período de subempleo (modelado como una menor productividad de los inmigrantes recién llegados al estar activo), que no envían remesas y que no están dispuestos a trabajar por un salario menor a los chilenos (modelado como una desutilidad de trabajar distinta para la proporción de inmigrantes al estar activo). García y Guerra-Salas (2020) también incluyen en su análisis los efectos de relajar cada uno de estos supuestos, mostrando que las consecuencias inflacionarias cambian significativamente.

Bajo los supuestos base, el canal de demanda del shock migratorio domina. Esto hace aumentar precios, salarios, PIB y tasas de interés, como se muestra en el Gráfico 2.

Gráfico 2 | Respuestas de distintas variables de interés a un flujo migratorio



Fuente: García y Guerra-Salas (2020).

El Gráfico 2 también nos permite ver los efectos del mismo *shock* migratorio, pero bajo el supuesto de que los inmigrantes están dispuestos, en el corto plazo, a trabajar por salarios más bajos. Como podemos ver, en este caso, el efecto oferta domina, lo que implica menores precios, tasas de interés y mayor producción. En su trabajo, García y Guerra-Salas (2020) también describen y analizan otros valores de los parámetros. Según la especificación preferida y en uso en el BCC, los efectos inflacionarios de los canales de oferta y demanda mayormente se cancelan.

3.2. Uso del modelo

Dada la dinámica migratoria observada, el BCC necesitaba tener un modelo que pudiera analizar los efectos y las implicancias para la política monetaria de este *shock*. La evaluación realizada fue que, dado que no se esperaba que los patrones de migración se revirtieran en el corto plazo, y este cambio puede tener efectos en todos los sectores de la economía, era útil incluir estas características directamente en XMAS, en lugar de utilizar un modelo satélite.

Para la estimación y la proyección del modelo se agregó como serie observada la participación de inmigrantes en la fuerza laboral, lo que permite identificar el impacto de los *shocks* migratorios en cada variable, tanto de forma histórica como en su proyección.

4. Ejemplos de modelos satélite

Como cualquier modelo es, en definitiva, una simplificación de la realidad, siempre se dejan fuera muchas alternativas y posibles especificaciones. El XMAS, como modelo principal para el análisis y las proyecciones del BCC, debe incluir únicamente los agentes y supuestos críticos que deben estar siempre presentes. Sin embargo, no necesariamente incluye todas las características, fricciones o agentes que, aunque a veces son muy importantes, no son siempre necesarios de incluir.

Como estrategia, el BCC desarrolla y utiliza modelos satélites para los casos en los que es necesario ser más específico en el análisis o proyecciones, o responder preguntas que el XMAS no está diseñado para responder en detalle. En esta sección, describimos brevemente dos de estos modelos, la razón de su existencia y uso actual: uno diseñado para estudiar la propagación sectorial de cambios en el tipo de cambio nominal, y otro desarrollado para estudiar las implicaciones económicas de cambios en el sistema de fondos de pensiones.

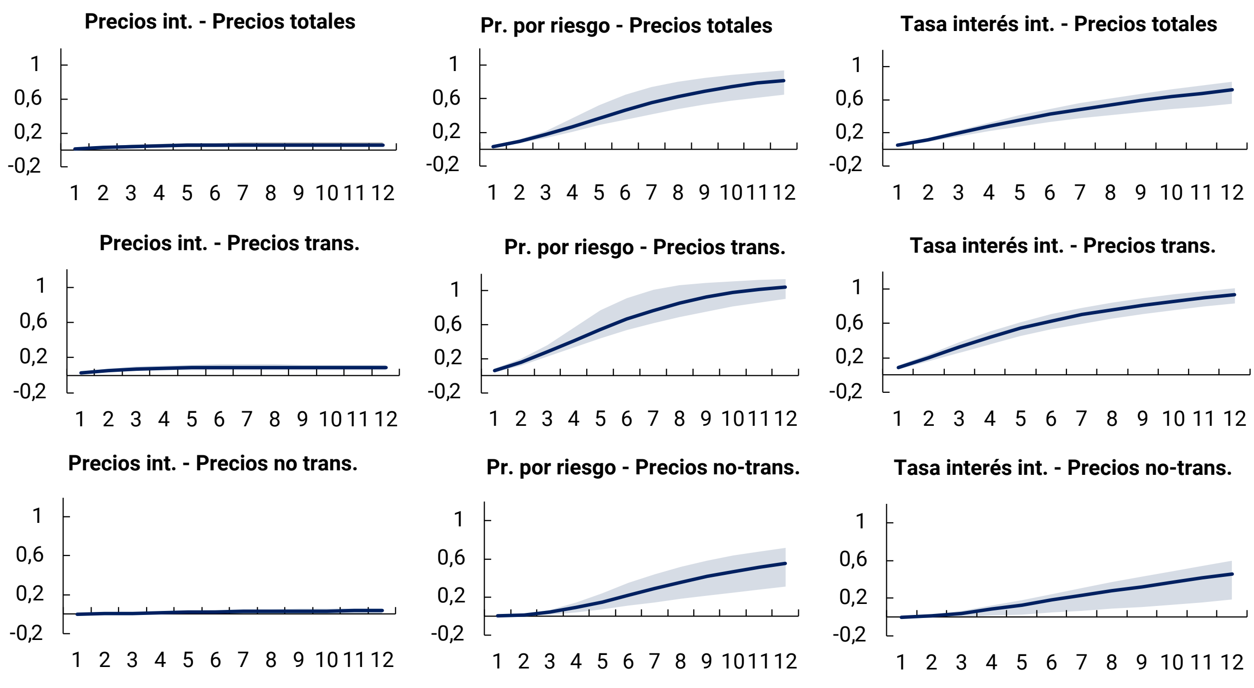
4.1. Un modelo de bienes transables y no transables para estudiar el efecto inflacionario de movimientos cambiarios

El modelo, descrito en García-Cicco y García-Schmidt (2020), incluye bienes transables y no-transables (por eso TNT), para caracterizar los diferentes mecanismos de transmisión de las variaciones del tipo de cambio nominal en diferentes sectores de la economía. El modelo resalta que, por una parte, dado un cambio del tipo de cambio, no todos los sectores se ven afectados de la misma manera y, por la otra, que no todos los *shocks* que afectan al tipo de cambio tienen las mismas consecuencias en la economía local y, por lo tanto, requieren la misma respuesta de política. Las principales diferencias con el XMAS son la inclusión del sector no-transable y el uso de un insumo importado más general para producir el bien exportable no minero y el bien no-transable. A cambio de estas adiciones, el modelo presenta una versión simplificada del problema del gobierno, la estructura del mercado laboral y otras características no esenciales.

El modelo TNT se usa frecuentemente en el BCC, particularmente en momentos de grandes movimientos en el tipo de cambio nominal. Las preguntas típicas a responder son: ¿qué *shock* originó el movimiento? ¿cuánto tiempo afectará ese *shock* a los diferentes sectores de la economía? y ¿cómo debería responder la política monetaria? El Gráfico 3 muestra el traspaso del tipo de cambio a distintos precios (ERPT, por sus siglas en inglés) de los tres *shocks* que más afectan al tipo de cambio nominal. La primera columna muestra el traspaso después de un *shock* que afecta todos los precios internacionales, la segunda columna es después de un *shock* a la prima por riesgo de la paridad descubierta de tasas de interés y la tercera columna es después de un *shock* a la tasa internacional libre de riesgo. La primera línea muestra los efectos en los precios locales totales, la segunda en los precios transables y la tercera en los precios no transables.

Una de las conclusiones que se destacan con este modelo, que se muestra en las diferentes filas del Gráfico 3, es que los *shocks* afectan a los sectores de la economía de manera muy diferente en términos de la magnitud y el momento de los efectos. Los efectos en el sector transable (segunda fila) son más inmediatos y de corta duración, mientras que en el sector no-transable (tercera fila) aparecen más tarde y duran más. La razón detrás de esta respuesta tardía pero persistente es que, si bien el sector no-transable no se ve tan directamente afectado como el transables, presenta mayores rigideces de precios e indexación a movimientos pasados del índice de precios al consumidor. El efecto sobre los precios totales es un promedio de los dos anteriores.

Gráfico 3 | Coeficientes de traspaso condicional a precios locales



Notas: Precios int.= precios internacionales, Pr. por riesgo = premio por riesgo, tasa interés int. = tasa interés internacional, trans. = transables y no-trans. = no-transables.
Fuente: Garcia-Cicco and Garcia-Schmidt (2020).

La segunda conclusión principal del modelo, que se muestra en las columnas del Gráfico 3, es que no todos los movimientos del tipo de cambio nominal tienen la misma consecuencia inflacionaria, dependiendo de forma muy importante del *shock* que originó el movimiento. Como se muestra en los gráficos de la primera columna, después de un *shock* a los precios internacionales, los efectos en los distintos índices de precios por un cambio del tipo de cambio son bajos y de corta duración. En cambio, como se muestra en los gráficos de la segunda y tercera columna, los efectos después de *shocks* a la prima por riesgo y a la tasa de interés internacional son mucho mayores y duran más tiempo.

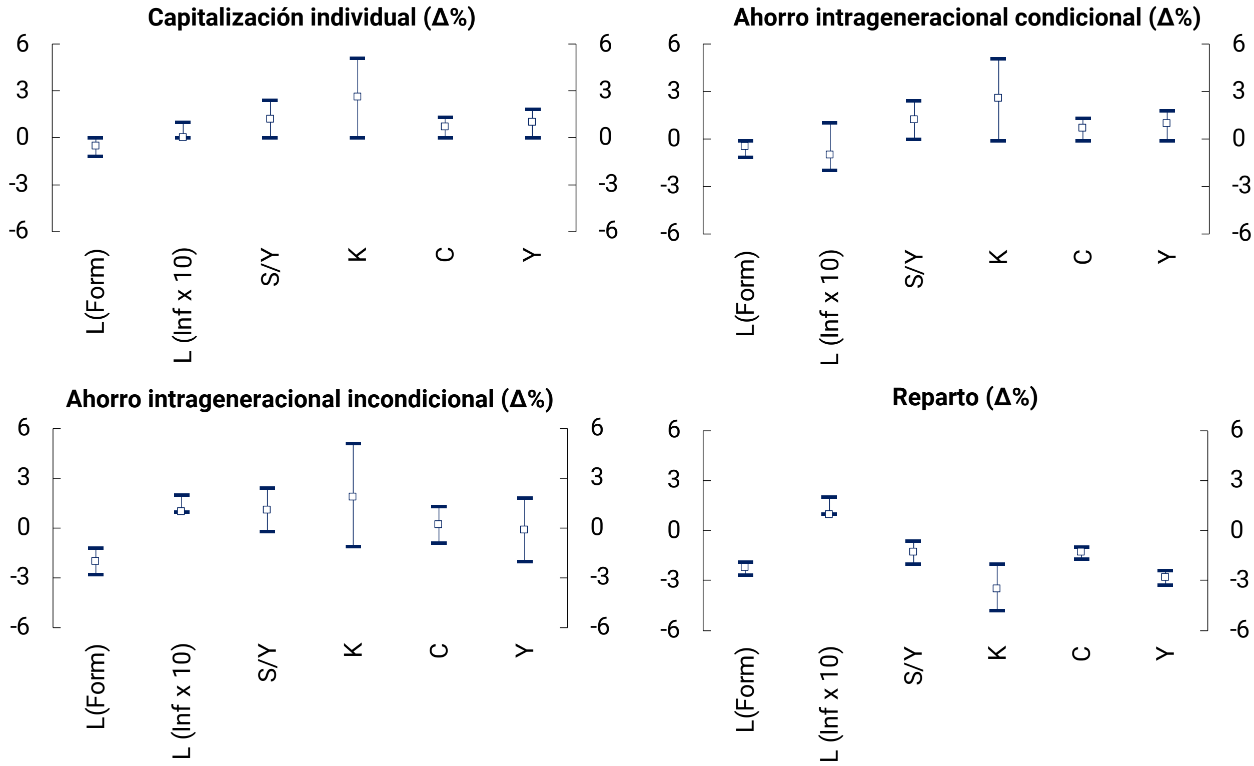
Los resultados discutidos anteriormente tienen implicancias para la política monetaria muy importantes, porque dependiendo del *shock* detrás de los cambios, la respuesta debiese ser distinta. Si el *shock* detrás del movimiento cambiario fue a los precios internacionales, la política monetaria no debería reaccionar, dado que incluso si lo hiciera, el efecto del *shock* se dejaría de sentir antes que la política tuviera efecto por el rezago en su actuar. En contraste, si el *shock* detrás del movimiento cambiario es a la prima por riesgo o a la tasa internacional, incluso fluctuaciones moderadas del tipo de cambio tendrán efectos significativos y no tan inmediatos sobre los precios y, por lo tanto, podrían requerir acciones de política más decisivas.

4.2. Un modelo de generaciones traslapadas para analizar el impacto económico de distintos sistemas de pensiones

Un segundo modelo satélite que recientemente ha ganado importancia en el conjunto de herramientas del BCC es un modelo OLG para estudiar los efectos de largo plazo de distintos sistemas de pensiones en Chile. Los modelos OLG no se utilizan habitualmente en los bancos centrales. Se centran en efectos de largo plazo, mientras que, en general, la banca central y la política monetaria tienen que ver con el ciclo y hay neutralidad monetaria a largo plazo. Sin embargo, a veces surgen preguntas de largo plazo que son de interés para los bancos centrales que necesitan herramientas especializadas para su análisis.

El sistema de pensiones en Chile ha sido parte de importantes discusiones desde hace algún tiempo. Para analizar las implicancias de diferentes alternativas al sistema de pensiones chileno, el BCC desarrolló un OLG descrito en Banco Central de Chile (2017). El modelo incluyó 3 generaciones (joven, adulto trabajador y adulto jubilado), producción formal con capital y trabajo, empleo informal y heterogeneidad en la capacidad y preferencias intertemporales para aproximar la distribución del ingreso y diferencias en ahorro observados. Además, el modelo incluyó fricciones de información que generan efectos reales de ahorrar obligadamente. En este marco, las personas en edad de trabajar no internalizan plenamente los beneficios futuros del ahorro previsional. El Gráfico 4 muestra los resultados cuantitativos de cambios bajo distintos sistemas de pensiones en el PIB, la inversión, el ahorro, la acumulación de capital y el empleo.

Gráfico 4 | Efectos de distintos sistemas de pensiones usando un modelo OLG



Notas: (1) Los gráficos muestran las desviaciones porcentuales del estado estacionario inicial. (2) L(Form): empleo formal; L(Inf X 10): (10 veces) empleo informal; S/Y: Ahorro sobre PIB; K: Capital; C: Consumo agregado; Y: PIB.
Fuente: Banco Central de Chile (2017).

El gráfico muestra los resultados de un aumento del 5% de los ahorros en 4 sistemas de pensiones. En el primero, de capitalización individual, que es el sistema actual, cada persona ahorra un porcentaje, que luego es recibido por esa misma persona después de la jubilación. En el segundo, ahorro intergeneracional condicional, lo que ahorra cada persona va a un fondo común que luego se distribuye entre todos los trabajadores de esa generación. En el tercero, ahorro intergeneracional incondicional, al igual que el anterior, lo ahorrado va a un fondo común, pero este se distribuye a todos los miembros de esa generación, trabajadores y no. Y finalmente, en el último, reparto, es el sistema en el que lo que se recauda cada período se distribuye entre los jubilados del mismo período.

Los resultados muestran que el aumento del ahorro en el primer y segundo sistema tiene efectos similares: efectos negativos moderados en el mercado laboral, aumento en el stock de capital y aumento en la producción. En cambio, si el aumento del ahorro ocurriera en el tercer sistema, los efectos serían más negativos en el mercado laboral y en la producción que sería más baja que sin la reforma, y menos positivos en el ahorro agregado y en el stock de capital. Finalmente, el último régimen implica los peores resultados en términos de variables macroeconómicas, llevando a una importante disminución de capital y trabajo.

Una extensión del modelo fue usada recientemente para estudiar los efectos de retiros parciales de cuentas de pensiones individuales, que han sido parte de las políticas promulgadas desde 2020 para ayudar con la pandemia. La extensión incluyó más cohortes (30) y una mejora importante de cómo se modela el sector informal, incorporando productividad marginal decreciente y mejorando la calibración de la elasticidad de participación. Las principales conclusiones mostraron que los retiros reducirán la tasa de ahorro en la economía, aumentarán de forma transitoria el consumo y contraerán de forma persistente el capital y el producto agregado. La razón de estos efectos es la internalización parcial de los ahorros generados por el sistema de pensiones. Debido a esta fricción de información, el sistema de pensiones genera ahorros, capital y producción más altos que sin el sistema.

5. Conclusiones

La modelación en general, y en los bancos centrales en particular, es una ciencia en continua evolución. Los bancos centrales deben proveer el mejor análisis y las más precisas proyecciones posibles, así como explicar la intuición y los principales mecanismos al hacer política. A medida que evolucionan la economía y las mejores prácticas de modelación, los modelos de los bancos centrales también deben evolucionar. Para mantenerse en la frontera del conocimiento y modelación, el BCC cuenta con un departamento especializado en la actualización y creación de nuevos modelos llamado Departamento de Modelación Económica.

Como se describe en este documento, la estrategia que sigue el BCC, es por un lado contar con modelos principales, siendo el XMAS el modelo estructural de mayor tamaño, que incorporan las características más esenciales de la economía. Por otro lado, el BCC cuenta con modelos satélite para abordar cuestiones concretas o mecanismos particulares que están en juego en algunas ocasiones.

Entre los modelos actualmente en desarrollo en el BCC se encuentra un modelo DSGE que incorpora fricciones en los mercados financieros y otorga un rol específico a las políticas macroprudenciales. El modelo Macro Financiero (MaFin) tiene un sector real un poco más simple que el del XMAS, y se extiende al incorporar emprendedores, viviendas y bancos que están sujetos a fricciones financieras causadas por información asimétrica entre prestatarios y prestamistas. Bajo este modelo, el monto de los préstamos corporativos y para la vivienda, junto con sus tasas de incumplimiento, se convierten en determinantes importantes del producto agregado, la inflación y la transmisión de la política monetaria. Además, este modelo permite la implementación de políticas macroprudenciales, las cuales tienen como objetivo mantener la estabilidad macroeconómica a través de instrumentos financieros y su interacción con la política monetaria.

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Flexible Inflation Targeting, Real Exchange Rate and Structural Change in a Kaldorian Model with Balance of Payments Constrained Growth

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Abstract

The present article contributes to the literature of Kaldorian growth models with balance of payments constraint introducing some changes in the basic structure of Santana and Oreiro (2018) model. First, we will assume that monetary policy is conducted under a *Flexible Inflation Targeting Regime* where the goal of the monetary policy is not only to achieve a certain target for inflation; but also stabilize capacity utilization at its potential or target level. Second, we will assume that potential or target level of capacity utilization depends on the lagged value of this variable. This hypothesis captures the *hysteresis effect of lower output growth over potential output,* which is a phenomenon well documented in recent literature (Cerra, Fatás and Saxena, 2020). Finally, we will assume that inflation expectations depend on the credibility of the Central Bank. In the case where Central Bank is fully credible then inflation expectations are equal to the inflation target. Although the model was developed for a *small open economy*, it is designed for a *mature economy* in the sense of Lewis (1954): labor supply is inelastic and real output growth had to be equal to the natural growth rate in the long run. The natural growth rate is, however, endogenous because productivity growth depends both on output growth and employment rate. The natural growth rate adjusts itself to the actual growth rate of real output, determined by the balance of payments constraint, due to changes in the level of employment. In order for a balanced growth path to exist, it was also

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necessary to make the autonomous component of investment demand an endogenous variable in the long-run, as done by Lavoie (2016). In the long run equilibrium with structural change, it was shown that a *decrease* in the inflation target could *increase* the growth rate of real output, the capacity utilization, the rate of employment and the manufacturing share in GDP, becoming a driver of the process of structural change. Since monetary policy can affect the productive structure of the economy as well as the growth rate of real output and the rate of employment; then it is not possible to separate macroeconomics from economic development, which is core of the so-called structuralist development macroeconomics, the theoretical basis of the Brazilian New-Developmentalism School.

JEL Classification: E12, E44, E52, F41, F43.

Keywords: balance of payments constrained growth, monetary policy, real exchange rate, structural change.

Fijación de metas de inflación flexible, tipo de cambio real y cambio estructural en un modelo de Kaldor con crecimiento restringido en la balanza de pagos

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Resumen

El presente artículo contribuye a la literatura de modelos de crecimiento de Kaldor con restricción de la balanza de pagos, introduciendo algunos cambios en la estructura básica del modelo de Santana y Oreiro (2018). Primero, asumiremos que la política monetaria se lleva a cabo bajo un Régimen de Metas de Inflación Flexible donde el objetivo de la política monetaria no es solo lograr una determinada meta de inflación sino también estabilizar la utilización de la capacidad productiva en su nivel potencial u objetivo. En segundo lugar, asumiremos que el nivel potencial u objetivo de utilización de la capacidad productiva depende del valor rezagado de esta variable. Esta hipótesis captura el efecto de histéresis de un menor crecimiento del producto sobre el producto potencial, que es un fenómeno bien documentado en la literatura reciente (Cerra, Fatás y Saxena, 2020). Finalmente, asumiremos que las expectativas de inflación dependen de la credibilidad del Banco Central. En el caso de que el Banco Central sea plenamente creíble, las expectativas de inflación son iguales a la inflación objetivo. Aunque el modelo se desarrolló para una economía pequeña y abierta, está diseñado para una economía madura en el sentido de Lewis (1954): la oferta de trabajo es inelástica y el crecimiento del producto real tiene que ser igual a la tasa de crecimiento natural de largo plazo. Sin embargo, la tasa de crecimiento natural es endógena porque el crecimiento de la productividad depende tanto del crecimiento de la producción como de la tasa de empleo. La tasa de crecimiento natural se ajusta a la tasa de crecimiento real de la producción, determinada por la restricción de la balanza de pagos, debido a cambios en el nivel de empleo. Para que exista una senda de crecimiento equilibrada también es necesario hacer del componente autónomo de la demanda de inversión una variable endógena en el largo plazo, como lo hizo Lavoie (2016). En el equilibrio de largo plazo con cambio estructural, se demuestra que una disminución en la inflación objetivo podría incrementar la tasa de crecimiento del producto real, la utilización de la capacidad, la tasa de empleo y la participación de la manufactura en el PIB, convirtiéndose en un motor del proceso de cambio estructural. Dado que la política monetaria puede afectar la estructura productiva de la economía, así como la tasa de crecimiento de la producción real y la tasa de empleo; entonces no es posible separar la macroeconomía del desarrollo económico, que es el núcleo de la llamada macroeconomía estructuralista del desarrollo, la base teórica de la Escuela Brasileña del Nuevo Desarrollismo.

Clasificación JEL: E12, E44, E52, F41, F43.

Palabras clave: cambio estructural, crecimiento restringido por la balanza de pagos, política monetaria, tipo de cambio real.

1. Introduction

The balance of payments constrained growth models (BPCG models, hereafter), pioneered developed by Anthony Thirlwall (1979), holds two fundamental problems. Firstly, they fully disregard the cumulative causation mechanism, so relevant to Kaldorian growth models. Indeed, assuming constant terms of trade then productivity gains induced by economic growth have no effect over the dynamics of the system, in a such way they become, strictly, irrelevant. However, in this case, the system no longer has any adjustment mechanism between aggregate supply and demand. This deficiency was observed by Palley (2002) for whom the balance of payments constrained growth model would be inconsistent in the extent that only in a "happy coincidence" would be possible the equality between the growth rate compatible with the balance of payments equilibrium and natural growth rate, i.e., the one that keeps the unemployment rate constant over the time. In this way, the balance of payments constrained growth models is not, in general, compatible with a balanced growth path.

Last but not least, the balance of payments constrained growth models fully neglected the relationship between the real exchange rate and the long-term growth. Indeed, in those models the long-term equilibrium growth rate depends on the ratio of export and import income elasticities multiplied by rest of the world growth rate. Thus, real exchange rate variations are assumed irrelevant to the long-term growth either because empirical evidence shows that finding that export and import price elasticities are low, in such a way that the impact of a real devaluation of exchange rate over the growth path of exports and imports is low; either because the terms of trade do not show a systematic trend to appreciation or depreciation in the long-term.

In recent years, an interesting literature has been developed about the relation between real exchange and economic growth. The Razin and Collins (1997) seminal paper indicated the existence of important non-linearities in the relationship between exchange rate misalignment - defined as a lasting deviation of the real exchange rate with respect to some reference value, determined by the "fundamentals"- and the real output growth in a sample of 93 developing and developed countries between 1975-1993. Indeed, the empirical results showed that while only large overvaluations of real exchange rate are associated with a slower economic growth in the long term, even moderated undervaluation of the real exchange rate have a positive effect on economic growth. Rodrik (2008), analyzing the development strategies adopted by a group of countries, noted that an important factor for the ignition of a process of sustained growth of the real output is the maintenance of an undervalued and stable real exchange rate.

More recently, Gabriel *et al.* (2020) analyzed the effects of manufacturing and of the real exchange rate (RER) on real per capita income growth. They use dynamic panel models and the calculation of output and employment multipliers for a diversified sample of countries from 1990 to 2011. Three important results can be highlighted. Two novel results were obtained. First, the authors provide new evidence that manufacturing is the most important tradable sector for achieving greater real per capita income growth for developing countries. Second, the greater a country's gap in relation to the technological frontier, the greater the positive effect of an undervalued RER on the real per capita income growth rate. Finally, the manufacturing industry's output multipliers and employment multipliers in the developing countries are higher than those in in developed ones, in all years analyzed.

For the Brazilian case, Oreiro *et al.* (2020) analyzed the determinants of the deindustrialization of the Brazilian economy in the period between 1998 and 2017, which was considered by the authors a typical example of 'premature deindustrialization' in the sense that the major reason for the fall in the manufacturing share has not been the increase in per-capita income but rather real exchange rate overvaluation. In the Brazilian case, real exchange rate overvaluation results both from an appreciation of the real effective exchange rate, and an increase in the equilibrium value of the real exchange rate, the "industrial equilibrium exchange rate" of the new developmentalist literature. The elimination of the real exchange rate overvaluation requires not only the adoption of a macroeconomic policy regime in which some kind of real exchange rate targeting is adopted, but also industrial policies designed to increase the economic complexity of the Brazilian economy and, hence, to reduce the equilibrium value of the real exchange rate. Therefore, the absence of a connection between the level of the real exchange rate and the long-term growth in the context of the balance of payments constrained growth models becomes theoretically unacceptable.

Some of these deficiencies in the BPCG models are addressed by Santana and Oreiro (2018) who developed a Kaldorian growth model that: (i) incorporates the balance of payments constraint, eliminating the inconsistency presented on balance of payments constrained growth models; (ii) establishes a mechanism by which the level of the real exchange rate may affect the long-term growth of capitalist economies.

Santana and Oreiro's (2018) model incorporates some innovations introduced by Oreiro (2009) into the structure of Kaldorian growth models, such as the conduction of monetary policy in an Inflation Target Regime, nominal interest rate determined by a Taylor rule, a floating exchange rate regime and imperfect capital mobility. In contrast to the Oreiro's (2009) model, however, Santana and Oreiro's (2018) model assumes a balance of payments constraint in which the growth rate of international capital inflows is a positive function of the differential between the domestic interest rate and the international interest rate plus the country risk premium. In this context, the differential between the domestic and international interest rates (plus the risk premium) will also determine the rate of depreciation (or appreciation) of the nominal exchange rate.

Another important innovation introduced in the model was the hypothesis that the Kaldor-Verdoorn coefficient -which captures the sensibility of the rate of growth of labor productivity with respect to the rate of growth of the real output- depends on the manufacturing share on output. This hypothesis allowed to introduce into the model the possibility of structural change, which is understood as a dynamic process by which the manufacturing share of output changes over time. In this way, it was possible to analyze the dynamic properties of the model both in the case where the productive structure is kept constant (case with no structural change), and in a situation in which it changes due to some economic process (case with structural change).

The structural change, in its turn, is defined by the exchange rate misalignment, that is, by the difference between the actual value of the real exchange rate and the level of the real exchange rate that would correspond to the "industrial equilibrium"; in other words, the exchange rate level in which domestic firms that use state-of-art technologies are competitive in international markets (Bresser-Pereira, Oreiro and Marconi; 2014, 2015).

The present article contributes to this line of research introducing some changes in the basic structure of Santana and Oreiro’s (2018) model. First of all, we will assume that monetary policy is conducted under a *Flexible Inflation Targeting Regime* where the goal of the monetary policy is not only to achieve a certain target for inflation; but also stabilize capacity utilization at its potential or target level. Second, we will assume that potential or target level of capacity utilization depends on the lagged value of this variable. This hypothesis captures the *hysteresis effect of lower output growth over potential output,* which is a phenomenon well documented in recent literature (Cerra, Fatás and Saxena, 2020). Finally, we will assume that inflation expectations depend on the credibility of the Central Bank. In the case where Central Bank is fully credible then inflation expectations are equal to the inflation target; otherwise, they are determined by a simple adaptive rule, which will introduce a level of inflation inertia in the model. In the long run equilibrium with structural change, it was shown that a *decrease* in the inflation target could *increase* the growth rate of real output, the capacity utilization, the rate of employment and the manufacturing share in GDP, becoming a driver of the process of structural change. Since monetary policy can affect the productive structure of the economy as well as the growth rate of real output and the rate of employment; then it is not possible to separate macroeconomics from economic development, which is core of the so-called structuralist development macroeconomics, the theoretical basis of the Brazilian New-Developmentalism School.

Although the model was developed for a small open economy, it is designed for a *mature economy* in the sense of Lewis (1954): labor supply is inelastic and real output growth had to be equal to the natural growth rate in the long run. The natural growth rate is, however, endogenous because productivity growth depends both on output growth and employment rate. The natural growth rate adjusts itself to the actual growth rate of real output, determined by the balance of payments constraint, due to changes in the level of employment. In order for a balanced growth path to exist, it was also necessary to make the autonomous component of investment demand an endogenous variable in the long-run, as done by Lavoie (2016).

2. Model structure

Let us consider a small open economy with a free-floating exchange rate regime and imperfect capital mobility, in which growth rate of exports (quantum) and imports (quantum) are given by:

$$\hat{x}_t = \chi_0(\hat{p}_t^* - \hat{p}_t + \hat{e}_t) + \chi_1 \hat{z}_t \quad (1)$$

$$\hat{m}_t = \mu_0(\hat{p}_t - \hat{p}_t^* - \hat{e}_t) + \mu_1 \hat{y}_t \quad (2)$$

In which $\hat{x}_t$ is the growth rate of exports (*quantum*) in the period *t*, $\hat{m}_t$ is the growth rate of imports (*quantum*) in the period *t*, $\hat{p}_t^*$ is the domestic rate of inflation in the period *t*, $\hat{p}_t$ is the rest of the world inflation in the period *t*, $\hat{e}_t$ is the rate of depreciation of the nominal exchange rate in the period *t*, $\hat{y}_t$ is the domestic income growth rate in the period *t*, $\hat{z}_t$ is the rest of the world income growth rate in the period *t*, χ_0 is the price elasticity of exports, μ_0 is the price elasticity of exports, μ_1 is the income elasticity of imports.

We will assume the validity of Marshall-Lerner's condition, so that, $|\chi_0 + \mu_0| > 1$. Moreover, we will follow Moreno-Brid's (2003) model in which the Balance of Payments restriction in period *t* is given by:

$$\hat{e}_t + \hat{p}_t^* + \hat{m}_t = \Theta_1(\hat{p}_t + \hat{x}_t) - \Theta_2(\hat{p}_t + \hat{d}_t) + \Theta_3(\hat{p}_t + \hat{f}_t) \quad (3)$$

In equation (3), $\Theta_3 \equiv (1 - \Theta_1 + \Theta_2)$, in which $\Theta_1 = \frac{P_x}{ep{*}m}$ is the ratio between the initial value of exports and the initial value of imports, $\Theta_2 = \frac{pr}{ep{*}m}$ is the ratio between the initial value of external liability services and the initial value of imports.

Moreover, $\hat{d}_t$ is the growth rate of services (interest and dividends) related to the external liabilities in the period *t*, and $\hat{f}_t$ is the real growth rate of external capital flows in period *t*.

As in Santana and Oreiro (2018) two important points can be observed. Firstly, the constraint imposed above is deflated in terms of value paid by imports. Secondly, we are considering an economy with a net debt to the rest of the world, since Θ_2 is a positive parameter and there is a negative signal before it.

Assuming capital mobility to be imperfect in Mundell's sense, the real rate of growth of external capital flows will be a function of the difference between the domestic interest rate and the international interest rate adjusted by the country-risk premium:

$$\hat{f}_t = f(i_t - i_t^* - r)\,;\ 0 \leq f < \infty \quad (4)$$

In equation (4), f is the sensibility of the growth of external capital flows to the interest differential, i_t is the domestic interest rate in the period *t*, i_t^* international interest rate and *r* is the country risk premium. This coefficient captures the level of capital controls of the economy. If $f = 0$ then the capital account is closed, and capital mobility is zero. Since $f < \infty$ then capital mobility is necessarily imperfect or limited due to the existence of some kind of capital controls.

Considering an economy with imperfect capital mobility, the dynamics of the nominal exchange rate depend on inflows and outflows of foreign capital; but also on the level or intervention of Central Bank in the foreign exchange market. By means of reserve accumulation, the Central Bank can reduce the impact of capital flows over the dynamics of nominal exchange rate. Thus, we will assume that the rate of change of the nominal exchange rate will be a negative function of the growth rate of the external capital flows:

$$\hat{e}_t = -\kappa \hat{f}_t\,,\ 0 \leq k < \infty \tag{5}$$

In equation (5), κ is the coefficient of sensibility of the rate of change of nominal exchange rate to the growth rate of external capital flows. The magnitude of this coefficient depends on the level of Central Bank intervention in the exchange rate market by means of reserve accumulation. If $\kappa = 0$, then the Central Bank acts as a market maker in the exchange rate market, buying all inflows of foreign capital and accumulating then as international reserves.

Using (4) in (5) we get:

$$\hat{e}_t = -\kappa f(i_t - i_t^* - r) \tag{5a}$$

Equation (5a) shows that the rate of change of nominal exchange rate is a negative function of the interest rate differential.

The determination of the nominal interest rate (i_t) follows the Taylor's (1993) rule:

$$i_t = \beta_0 + \beta_1(\hat{p}_t - \hat{p}^T) + \beta_2(u_t - u^T) \tag{6}$$

According to equation (6), the nominal interest rate essentially depends on the deviation of the effective inflation rate $(\hat{p}_t)$ from the target based on the monetary authority and the output gap. The latter is the difference between the actual real level of capacity utilization, u_t, and the *target level of capacity utilization* by monetary authorities, u^T.[2] All (β_i) are positive.

In particular, the parameter (β_0) can be seen as the sum of the international interest rate and the country risk premium:

$$\beta_0 \equiv i_t^* + r \tag{6a}$$

[2] This hypothesis deserves further explanation. Mainstream models generally take for granted that potential output is determined by the availability of factors of production (capital and labor) and by the level of technological knowledge measured by the so-called total factor productivity. When applied to capacity utilization, this "vision" would impose the existence of a potential or normal level of capacity utilization, which is exogenous and independent of aggregate demand. The same idea is presented in some heterodox growth models like the Sraffian Super-Multiplier Models developed by Freitas and Serrano (2015). Demand-led growth models, however, calls into question the idea that output is supply constrained in the long-run. Kaldor (1988) argued that the growth rate of capital accumulation, growth rate of labor force and the growth rate of labor productivity depends, in the long-run, on the rate of growth of autonomous demand, which means that natural growth rate is an endogenous variable demand determined. The endogeneity of natural growth rate was tested by Leon-Ledesma and Thirlwall (2002) for a sample of 15 OECD countries in the period of 1961 to 1985. The results clearly show that natural growth rate is elastic to demand and output growth. Oreiro et al. (2012) make the same econometric tests for the Brazilian economy in the period between 1980 and 2002 and obtained similar results. This means that "normal" or potential level of capacity utilization can be considered a dependent variable, influenced by the lagged values of effective capacity utilization.

The *target level of capacity utilization* is determined by equation (7):

$$u^T = u^{T-1} + \tilde{\theta}(u_{t-1} - u^{T-1});\ 0 < \tilde{\theta} < 1 \quad (7)$$

In equation (7) we can see that the target level of capacity utilization (its own estimates about normal rate of capacity utilization) is adjusted over time as long as the actual level of capacity utilization in previous period is different from its previous estimates. It is clear that in steady-state $u^T = u^{T-1} = u^n = u$, which means that target level of capacity utilization is a full endogenous variable.

Using (6) in (5a) we get:

$$\hat{e}_t = -\kappa f\left[\beta_1\left(\hat{p}_t - \hat{p}^T\right) + \beta_2(u_t - u^T)\right] \quad (5b)$$

We will consider a small open economy without government activities. In the short-run, firms operate with idle capacity, which means that output is demand determined. The aggregate demand is the sum of household consumption (C_t), firms' investment (I_t) and net exports of final goods (Nx_t). So, the level of real output is given by:

$$y_t = C_t + I_t + Nx_t \quad (8)$$

Household income is composed by wages and profits. Following Kaldor (1956, 1966) we will suppose that propensity to save out of wages is zero. For sake of simplicity, we will take the propensity to save out of profits to be equal to one. So, the real consumption expenditure is given by:

$$C_t = V_t L_t = V_t \frac{u_t}{q_t} K_t \quad (9)$$

Where: V_t is the real wage rate; L_t is the number of workers employed, q_t is the level of labor productivity.

In the absence of depreciation of the capital stock, the aggregate investment is equal to the product of the capital stock (K_t) with the desired growth rate of capital stock (g). This rate, in turn, is influenced by autonomous investment and by the expected real interest rate:

$$I_t = gK_t = [\varphi_0 - \varphi_1(i_t - \hat{p}_t^e)]K_t \quad (10)$$

Where: $g = [\varphi_0 - \varphi_1(i_t - \hat{p}_t^e)]$

In which $(\hat{p}_t^e)$ is the expected inflation rate, (φ_0) is the autonomous component of investment (positive) and, (φ_1) a sensitivity coefficient (positive) that captures the influence of the expected real interest rate on investment decisions.

Inflation expectations are formulated according to the agents' perception of the monetary authority's credibility. In a context in which monetary policy is *fully credible*, the inflation expectation converges to the inflation target established by the monetary authority -equation (10a).

$$\hat{p}_t^e = \hat{p}^T \tag{10a}$$

The net exports (Nx_t) –as a proportion of the capital stock– depend on the actual level of capacity utilization (u_t) and on the real exchange rate of the previous period (E_{t-1}). The time lag of the real exchange rate over net-exports captures the "J" curve effect.

$$Nx_t = (\eta_0 - \eta_1 u_t + \eta_2 E_{t-1})K_t \tag{11}$$

In which (η_0) is a positive parameter, which incorporates the other variables that affect net exports, such as world income.

In order to determine the actual level of capacity utilization let us substitute equations (9)-(11) in (8):

$$u_t = \left(\frac{\varphi_0 + \eta_0}{\pi_t + \eta_1}\right) - \left[\frac{\varphi_1}{\pi_t + \eta_1}\right](i_t - \hat{p}_t^e) + \left[\frac{\eta_2}{\pi_t + \eta_1}\right]E_{t-1} \tag{12}$$

Where: $u_t = \frac{y_t}{K_t}$ is the actual level of capacity utilization and $\pi_t \equiv 1 - \frac{V_t}{q_t}$ is the profit share.

Substituting (6) in (12) we get:

$$u_t = \left(\frac{1}{\pi_t + \eta_1 + \varphi_1\beta_1}\right) \; [(\varphi_0 + \eta_0 - \varphi_1\beta_0) + \varphi_1\beta_2 u^T + \eta_2 E_{t-1} + \varphi_1\hat{p}_t^e - \varphi_1\beta_1(\hat{p}_t - \hat{p}^T)] \tag{13}$$

Equation (13) determines the short-run equilibrium value for the actual level of capacity utilization. Considering a *fully credible monetary policy* we had $\hat{p}_t^e = \hat{p}^T$ so:

$$u_t = \left(\frac{1}{\pi_t + \eta_1 + \varphi_1\beta_1}\right) \; [(\varphi_0 + \eta_0 - \varphi_1\beta_0) + \varphi_1\beta_2 u^T + \eta_2 E_{t-1} + \varphi_1\big((1-\beta_1)\hat{p}^T - \beta_1\hat{p}_t\big)] \tag{13a}$$

From (13a) we get:

$$\frac{\partial u_t}{\partial(\varphi_0 + \eta_0)} = \left(\frac{1}{\pi_t + \eta_1 + \varphi_1\beta_1}\right) > 0 \tag{13b}$$

$$\frac{\partial u_t}{\partial u^T} = \left(\frac{\varphi_1\beta_2}{\pi_t + \eta_1 + \varphi_1\beta_1}\right) > 0 \tag{13c}$$

$$\frac{\partial u_t}{\partial E_{t-1}} = \left(\frac{\eta_2}{\pi_t + \eta_1 + \varphi_1\beta_1}\right) > 0 \quad (13d)$$

$$\frac{\partial u_t}{\partial \hat{p}^T} = \left(\frac{\varphi_1(1-\beta_1)}{\pi_t + \eta_1 + \varphi_1\beta_1}\right) > 0 \quad (13e)$$

$$\frac{\partial u_t}{\partial \hat{p}_t} = -\left(\frac{\beta_1}{\pi_t + \eta_1 + \varphi_1\beta_1}\right) < 0 \quad (13f)$$

We have now to describe the supply side of the economy. Following Blecker (2002), we will suppose that domestic firms produce a homogeneous good which is imperfect substitute from the goods produced by foreign firms. Labor is the only variable input used in production and domestic firms have monopoly power so that they can fix the prices of their goods in the level higher than unit labor cost. Then prices are fixed by a mark-up over unit direct costs of production, but mark-up depends on the level of real exchange rate: the more depreciated is the level of real exchange rate, higher will be the mark-up that domestic firms can set without losing market-share for foreign firms.

Then domestic prices are determined by equation (14):

$$p_t = \sigma_0 E_t^{\theta} \frac{w_t}{q_t} \quad (14)$$

Where: $1 + \tau = \sigma_0 E_t^{\theta} > 1$, τ is the mark-up rate and $\theta > 0$ is the sensitivity of the mark-up rate to real exchange rate.

From (14) we can define the real product wage as:

$$\frac{w_t}{p_t} = \frac{q_t}{\sigma_0 E_t^{\theta}} \quad (14a)$$

Households spend their wage income both in domestic and foreign consumption goods. So, the workers effective real wage rate will be given by:

$$V_t = \frac{w_t}{(p_t)^{\varepsilon}(e_t p_t^*)^{1-\varepsilon}} \quad (15)$$

Where: $0 < \varepsilon < 1$ is the weight of domestic goods in the consumption basket of households.

From (14a) and (15) we get:

$$V_t = \frac{q_t}{\sigma_0 E_t^{\sigma_1}} \quad (16)$$

Where: $\sigma_1 \equiv 1 + \theta - \varepsilon > 0$.

Equation (16) shows that workers effective real wage rate is a positive function of labor productivity and a negative function of the level of real exchange rate.

Regarding the labor market, we will consider an economy where workers are organized by means of unions so that wages are set by a collective bargaining between labor unions and firms. Labor unions define a real wage target ($\bar{V}_t$), which will be used as the reference for nominal wage bargaining with firms. We will suppose that the real wage target depends on the rate of employment (l), due to the fact that a tight labor market increases the bargaining power of unions. So, we get:

$$\bar{V}_t = \nu_0 + \nu_1 l_t \qquad (17)$$

Where: $l_t = \frac{L_t}{N_t}$ is the rate of employment, N_t is the labor force and L_t is the number of workers that are employed.

It can be easily shown that the rate of employment is given by:

$$l_t = \frac{u_t k_t}{q_t} \qquad (17a)$$

Where: $k_t = \frac{K_t}{N_t}$ is the stock of capital per-worker.

The growth rate of nominal wages is thus determined by:

$$\hat{w}_t = \hat{p}^T + \varpi(\bar{V}_t - V_t) \qquad (18)$$

In which (ϖ) is a positive coefficient that measures the bargaining power of workers.[3]

Taking logs in (14) and time derivative of the resulting expression we get:

$$\hat{p}_t = \left[\frac{\theta}{1+\theta}\right](\hat{e}_t + \hat{p}_t^*) + \left[\frac{1}{1+\theta}\right](\hat{w}_t - \hat{q}_t) \qquad (19)$$

Equation (19) shows that domestic inflation is a weighted average of the growth rate of prices of foreign goods (which is the sum of the rate of nominal exchange rate devaluation and international inflation) and the growth rate of unit labor cost (which is the difference between wage inflation and productivity growth).

[3] This coefficient depends on several structural variables of the labor market as the level of centralization of wage bargains, the share of workers that are unionized, the level of unemployment insurance, among other variables. See Amadeo (1994) for a detailed discussion regarding this issue.

The growth rate of labor productivity is given by:

$$\hat{q}_t = \alpha_0 + \alpha_1 h_{t-1}\hat{y}_{t-1} + \alpha_2 l_{t-1} \quad (20)$$

In equation (20), the labor productivity growth rate ($\hat{q}_t$) depends on an autonomous component (α_0) and on the growth rate of output in the previous period multiplied by the manufacturing share in output and a positive coefficient (α_1). The influence of the previous period growth rate of output over productivity growth is due to the existence of dynamic economies of scale in the manufacturing industry, which is the basis of the so-called "Kaldor-Verdoorn Law". The magnitude of such an effect depends on the size of the manufacturing sector relative to the rest of the economy (Oreiro *et al*. 2020; Botta, 2009, Gabriel *et al*. 2016). The third element on equation (20) captures the Marxist idea that a tight labor market may induce capitalists to introduce labor-saving innovations in order to preserve the rate of profit in an environment of increasing real wages.

Using (16), (17) and (17a) in (18) we get:

$$\widehat{w}_t = (\varpi\nu_0 + \hat{p}^T) + \varpi\left(\frac{\nu_1\sigma_0 k_t u_t E_t^{\sigma_1} - q_t^2}{\sigma_0 q_t E_t^{\sigma_1}}\right) \quad (18a)$$

Using (5b), (18a), (20) in (19) we get:

$$\hat{p}_t = \left[\frac{1}{1+\theta(1+f\kappa\beta_1)}\right]\left[\begin{matrix}(1+f\kappa\theta\beta_1)\hat{p}^T + \theta\hat{p}_t^* + (\varpi\nu_0 - \alpha_0) - \dfrac{\alpha_2 u_{t-1}k_{t-1}}{q_{t-1}} - \\ \dfrac{\varpi q_t}{\sigma_0 E_t^{\sigma_1}} - \alpha_1 h_{t-1}\hat{y}_{t-1} + f\kappa\theta\beta_2 u^T + \left(\dfrac{\varpi\nu_1 k_t - f\kappa\theta\beta_2 q_t}{q_t}\right)u_t\end{matrix}\right] \quad (21)$$

From equation (21) we get:

$$\frac{\partial\hat{p}_t}{\partial\hat{p}^T} = \left[\frac{(1+f\kappa\theta\beta_1)}{1+\theta(1+f\kappa\beta_1)}\right] > 0 \quad (21a)$$

$$\frac{\partial\hat{p}_t}{\partial\hat{p}_t^*} = \left[\frac{\theta}{1+\theta(1+f\kappa\beta_1)}\right] > 0 \quad (21b)$$

$$\frac{\partial\hat{p}_t}{\partial u_t} = \left[\frac{\varpi\nu_1 k_t - f\kappa\theta\beta_2 q_t}{(1+\theta(1+f\kappa\beta_1)q_t)}\right] \quad (21c)$$

In equation (21c) $\frac{\partial\hat{p}_t}{\partial u_t} > 0$ if and only if $(\varpi\nu_1 k_t - f\kappa\theta\beta_2 q_t) > 0$.

3. Short run equilibrium

In the short run the real exchange rate, the profit-share, the growth rate of world income, the international inflation rate, the target capacity utilization, the stock of capital per-worker and the manufacturing share are constants, as well as all variables that had pre-determined values, i.e., determined from previous periods. The model is thus composed by the following equations:

$$\hat{x}_t = \chi_0(\hat{p}_t^* - p_t + \hat{e}_t) + \chi_1 \hat{z}_t \tag{1}$$

$$\hat{m}_t = \mu_0(\hat{p}_t - \hat{p}_t^* - \hat{e}_t) + \mu_1 \hat{y}_t \tag{2}$$

$$\hat{e}_t + \hat{p}_t^* + \hat{m}_t = \Theta_1(\hat{p}_t + \hat{x}_t) - \Theta_2(\hat{p}_t + \hat{d}_t) + \Theta_3(\hat{p}_t + \hat{f}_t) \tag{3}$$

$$\hat{f}_t = f\left[\beta_1(\hat{p}_t - \hat{p}^T) + \beta_2(u_t - u^T)\right] \tag{4a}$$

$$\hat{e}_t = -\kappa f\left[\beta_1(\hat{p}_t - \hat{p}^T) + \beta_2(u_t - u^T)\right] \tag{5b}$$

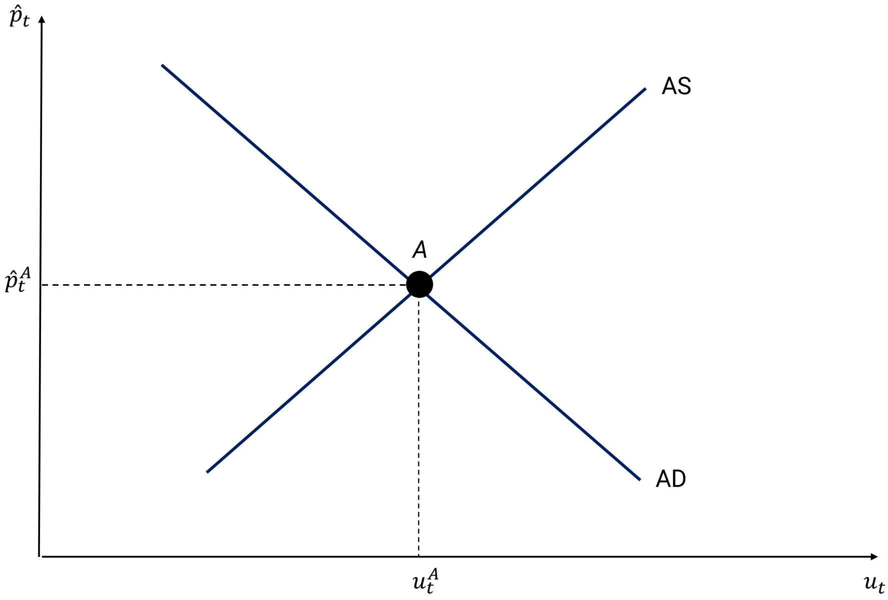
$$u_t = \left(\frac{1}{\pi_t + \eta_1 + \varphi_1\beta_1}\right) \left[(\varphi_0 + \eta_0 - \varphi_1\beta_0) + \varphi_1\beta_2 u^T + \eta_2 E_{t-1} + \varphi_1\left((1-\beta_1)\hat{p}^T - \beta_1\hat{p}_t\right)\right] \tag{13a}$$

$$\hat{p}_t = \left[\frac{1}{1+\theta(1+f\kappa\beta_1)}\right]\left[(1+f\kappa\theta\beta_1)\hat{p}^T + \theta\hat{p}_t^* + (\varpi v_0 - \alpha_0) - \frac{\alpha_2 u_{t-1}k_{t-1}}{q_{t-1}} - \frac{\varpi q_t}{\sigma_0 E_t^{\sigma_1}} - \alpha_1 h_{t-1}\hat{y}_{t-1} + f\kappa\theta\beta_2 u^T + \left(\frac{\varpi v_1 k_t - f\kappa\theta\beta_2 q_t}{q_t}\right)u_t\right] \tag{21}$$

Then we have a system of seven independent equations with seven unknows: $\hat{x}_t$, $\hat{m}_t$, $\hat{y}_t$, $\hat{f}_t$, $\hat{e}_t$, u_t and $\hat{p}_t$. This means that we have a determinate system. Some observations are required to make about this system of equations. First of all, it allows us to calculate the level of employment and capacity utilization as well as the growth rate of real output. This is an important advance in respect with balance of payments constrained growth models where only the growth rate of real output can be determined, but not the general level of resources utilization. Second, the interdependence of the equations of the model is not general: the model is ***block-recursive*** (Sargent, 1987). Indeed, the short-run equilibrium values of capacity utilization and inflation rate could be entirely determined by equations (13a) and (21) alone. Once these values are determined, equations (4a) and (5b) determine the growth rate of foreign capital flows and the rate of exchange rate depreciation. Once these values are determined, equations (1)-(3) determine the growth rate of imports, the growth rate of exports and the growth rate of real output that is compatible with the balance of payments equilibrium.

Equations (13a) and (21) are, respectively, the aggregate demand and aggregate supply equations of the model. The determination of the short-run equilibrium values for the inflation rate and capacity utilization can be visualized in Figure 1.

Figure 1 | Aggregate demand and aggregate supply curves and short-run equilibrium



Solving the model for equations (13a) and (21) we get the short-run equilibrium value for the domestic rate of inflation:

$$\hat{p}_t^A = \rho_0 + \rho_2 \hat{p}_t^* + (\rho_1 + \rho_3)\hat{p}^T + \rho_4 u^T + \rho_5 E_{t-1} - \frac{\rho_6 u_{t-1} k_{t-1}}{q_{t-1}} - \rho_7 h_{t-1} \hat{y}_{t-1} \tag{22}$$

Where:

$$\rho_0 = \frac{(\varpi\nu_0 - \alpha_0)\ \ (\pi_t + \eta_1 + \varphi_1\beta_2) + (\varpi\nu_1 k_t - f\kappa\beta_2 q_t)\ \ q_t^{-1}\ \ (\varphi_0 + \eta_0 - \varphi_1\beta_0)}{[1 + \theta(1 + f\kappa\beta_1)]\ \ (\pi_t + \eta_1 + \varphi_1\beta_2) + (\varpi\nu_1 k_t - f\kappa\beta_2 q_t)\ \ q_t^{-1}\ \ \varphi_1\beta_1} > 0$$

$$\rho_1 = \frac{(\pi_t + \eta_1 + \varphi_1\beta_2) + (\varpi\nu_1 k_t - f\kappa\beta_2 q_t)\ \ q_t^{-1}\ \ \varphi_1}{[1 + \theta(1 + f\kappa\beta_1)]\ \ (\pi_t + \eta_1 + \varphi_1\beta_2) + (\varpi\nu_1 k_t - f\kappa\beta_2 q_t)\ \ q_t^{-1}\varphi_1\beta_1} > 0$$

$$\rho_2 = \frac{\theta(\pi_t + \eta_1 + \varphi_1\beta_2)}{[1 + \theta(1 + f\kappa\beta_1)]\ \ (\pi_t + \eta_1 + \varphi_1\beta_2) + (\varpi\nu_1 k_t - f\kappa\beta_2 q_t)\ \ q_t^{-1}\ \ \varphi_1\beta_1} > 0$$

$$\rho_3 = \frac{f\kappa\beta_1(\pi_t + \eta_1 + \varphi_1\beta_2) + (\varpi\nu_1 k_t - f\kappa\beta_2 q_t)\ \ q_t^{-1}\varphi_1\beta_1}{[1 + \theta(1 + f\kappa\beta_1)](\pi_t + \eta_1 + \varphi_1\beta_2) + (\varpi\nu_1 k_t - f\kappa\beta_2 q_t)\ \ q_t^{-1}\varphi_1\beta_1} > 0$$

$$\rho_4 = \frac{f\kappa\theta\beta_2(\pi_t + \eta_1 + \varphi_1\beta_2) + (\varpi\nu_1 k_t - f\kappa\beta_2 q_t)\ \ q_t^{-1}\varphi_1\beta_2}{[1 + \theta(1 + f\kappa\beta_1)](\pi_t + \eta_1 + \varphi_1\beta_2) + (\varpi\nu_1 k_t - f\kappa\beta_2 q_t)\ \ q_t^{-1}\varphi_1\beta_1} > 0$$

$$\rho_5 = \frac{(\varpi \nu_1 k_t - f\kappa\beta_2 q_t) \quad q_t^{-1}\eta_2}{[1+\theta(1+f\kappa\beta_1)](\pi_t+\eta_1+\varphi_1\beta_2)+(\varpi\nu_1 k_t - f\kappa\beta_2 q_t) \quad q_t^{-1}\varphi_1\beta_1} > 0$$

$$\rho_6 = \frac{\alpha_2(\pi_t+\eta_1+\varphi_1\beta_2)}{[1+\theta(1+f\kappa\beta_1)](\pi_t+\eta_1+\varphi_1\beta_2)+(\varpi\nu_1 k_t - f\kappa\beta_2 q_t) \quad q_t^{-1}\varphi_1\beta_1} > 0$$

$$\rho_7 = \frac{\alpha_1(\pi_t+\eta_1+\varphi_1\beta_2)}{[1+\theta(1+f\kappa\beta_1)](\pi_t+\eta_1+\varphi_1\beta_2)+(\varpi\nu_1 k_t - f\kappa\beta_2 q_t) \quad q_t^{-1}\varphi_1\beta_1} > 0$$

Substituting (22) in (13a) we get the short-run equilibrium value for the capacity utilization:

$$u_t^A = \frac{\gamma_0+\gamma_1 u^T+\gamma_2 E_{t-1}+(\gamma_3+\gamma_4)\hat{p}^T-\gamma_5\hat{p}_t^*+\gamma_6 u_{t-1}k_{t-1}q_{t-1}^{-1}+\gamma_7 h_{t-1}\hat{y}_{t-1}}{\pi_t+\eta_1+\varphi_1\beta_2} \tag{23}$$

Where:

$\gamma_0 = (\varphi_0+\eta_0-\varphi_1\beta_0)-\varphi_1\beta_1\rho_0 > 0 \leftrightarrow (\varphi_0+\eta_0) > \varphi_1(\beta_0+\beta_1\rho_0)$

$\gamma_1 = \varphi_1(\beta_2-\beta_1\rho_4) \leftrightarrow \beta_2 > \beta_1\rho_4$[4]

$\gamma_2 = (\eta_2-\varphi_1\beta_1\rho_5) > 0 \leftrightarrow \eta_2 > \varphi_1\beta_1\rho_5$[5]

$\gamma_3 = \varphi_1(1-\beta_1\rho_1) > 0 \leftrightarrow 1 > \beta_1\rho_1$

$\gamma_4 = \varphi_1\beta_1(1-\rho_3) > 0 \leftrightarrow 1 > \rho_3$

$\gamma_5 = \varphi_1\beta_1\rho_2 > 0$

$\gamma_6 = \varphi_1\beta_1\rho_6 > 0$

$\gamma_7 = \varphi_1\beta_1\rho_7 > 0$

From equation (23) we get:

$$\frac{\partial u_t^A}{\partial \gamma_0} = \frac{1}{\pi_t+\eta_1+\varphi_1\beta_2} > 0 \tag{23a}$$

$$\frac{\partial u_t^A}{\partial E_{t-1}} = \frac{\gamma_2}{\pi_t+\eta_1+\varphi_1\beta_2} > 0 \tag{23b}$$

$$\frac{\partial u_t^A}{\partial \hat{p}^T} = \frac{(\gamma_3+\gamma_4)}{\pi_t+\eta_1+\varphi_1\beta_2} > 0 \tag{23c}$$

[4] This requires that Monetary Authorities give more weight to deviations of actual capacity utilization from the target level than deviations of inflation from the target level. This could occur in a double mandate regime of monetary policy.
[5] This condition requires a high price elasticity of net exports to real exchange rate variation, which means that the economy under consideration is mainly an exporter of manufacturing goods.

$$\frac{\partial u_t^A}{\partial \hat{p}_t^*} = -\frac{\gamma_5}{\pi_t + \eta_1 + \varphi_1 \beta_2} < 0 \quad (23d)$$

$$\frac{\partial u_t^A}{\partial \pi_t} = -\frac{u_t^A}{\pi_t + \eta_1 + \varphi_1 \beta_2} < 0 \quad (23e)$$

Two results are noteworthy to be commented. The first one is equation (23b). A real exchange devaluation in period *t*-1 will increase the actual level of capacity utilization. This means that exchange rate devaluation has an expansionary effect over aggregate demand only after a time lag. The second one is equation (23e), which shows that an increase in the profit share in period *t* –due, for example, a real exchange rate devaluation in period *t*– will decrease the actual level of capacity utilization, which means that demand regime is wage-led in the short run, and a devaluation of real exchange rate has a short-run negative impact over the level of economic activity.

Using equations (23) and (22) in the system (1)-(3), (4a) and (5b) we arrive at the value of the growth rate of real output that is compatible with balance of payments equilibrium:

$$\hat{y}_t = \phi_0 + \phi_2(u_t^A - u^T) + \phi_3 \hat{p}_t^* - (\phi_1 + \phi_4)\hat{p}^T \quad (24)$$

Where:[6]

$$\phi_0 = \left(\phi\beta_0 - \Theta_1\chi_1\hat{z}_t + \Theta_2\hat{d}\right) \ \mu_1^{-1} > 0$$

$$\phi_1 = (\phi f \beta_1 + \Theta_1\chi_0 + \mu_0) \ \mu_1^{-1} > 0$$

$$\phi_2 = \phi f \beta_2 \mu_1^{-1} > 0$$

$$\phi_3 = (\Theta_1\chi_0 + \mu_0) \ \mu_1^{-1} = \left(\Theta_1\left(\frac{\chi_0}{\mu_0}\right) + 1\right)\mu_1^{-1} > 0$$

$$\phi_4 = \phi f \beta_1 \mu_1^{-1} > 0$$

$$\phi = (1 + \mu_0 - \Theta_1\chi_1)(\kappa\mu_1 + \Theta_3) > 0$$

From equation (24) we get:

$$\frac{\partial \hat{y}_t}{\partial u_t^A} = \phi_2 > 0 \ (24a) \quad (24a)$$

Expression (24a) shows that an increase in the short-run equilibrium level of capacity utilization produces an increase in the growth rate of real output compatible with balance of payments equilibrium. This occurs because an increase in the level of capacity utilization will increase the rate of employment and hence the domestic rate of inflation. For a given rate of change of nominal

[6] The sufficient conditions for these parameters be positive are: $[\beta_0(1 + \mu_0)] > \Theta_1\chi_1$ and $\left(\phi\beta_0 + \Theta_2\hat{d}\right) > \Theta_1\chi_1\hat{z}_t$.

exchange rate and international inflation, this will allow an increase in the *terms of trade* and hence on the growth rate of imports (and growth rate of real output) compatible with balance of payments equilibrium. Furthermore, the increase in the domestic inflation will induce Central Bank to increase the level of domestic interest rate, increasing interest rate differential and hence increasing the growth rate of capital flows. The balance of payments constraint is thus relaxed, allowing a faster growth rate of real output in the short run.

From expressions (23e) and (24a) we can conclude that the short-run effect of an exchange rate devaluation will be (i) a decrease in the actual level of capacity utilization and, hence, in the rate of employment and (ii) a decrease in the growth rate of real output that is compatible with the balance of payments equilibrium.

4. Balanced growth without structural change

In the steady-steady balanced growth path it is required that the following conditions hold:[7]

$$\hat{p}_{t-1} = \hat{p}_t = \hat{p} \quad (25a)$$

$$\hat{p}^e = \hat{p}^T \quad (25b)$$

$$u_{t-1} = u_t = u^T = u \quad (25c)$$

$$\hat{y}_{t-1} = \hat{y}_t = \hat{y} \quad (25d)$$

$$h_{t-1} = h_t = h \quad (25e)$$

$$E_{t-1} = E_t = E \quad (25f)$$

Substituting (25a) - (25f) in equations (23) and (24) we get:

$$u^* = \frac{\gamma_0 + \gamma_1 u^* + \gamma_2 E + (\gamma_3 + \gamma_4)\hat{p}^T - \gamma_5 \hat{p}^* + \gamma_6 l^* + \gamma_7 h \hat{y}^*}{\pi + \eta_1 + \varphi_1 \beta_2} \quad (26)$$

$$\hat{y}^* = \phi_0 + \phi_3 \hat{p}_t^* - (\phi_1 + \phi_4)\hat{p}^T \quad (27)$$

Solving (26) for u^* we get:

$$u^* = \frac{\gamma_0 + \gamma_2 E + (\gamma_3 + \gamma_4)\hat{p}^T - \gamma_5 \hat{p}^* + \gamma_6 l^* + \gamma_7 h \hat{y}^*}{(\pi + \eta_1 + \varphi_1 \beta_2)(1 - \gamma_1)} \quad (26a)$$

In equation (26a) we can see that the steady-state value of capacity utilization is a function of the steady-state rate of employment. The issue is how the steady-state level of employment is determined?

[7] Throughout this section we will consider both the real exchange rate and manufacturing share as exogenous variables.

In order to answer this question, we have to notice that in a balanced growth path the actual growth rate of output must be equal to the natural growth rate, which is the sum of the growth rate of the labor force and the growth rate of labor productivity. Let us assume that the growth rate of labor force is exogenous and equal to *n*. Then, the natural growth rate is given by:

$$g_N = n + \alpha_0 + \alpha_1 h\hat{y} + \alpha_2 l \tag{28}$$

For a balanced growth path to exist is required that $g_N = \hat{y}$, so we get:

$$l^* = \frac{\hat{y}(1 - \alpha_1 h) - (n + \alpha_0)}{\alpha_2} \tag{29}$$

Equation (29) presents the rate of employment in the balanced growth path as a positive function of the growth rate of real output and a negative function of the manufacturing share.[8] The rate of employment is the variable that adjusts the natural growth rate, which is an endogenous variable, to the actual growth rate of real output, through variations in the rate of productivity growth. **It is important to notice that there is no reason to believe that l^* corresponds to the full employment of the labor force.**

Notice that an increase in the manufacturing share will have a negative impact over the steady-state level of employment (see equation 28a). This occurs because an increase in the employment rate will increase the growth rate of productivity for a given growth rate of real output, thereby reducing the demand for labor in the economy.

$$\frac{\partial l^*}{\partial h} = -\frac{\alpha_1}{\alpha_2}\hat{y}^* < 0 \tag{29a}$$

The domestic rate of inflation in the balanced growth path is given by:

$$\hat{p}^{**} = \rho_0 + \rho_2\hat{p}^* + (\rho_1 + \rho_3)\hat{p}^T + \rho_4 u^* + \rho_5 E - \rho_6 l^* - \rho_7 h\hat{y}^* \tag{30}$$

In equation (30) we can see that in steady state, for a given level of real exchange rate, the value for the domestic inflation will be equal to the inflation target only by chance.[9]

For a balanced growth path to exist it is necessary that the growth rate of real output is equal to the growth rate of capital stock in order for the capacity utilization to be constant over time. This condition requires that:

[8] The approach used here follows Ros (2013, chapter 10).

[9] If actual inflation does not converge in the long-run to the inflation target one could ask why monetary policy is taken to be credible by economic agents, making then to set their inflation expectations equal to the target set by Monetary Authorities? The most obvious reason is that in most countries that adopt an Inflation Targeting Regime, the inflation target is not a number but a band with floor and ceiling for the inflation rate. This is, for example, the case of Brazil. This means that if the inflation rate is within this band there is no reason to distrust the commitment of the Central Bank with the inflation target.

$$\phi_0 + \phi_3\hat{p}_t^* - (\phi_1 + \phi_4)\hat{p}^T = [\varphi_0 - \varphi_1(i^* + r - \hat{p}^T)] \tag{31}$$

In equation (31) all variables are parameters, which means that this condition will be satisfied only by chance. We came back to Harrod's first problem. In order to solve this problem, we will assume that in the long-run the autonomous component of investment is no longer an exogenous variable but adjusts over time according to the following equation (See Lavoie, 2016):

$$\frac{d\varphi_0}{dt} = \varphi(\hat{y}^* - g) = \phi_0 + \phi_3\hat{p}_t^* - (\phi_1 + \phi_4)\hat{p}^T - [\varphi_0 - \varphi_1(i^* + r - \hat{p}^T)] \tag{32}$$

In steady state, we have $\frac{d\varphi_0}{dt} = 0$, so we get:

$$\varphi_0^* = \phi_0 + \phi_3\hat{p}_t^* - (\phi_1 + \phi_4 + \varphi_1)\hat{p}^T + \varphi_1(i^* + r) \tag{32a}$$

Summing-up, the steady-state balanced growth path solution of the model is given by:

$$u^* = \frac{\gamma_0 + \gamma_2 E + (\gamma_3 + \gamma_4)\hat{p}^T - \gamma_5\hat{p}^* + \gamma_6 l^* + \gamma_7 h\hat{y}^*}{(\pi + \eta_1 + \varphi_1\beta_2)(1 - \gamma_1)} \tag{26a}$$

$$\hat{y}^* = \phi_0 + \phi_3\hat{p}_t^* - (\phi_1 + \phi_4)\hat{p}^T \tag{27}$$

$$l^* = \frac{\hat{y}^*(1 - \alpha_1 h) - (n + \alpha_0)}{\alpha_2} \tag{29}$$

$$\hat{p}^{**} = \rho_0 + \rho_2\hat{p}^* + (\rho_1 + \rho_3)\hat{p}^T + \rho_4 u^* + \rho_5 E - \rho_6 l^* - \rho_7 h\hat{y}^* \tag{30}$$

$$\varphi_0^* = \phi_0 + \phi_3\hat{p}_t^* - (\phi_1 + \phi_4 + \varphi_1)\hat{p}^T + \varphi_1(i^* + r) \tag{32}$$

Regarding the steady-state solution of the model, it should be noticed the non-neutrality of the monetary policy. In fact, if the Monetary Authority changes the inflation target, then this will affect the growth rate of real output, the capacity utilization and the rate of employment. From equation (27) we get:

$$\frac{\partial\hat{y}^*}{\partial\hat{p}^T} = -(\phi_1 + \phi_4) < 0 \tag{27a}$$

In expression (27a) we can see that an increase in the inflation target will produce a reduction in the long-run growth rate of real output.

From (26a) and (27a) we get:

$$\frac{\partial u^*}{\partial\hat{p}^T} = \left[\frac{(\gamma_3 + \gamma_4)}{(\pi + \eta_1 + \varphi_1\beta_2)(1 - \gamma_1)}\right] - \left[\frac{\gamma_7 h(\phi_1 + \phi_4)}{(\pi + \eta_1 + \varphi_1\beta_2)(1 - \gamma_1)}\right] \tag{26b}$$

From (29) and (27a) follows:

$$\frac{\partial l^*}{\partial \hat{p}^T} = -\frac{(1-\alpha_1 h)(\phi_1 + \phi_4)}{\alpha_2} < 0 \qquad (29b)$$

In expression (28b), the effect of an increase in the inflation target is clearly negative over the long-run value of employment rate. **This means that the long-run Phillips curve is positive sloped**. The effect of an increase in the inflation target over long-run utilization capacity is ambiguous in equation (26b), but the second term in the brackets is clearly an increasing function of the manufacturing share. This means that for highly industrialized small open economies, an increase in the inflation target is likely to be associated with a reduction in the long-run level of capacity utilization.

5. Monetary policy, real exchange rate and structural change

Until now, we have maintained manufacturing's share and the real exchange rate constant throughout the analysis. Thus, the present section has the purpose of relaxing the hypothesis of constant of real exchange rate and manufacturing share.

The dynamic of manufacturing share over time is influenced by *price competitiveness* as well as *non-price competitiveness*. With regards to *price competitiveness*, an overvalued exchange rate (i.e., a real exchange rate below some long-run equilibrium value), may lead to a progressive reduction of the share of manufacturing industry in GDP, since such a situation induces an increased transfer of productive activities to other countries. We will call this level of the real exchange rate the "industrial equilibrium level".[10] Thus, an overvalued RER is associated with a negative structural change on the economy, which we may call premature deindustrialization (Palma, 2005). An undervalued exchange rate, that is, above its industrial equilibrium level would have the opposite effect, to induce a transfer of productive activities to the domestic economy, thereby increasing the share of the manufacturing industry in the GDP.

A fundamental feature of developing economies is that these economies are far from the technological frontier and therefore their firms cannot operate with the state-of-art technology. This technological gap negatively affects the *non-price competitiveness* of manufacturing firms in developing economies, which produce manufactured goods that are of inferior quality and/or lower technological intensity than the manufactured goods produced in the developed economies (Verspagen, 1993). It follows that the existence of the technological gap is an aspect that acts to reduce the competitiveness of developing countries industries, thus contributing to a reduction of the share of the manufactured industry in real output.

[10] See Bresser-Pereira and Gala (2010) and Bresser-Pereira, Oreiro and Marconi (2015) about the exchange rate at the industrial equilibrium level. Industrial equilibrium exchange rate is defined in these papers as the level of real exchange rate that makes firms which operate with the state of art technology competitive both in domestic and international markets. The problem with this concept is that, for developing countries, firms in general operate behind the technological frontier. For overcome this conceptual problem, we will redefine industrial equilibrium exchange rate as the level of real exchange rate that, for a given level of technological gap, makes the share of manufacturing industry on real output constant over time.

From the above discussion, we will assume that the dynamic of the share of manufacturing industry in real output is given by the following differential equation:

$$\hat{h} = h_0 + h_1 E - h_2 G \quad (33)$$

Where: $\hat{h}$ is the growth rate of the share of manufacturing industry in real output ; E is the level of the real exchange rate; $G = \frac{T_f}{T_d}$ is the *technological gap*, defined as the ratio between the level of scientific and technological knowledge at the technological frontier (T_f) and level of scientific and technological knowledge at domestic economy (T_d); $h_1 > 0$ is a parameter that represents the discretionary policies that directly address the industrial development, such as trade tariffs; $h_2 > 0$ is a coefficient that captures the sensitivity of the productive structure to the technological gap and $h_0 < 0$ is a parameter that captures the effect of "mature deindustrialization" due to the effects of the rising levels of per-capita income over the demand for manufacturing goods (Rowthorn and Ramaswamy, 1999).

The industrial equilibrium exchange rate will be defined as the level of real exchange rate for which the manufacturing share is constant over time (Oreiro, 2020). From (33), making $\hat{h} = 0$, we get:

$$E^i = \frac{h_2}{h_1} G - \frac{h_0}{h_1} \quad (34)$$

Where: E^i is the industrial equilibrium level of real exchange rate.

In equation (34) we can see that the industrial equilibrium level of real exchange rate is an increasing function of the technological gap, which means that higher is the distance of a developing country to the technological frontier, higher will be the real exchange rate required to hold manufacturing share constant over time. We can also see that industrial equilibrium exchange rate is a negative function of the level of trade tariffs, captured by the coefficient h_1.

It can be easily shown that the dynamics of manufacturing share will be dependent on the level of real exchange rate overvaluation compared to the industrial equilibrium level. For doing so, let us make some algebraic manipulation in equation (33), as shown below.

$$\hat{h} = h_0 + h_1 E^i + h_1 (E - E^i) - h_2 G = h_0 + h_2 G - h_0 + h_1 (q - q^i) - h_2 G \quad (35)$$

Then we get:

$$\hat{h} = h_1 (E - E^i) \quad (36)$$

In steady state $\hat{h} = 0$, so we get:

$$E^* = E^i = \left[\frac{h_2}{h_1} G - \frac{h_0}{h_1}\right] \quad (36a)$$

The dynamics of real exchange rate is given by:

$$\hat{E}_t = \hat{e}_t + \hat{p}_t^* - \hat{p}_t \quad (36b)$$

From equation (5b) that in steady state we have:

$$\hat{e}_t = -\kappa f[\beta_1(\hat{p}_t - \hat{p}^T)] \quad (37)$$

Substituting (37) in (36b) we get:

$$\hat{E}_t = -\kappa f[\beta_1(\hat{p}_t - \hat{p}^T)] + \hat{p}_t^* - \hat{p}_t = \hat{p}_t^* + \kappa f \beta_1 \hat{p}^T - (1 + \kappa f \beta_1)\hat{p}_t \quad (38)$$

Substituting (30) in (38) we get:

$$\begin{aligned}\hat{E}_t = \{[1 - (1 + \kappa f \beta_1)]\rho_2\}\hat{p}^* &- (1 + \kappa f \beta_1)\rho_0 \\ &+ [\kappa f \beta_1 - (1 + \kappa f \beta_1)(\rho_1 + \rho_3)]\hat{p}^T - (1 + \kappa f \beta_1)\rho_4 u^* \\ &- (1 + \kappa f \beta_1)\rho_5 E + (1 + \kappa f \beta_1)\rho_6 l^* + (1 + \kappa f \beta_1)\rho_7 h \hat{y}^*\end{aligned} \quad (39)$$

In steady state we have $\hat{E}_t = 0$, so we get:

$$\begin{aligned}E = \frac{1}{(1 + \kappa f \beta_1)\rho_5}\big\{\{[1 - (1 + \kappa f \beta_1)]\rho_2\}\hat{p}^* &- (1 + \kappa f \beta_1)\rho_0 \\ &+ [\kappa f \beta_1 - (1 + \kappa f \beta_1)(\rho_1 + \rho_3)]\hat{p}^T - (1 + \kappa f \beta_1)\rho_4 u^* \\ &+ (1 + \kappa f \beta_1)\rho_6 l^* + (1 + \kappa f \beta_1)\rho_7 h \hat{y}^*\big\}\end{aligned} \quad (40)$$

Equation (40) defines a locus of combinations between the level of the real exchange rate and the manufacturing share for which the real exchange rate is constant over time. Taking the derivative of (40) in respect to E and h, we get:

$$\left[\frac{\partial E}{\partial h}\right]_{\hat{E}=0} = -\frac{\rho_4}{\rho_5}\frac{\partial u^*}{\partial h} + \frac{\rho_6}{\rho_5}\frac{\partial l^*}{\partial h} + \frac{\rho_7}{\rho_5}\hat{y}^* \quad (41)$$

We know that:

$$\frac{\partial l^*}{\partial h} = -\frac{\alpha_1}{\alpha_2}\hat{y}^* < 0 \quad (29a)$$

Taking the derivative of u in respect to h in (26a) we get:

$$\frac{\partial u^*}{\partial h} = \left[-\frac{\gamma_6}{\pi + \eta_1 + \varphi_1\beta_2}\left(\frac{\alpha_1}{\alpha_2}\right) + \frac{\gamma_7}{\pi + \eta_1 + \varphi_1\beta_2}\right]\hat{y}^* \quad (42)$$

Substituting (42) and (28a) in (41) we get:

$$\left[\frac{\partial E}{\partial h}\right]_{\hat{E}=0}=\left\{\left[\frac{\gamma_6}{\pi+\eta_1+\varphi_1\beta_2}\left(\frac{\alpha_1}{\alpha_2}\right)-\frac{\gamma_7}{\pi+\eta_1+\varphi_1\beta_2}\right]\left(\frac{\rho_4}{\rho_5}\right)-\left[\left(\frac{\rho_6}{\rho_5}\right)\left(\frac{\alpha_1}{\alpha_2}\right)\right]+\left(\frac{\rho_7}{\rho_5}\right)\right\}\hat{y} \quad (43)$$

In expression (43), the third component is positive $\left(\frac{\rho_7}{\rho_5}\right)$, the second component is negative $\left\{-\left[\left(\frac{\rho_6}{\rho_5}\right)\left(\frac{\alpha_1}{\alpha_2}\right)\right]\right\}$ and the first component can be positive or negative $\left\{\left[\frac{\gamma_6}{\pi+\eta_1+\varphi_1\beta_2}\left(\frac{\alpha_1}{\alpha_2}\right)-\frac{\gamma_7}{\pi+\eta_1+\varphi_1\beta_2}\right]\left(\frac{\rho_4}{\rho_5}\right)\right\}$. So, the locus $\hat{E}=0$ can be either positive or negative sloped.

The stability of the system composed by equations (36) and (38) can be analyzed once the system is linearized around its long-run equilibrium position and presented in the matrix form:

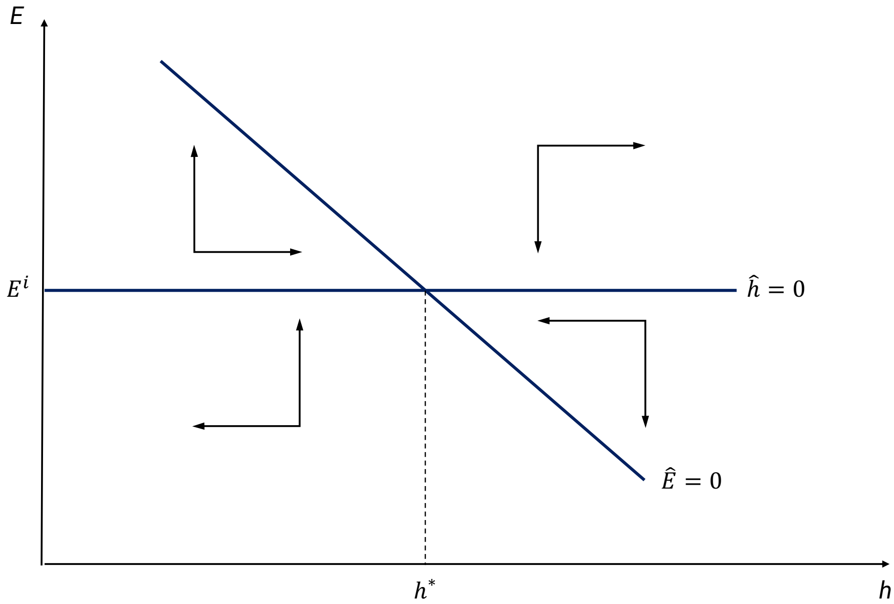
$$\begin{bmatrix}\hat{h}\\ \hat{E}\end{bmatrix}=\begin{bmatrix}\frac{\partial\hat{h}}{\partial h} & \frac{\partial\hat{h}}{\partial E}\\ \frac{\partial\hat{E}}{\partial h} & \frac{\partial\hat{E}}{\partial h}\end{bmatrix}\begin{bmatrix}h-h^*\\ E-E^*\end{bmatrix} \quad (44)$$

The Jacobian Matrix is given by: $\begin{bmatrix}\frac{\partial\hat{h}}{\partial h} & \frac{\partial\hat{h}}{\partial E}\\ \frac{\partial\hat{E}}{\partial h} & \frac{\partial\hat{E}}{\partial h}\end{bmatrix}$. According to Olech's Theorem, for the system to be asymptotically stable in the large the Trace of the Jacobian Matrix must be negative, and the Determinant must be positive (Gandolfo, 1997, pp. 354-355).

The trace is given by: $TR\,J=\left(\frac{\partial\hat{h}}{\partial h}+\frac{\partial\hat{E}}{\partial E}\right)$. From equation (36) we know that $\frac{\partial\hat{h}}{\partial h}=0$ and from equation (43) we know that $\frac{\partial\hat{E}}{\partial E}=-(1+\kappa f\beta_1)\rho_5<0$ which is negative. The determinant is given by: $DET\,J=\frac{\partial\hat{h}}{\partial h}\frac{\partial\hat{E}}{\partial E}-\frac{\partial\hat{E}}{\partial h}\frac{\partial\hat{h}}{\partial E}$. The first term of the determinant is equal to zero because $\frac{\partial\hat{h}}{\partial h}=0$. From equation (36) we get $\frac{\partial\hat{h}}{\partial E}=h_1>0$. So, the sign of the determinant depends on the sign of $\frac{\partial\hat{E}}{\partial h}$. If $\frac{\partial\hat{E}}{\partial h}<0$ then the determinant will be positive, and the system will be stable; otherwise, the determinant will be negative, and the system will have a saddle-path.

Assuming $\frac{\partial\hat{E}}{\partial h}<0$ we can show the long-run equilibrium position by means of Figure 2.

Figure 2 | Equilibrium with structural change

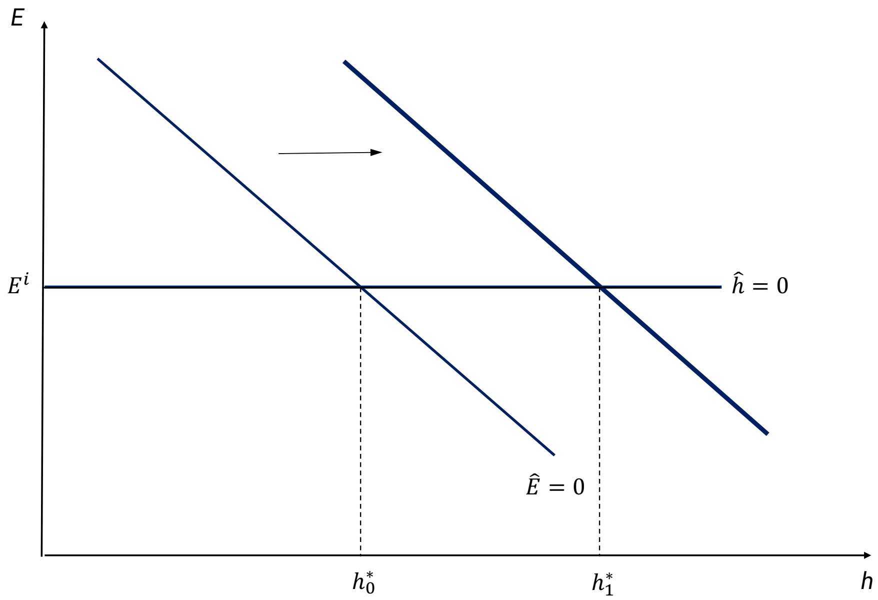


Let us analyze the effect of a reduction of the inflation target over the long-run equilibrium value of manufacturing share and real exchange rate. According to equation (36a) the long run equilibrium value of real exchange rate depends only on the level of technological gap, so it is independent of monetary policy. However, the position of the locus $\hat{E} = 0$ depends on inflation target as we can see in equation (40). Taking the derivative of this equation to *E* and $\hat{p}^T$, we get:

$$\frac{\partial E}{\partial \hat{p}^T} = \left\{\frac{[\kappa f \beta_1 - (1 + \kappa f \beta_1)(\rho_1 + \rho_3)]}{(1 + \kappa f \beta_1)\rho_5}\right\} - \frac{\rho_4}{\rho_5}\left(\frac{\partial u^*}{\partial \hat{p}^T}\right) + \frac{\rho_6}{\rho_5}\left(\frac{\partial l^*}{\partial \hat{p}^T}\right) + \frac{\rho_7}{\rho_5}\left(\frac{\partial \hat{y}^*}{\partial \hat{p}^T}\right) \quad (45)$$

From equations (27a) and (28b) we know that $\left(\frac{\partial l^*}{\partial \hat{p}^T}\right) < 0$ and $\left(\frac{\partial \hat{y}^*}{\partial \hat{p}^T}\right) < 0$, so the last two terms in the R.H.S of equation (45) are clearly negative. From (26b) we know that the sign of $\left(\frac{\partial u^*}{\partial \hat{p}^T}\right)$ is ambiguous, but a decreasing function of h. For low levels of manufacturing share $\left(\frac{\partial u^*}{\partial \hat{p}^T}\right) > 0$, so the term $-\frac{\rho_4}{\rho_5}\left(\frac{\partial u^*}{\partial \hat{p}^T}\right)$ will be negative. Finally, it seems reasonable to assume that $\kappa f \beta_1 - (1 + \kappa f \beta_1)(\rho_1 + \rho_3) < 0$, so the term $\left\{\frac{[\kappa f \beta_1 - (1+\kappa f \beta_1)(\rho_1+\rho_3)]}{(1+\kappa f \beta_1)\rho_5}\right\} < 0$. This means that: $\frac{\partial E}{\partial \hat{p}^T} < 0$, and a decrease in inflation target will shift the $\hat{E} = 0$ to the right, as it is show in Figure 3, producing an increase in the steady-state level of the manufacturing share.

Figure 3 | Decrease in the inflation target and equilibrium with structural change



The effect of changes in inflation target over the growth rate of real output, capacity utilization, employment rate and manufacturing share are summarized in Table I below.

Table 1 | Effects of changes in the inflation target over the growth rate of real output, capacity utilization, employment rate and manufacturing share

	$\hat{y}^*$	l^*	u^*	h^*
$\hat{p}^T$	-	-	-	-

6. Concluding Remarks

The main objective of this paper is to show that monetary policy, specifically the target inflation, can have a long-term influence on real output growth, capacity utilization, employment rate and the productive structure of a small open economy with imperfect capital mobility, flexible inflation targeting and hysteresis. With this goal, a Kaldorian model of balance of payments constrained growth was developed in which monetary policy, price and wage setting, productivity growth and structural change have a central role in the interaction between inflation and economic growth.

Although the model was developed for a small open economy, it is designed for a *mature economy* in the sense of Lewis (1954): labor supply is inelastic and real output growth has to be equal to the natural growth rate in the long run. The natural growth rate is, however, endogenous because productivity growth depends both on output growth and the employment rate. The natural growth rate adjusts to the actual growth rate of real output, determined by the balance of payments constraint, due to changes in the level of employment. In order for a balanced growth path to exist, it was also necessary to make the autonomous component of investment demand an endogenous variable in the long-run, as done by Lavoie (2016).

The main result of the model is that a reduction in the inflation target will result in an increase in the long run growth rate of real output, rate of employment, capacity utilization and manufacturing share. This means that monetary policy is not neutral, even in the long-run and has the capacity to permanently change the productive structure of the economy, increasing the manufacturing share. As the manufacturing share is decisive for the process of technological progress and economic development; it is clear that monetary policy is capable of affecting the development path of an economy. This means that is not possible to separate macroeconomics from economic development. This conclusion is in accordance with the so-called structuralist development macroeconomics, which is the theoretical basis of the Brazilian New-Developmentalism school.[11]

[11] See www.sdmrg.com.br.

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Appendix I. Stability analysis of the dynamic model in the case with no structural change

The stability analysis of the two-dimensional linear systems of short and long term was based on Shone (1997).

From equations (22) and (23) and considering (7), we have:

$$\hat{p}_t = \rho_0 + \rho_2 \hat{p}_t^* + (\rho_1 + \rho_3)\hat{p}^T + \rho_4\left[u^{T-1} + \tilde{\theta}(u_{t-1} - u^{T-1})\right] + \rho_5 E_{t-1} - \rho_6 \frac{k_{t-1}}{q_{t-1}} u_{t-1} - \rho_7 h_{t-1}\hat{y}_{t-1} \tag{22a}$$

$$\hat{u}_t = \left(\frac{1}{\pi_t + \eta_1 + \varphi_1\beta_2}\right)\left[\gamma_0 + \gamma_1\left[u^{T-1} + \tilde{\theta}(u_{t-1} - u^{T-1})\right] + \gamma_2 E_{t-1} + (\gamma_3 + \gamma_4)\hat{p}^T - \gamma_5\hat{p}^* + \gamma_6\frac{k_{t-1}}{q_{t-1}} u_{t-1} + \gamma_7 h_{t-1}\hat{y}_{t-1}\right] \tag{23a}$$

So, the matrix form of the system (22.a) and (23.a) has the following arrangement:

$$\begin{bmatrix}\hat{p}_t\\ \hat{u}_t\end{bmatrix} = \begin{bmatrix} 0 & \rho_4\tilde{\theta} - \rho_6\dfrac{k_{t-1}q_{t-1}^{-1}}{\pi_t + \eta_1 + \varphi_1\beta_2} \\ 0 & \dfrac{\gamma_1\tilde{\theta} + \gamma_6 k_{t-1}q_{t-1}^{-1}}{\pi_t + \eta_1 + \varphi_1\beta_2}\end{bmatrix}\begin{bmatrix}\hat{p}_{t-1}\\ u_{t-1}\end{bmatrix}$$

The determinant of matrix A is clearly equal to zero. In effect, the eigenvalues are real and equal. In this case, if the matrix A feature is negative, the system will be a stable node. For this to occur, the following condition must be met:

$$\left|\frac{\gamma_1\tilde{\theta} + \gamma_6 k_{t-1}q_{t-1}^{-1}}{\pi_t + \eta_1 + \varphi_1\beta_2}\right| < 1$$

Or to be more specific:

$$\gamma_1\tilde{\theta} + \gamma_6 k_{t-1}q_{t-1}^{-1} \quad < \pi_t + \eta_1 + \varphi_1\beta_2$$

Condition that is most likely to be satisfied if: $\beta_2 < \beta_1\rho_4$.

Appendix II. Stability analysis of the dynamic model in the case with structural change

Equations (36) and (39) make up the system of the model of section 5.

$$\hat{h} = h_1\left(E - E^i\right) \tag{36}$$

$$\hat{E}_t = (1-\tilde{\epsilon})\rho_2\hat{p}^* - \tilde{\epsilon}\rho_0 + [(\tilde{\epsilon}-1) - \tilde{\epsilon}(\rho_1+\rho_3)]\hat{p}^T - \tilde{\epsilon}\rho_4 u^* - \tilde{\epsilon}\rho_5 E + \tilde{\epsilon}\rho_6 l^* + \tilde{\epsilon}\rho_7 h\hat{y}^* \tag{39}$$

Where $\tilde{\varepsilon} \equiv (1+\kappa f\beta_1) > 1$.

So, the matrix from of the system (36) and (39) has the following arrangement:

$$\begin{bmatrix}\hat{h}\\ \hat{E}\end{bmatrix} = \begin{bmatrix}0 & h_1\\ J_{21}<0 & J_{22}<0\end{bmatrix}\begin{bmatrix}h-h^*\\ E-E^*\end{bmatrix} \tag{A1}$$

Where:

$$J_{21} \equiv \frac{\partial\hat{E}}{\partial h} = -\tilde{\varepsilon}\rho_4\frac{\partial u^*}{\partial h} - \tilde{\varepsilon}\rho_6\frac{\alpha_1}{\alpha_2}\hat{y}^* < 0 \tag{A2}$$

$$J_{22} \equiv \frac{\partial\hat{E}}{\partial E} = -\tilde{\varepsilon}\rho_5 < 0 \tag{A3}$$

The partial derivative $\frac{\partial u^*}{\partial h}$ will be positive as long as $\alpha_2 > \alpha_1$. That is, as long as the rate of growth in labor productivity is more sensitive to the rate of employment than the growth rate of output.

So, we have to $Tr = J_{22} < 0$ and $Det = -h_1 J_{21} > 0$. Therefore, the system has a stable equilibrium. *Quod erat demonstrandum.*

Appendix III. Calibration of model parameters and initial conditions

The model calibration was performed using Matlab/Simulink R12. As the model is hybrid, that is, it presents discrete dynamics in the short term and continuous dynamics in the long term (when there is structural change), the 50 years calibrated in the long term was based on 50,000 short term interpolations.

The calibration procedure consisted of determining the values of the short-term parameters that would generate a *plausible equilibrium* in economic terms. These values were used to *calibrate* the parameters in the presence of structural change (long term). Thus, the long-term behavior is, at each instant, consistent with the short-term equilibrium.

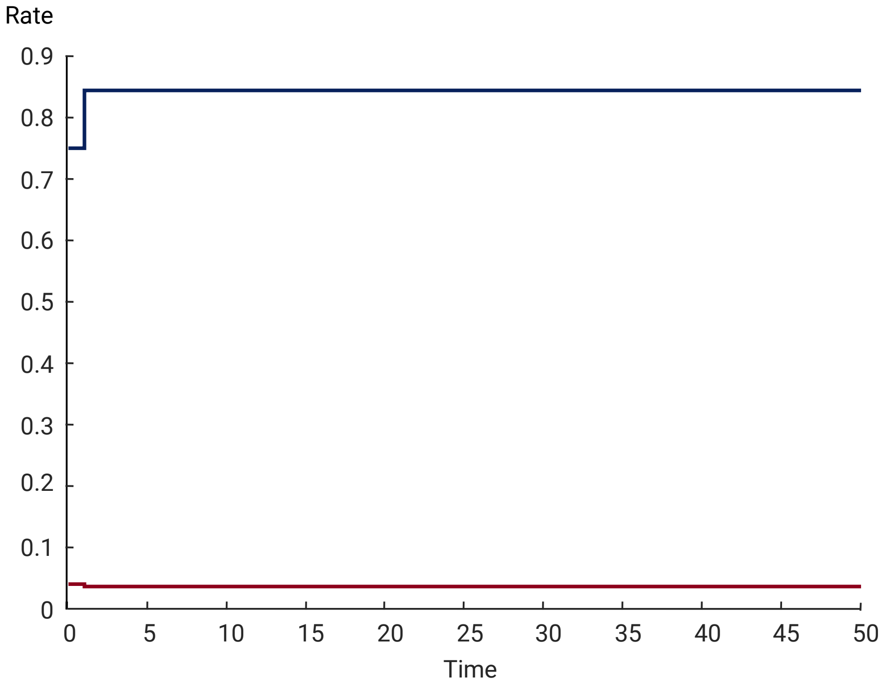
Table A1 | Model calibrated initial values of the model

Initial Variables	Description	Calibrated values
y_{t-1}	Domestic income growth rate in the period t-1	1
h_{t-1}	Industry share in GDP	0.25
E_{t-1}	Real exchange rate in period t-1	1
u_{t-1}	Degree of capacity utilization in period t-1	0.75
E_t	Real exchange rate in period t	1
u^{T-1}	Target Capacity utilization in period t-1	0.75
$\hat{p}^T$	Inflation Target	0.05
$\hat{p}_t^*$	International inflation rate	0.02
i_t^*	International interest rate	0.02
R	Country risk	0.10
K_t	Capital stock	1
k_t	Capital stock per worker	1
N_t	Workforce	1
q_t	Labor productivity	1
π_t	Profit share in income	0.25
$\hat{z}_t$	International GDP growth rate in period t	0.05
Θ_1	Ratio between the initial value of exports and the initial value of imports	1
Θ_2	Ratio between the initial value of external liability services and the initial value of imports	0.24
Θ_3	Restriction $\Theta_3 \equiv (1 - \Theta_1 + \Theta_2)$	0.24
G	Technological gap	0.50

Table A2 | Calibrated model parameter values

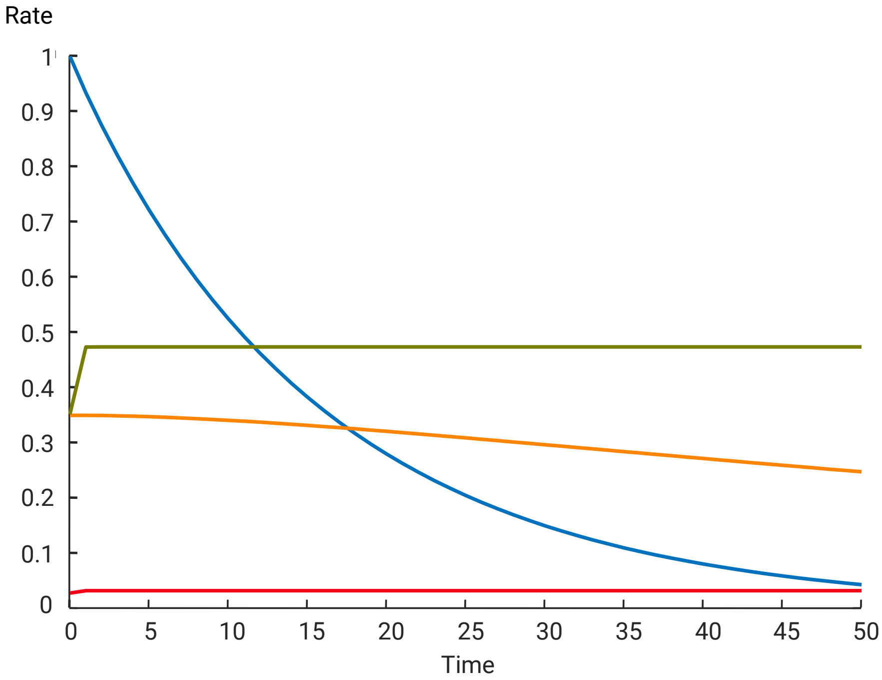
Parameter	Description	Calibrated values
χ_0	Price elasticity of exports	0.40
χ_1	Income elasticity of exports	0.25
μ_0	Price elasticity of exports	0.01
μ_1	Income elasticity of imports	0.25
κ	Coefficient of sensibility of the rate of change of nominal exchange rate in relation to the growth rate of external capital flows	0.25
f	Sensibility of the growth of external capital flows to the interest differential	0.25
β_0	Sum of the international interest rate and the country risk premium	0.12
β_1	Coefficient of sensibility of the interest rate to the inflation gap	0.25
β_2	Coefficient of sensibility of the interest rate to the output gap	0.25
$\tilde{\theta}$	Coefficient of sensibility of the target level of capacity utilization to the capacity utilization gap	0.25
φ_0	Autonomous component of investment	0.06
φ_1	Sensitivity coefficient (positive) that captures the influence of the expected real interest rate on investment decisions	0.25
η_0	Autonomous component of net exports	0.12
η_1	Sensitivity of net exports the degree of capacity utilization	0,80
η_2	Marshall-Lerner's condition	0.41
ϖ	Coefficient that measures the bargaining power of workers	0.12
α_0	Autonomous component	0.01
α_1	Coefficient of Kaldor-Verdoorn	0.12
α_2	Sensibility of labor productivity growth rate to the employment rate	0.02
h_0	Autonomous share of the manufacturing industry in GDP	0.50
h_1	Sensibility of structural change to the real exchange rate	0.01
h_2	Sensibility of structural change to the technological gap	1
n	Population growth rate	0.01
θ	Sensitivity of the mark-up rate to real exchange rate	0.50

Figure A1 | Dynamics of the level of capacity utilization and the rate of inflation



Source: authors' own elaboration. Note: blue - capacity utilization; red - inflation rate.

Figure A2 | Dynamics with structural change, growth, and employment



Source: authors' own elaboration. Note: red – manufacturing share in GDP, yellow - employment rate and purple: GDP growth rate.

Relative Quantities and Prices in Small and Open Developing Economies

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Abstract

This paper employs variants of a simple framework to discuss the determination of sectoral output and relative prices in a stylized small open developing economy which consists of a traditional sector that produces non-tradables and a modern sector that produces internationally traded goods. The baseline model has the flavor of the traditional two-good *dependent economy* framework with surplus labor. I then introduce a series of modifications in the structure of the framework to (briefly) explore aspects such as distributional conflict, external balance constraints, capital account considerations, natural resource discoveries, and supply-side bottlenecks. The analysis demonstrates that the basic structure of the framework provides a flexible tool for investigating important aspects of the development process in a small open economy.

JEL Classification: F41, F43, O11, O14.

Keywords: industrialization, income distribution, real exchange rate, surplus labor.

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Cantidades y precios relativos en economías en desarrollo pequeñas y abiertas

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Resumen

Este documento emplea variantes de un marco simple para discutir la determinación de la producción sectorial y los precios relativos en una economía en desarrollo pequeña y abierta, con un sector tradicional que produce bienes no transables y un sector moderno que produce bienes comercializados internacionalmente. El modelo base se inspira en el marco tradicional de una economía dependiente con dos bienes y con mano de obra excedente. Luego se realizan una serie de modificaciones en la estructura del modelo para explorar (brevemente) aspectos como el conflicto distributivo, las restricciones de equilibrio externo, la cuenta de capital, los descubrimientos de recursos naturales y los cuellos de botella del lado de la oferta. El análisis demuestra que la estructura básica del modelo proporciona una herramienta flexible para investigar aspectos importantes del proceso de desarrollo en una economía pequeña y abierta.

Clasificación JEL: F41, F43, O11, O14.

Palabras clave: distribución del ingreso, excedente de mano de obra, industrialización, tipo de cambio real.

1. Introduction and background

Developing and emerging economies now constitute a significantly larger share of the global economy than a few decades ago. This is true in terms of economic activity, output, and international transactions of assets, goods, and services. In line with this development, the focus of macroeconomics in a developing country context too continues to evolve. While mainstream open economy macroeconomics has mirrored developments in closed economy macroeconomic theory and focused on incorporating welfare considerations in a representative agent/intertemporal optimization context, the so-called neo-structuralists too have broadened their analysis to incorporate structural features that characterize developing economies as they modernize and interact with the rest of the world. The present contribution seeks to discuss some development-related open economy issues with the help of a simple set-up designed to analyze the interactions of quantities and prices over time.

In the next section I discuss the broad contours of the framework I employ in the rest of the paper. I then briefly discuss the justification for treating the stylized tradable sector in a developing economy as a price-taker, at least for the medium- and long-runs. I then develop the analysis by first building a simple framework in the tradition of the dependent economy model modified to incorporate structural features of developing economies such as dual labor markets and surplus labor/underemployment. After exploring some of the properties of this framework, I then incorporate complications such as external balance constraints (section 4.3), the possibility of capital ow reversals (section 4.4), terms of trade shocks (section 4.5), and finally supply-side bottlenecks (section 4.6). The emphasis throughout is on the big picture intuition rather than the details of macroeconomic and microeconomic behavior, and at various points, therefore, I sacrifice depth for breadth of vision.

2. A generic two-sector framework

I organize the analysis around a stylized small open developing economy with two sectors; a modern industrial sector and a traditional one. Developing economies are often characterized by stark structural differences between sectors. I limit my attention to two such differences. One that is also applicable to advanced economies, but typically much less so, is the distinction in the nature of production between the tradable sector and the non-tradable one. My analysis assumes that the tradable good is produced using modern production methods while the output of the traditional sector is non-tradable. Only the former uses capital and, owing to the underdeveloped nature of the industrial sector, all capital goods are imported. Second, unlike developed economies, least developed countries (LDCs) typically have large amounts of (hidden) unemployment and the development process involves the mobilization of these unemployed resources. An example often cited is that of China where record growth rates over the last four decades have involved moving millions of workers from the rural hinterland to the industrialized urban areas, mainly in the coastal provinces in the south and south east. The rural areas have low productivity and significant under- and informal employment, and the goods produced in these informal sectors tend to be relatively non-traded in nature.[1] An important implication is that, in the early stages of development, the development process involves shifting labor from low to higher productivity sectors that produce standardized, less sophisticated goods, before the focus can shift to imitation, reverse engineering, and learning from producing more sophisticated products.

I will utilize the classic Arthur Lewis conception of underemployment in the traditional sector with an elastic supply of (surplus) labor at any given point in time in order to capture the dual nature of the labor market. Growth under such circumstances becomes endogenous, although constraints other than diminishing returns to factors of production may hinder growth over time. Such factors, analyzed in subsequent sections, include but are not limited to distributional conflict and balance of payment constraints.

As I argue in the next section, it is plausible to assume for most developing countries that tradable goods producers are price-takers in international markets (although there are likely to be deviations from this in the short run). The incorporation of the classic Lewis duality and the presence of a non-tradable sector, where prices are determined internally, allows me to consider Keynesian/Kaleckian demand-side considerations. Like this latter family of models, the analysis here focuses on the mobilization of unemployed resources, but there are crucial differences. Output and growth in the modern sector are constrained from the supply side and the real exchange rate (the price of tradables relative to that of non-tradables) is a key variable that affects growth, the balance of payments, and income distribution.

Unlike the direction that much mainstream macroeconomic theory has taken over recent decades, I eschew basing consumption and investment behavior around intertemporal optimization by an optimizing representative agent. In such a framework, the real exchange rate, for example, naturally emerges as an endogenous variable whose value is determined in a general equilibrium set-up by deeper parameters such as preferences, factor endowments, and productivity. While such assumptions may or may not be useful in a long-run advanced economy context, their utility for developing economies is rather limited, given the presence of surplus labor, structural change, and rapidly evolving economic policy frameworks. The specifications for consumption behavior here, however, can be derived from microfoundations if we do away with perfect foresight and forward-looking expectations.

Finally, parts of the analysis below assume that policy makers have significant control over the real exchange rate. A body of literature going back to Mussa (1986) shows that the real exchange rate tracks the nominal exchange rate quite closely over time which suggests that targeting the latter

[1] A significant body of empirical literature now supports the relevance of sectoral productivity differences and duality in developing economies. Temple (2005) document that, in 1996, labor productivity in manufacturing relative to agriculture was almost 6 times higher in Sub-Saharan Africa while the corresponding number for OECD countries was 1.7. These estimates may be somewhat biased due to the fact that the agricultural sector is less well documented. Moreover, as they recognize, differences in average productivity are not the same as differences in marginal productivity. The direction of the bias, however, is not clear. Temple and Woessmann (2006) find that labor reallocation has a significant effect on country growth rates. Vollrath (2009), among others, finds that inefficiencies originating from duality could explain over half of the country-level variation in total factor productivity. See Temple (2005) for a comprehensive overview of dual economy growth models.

may effectively target the former as well, at least in the short- and medium-run (see Disyatat and Galati, 2005; for a more detailed discussion). Governments have a variety of policy options including monetary and fiscal policy, saving incentives, capital controls, and reserve management, and the evidence suggests that governments do indeed use these instruments to influence exchange rates.[2] One must recognize, however, that this assumption becomes less plausible over longer periods of time, especially in the presence of liberalized capital accounts.

3. Relative price determination in a small and open developing economy

Typically developing countries are not large or specialized enough in most sectors to influence the world price of their exports (and especially) imports. To what extent can the typical country be treated as a price taker in international markets? The answer mainly depends on: (1) the degree of substitutability between its products and those of its trading partners, and (2) the market power that it has in different sectors. To illustrate this, it would help to consider the matter more formally.[3]

Let's start with a closed economy which has a large number of firms producing *differentiated* products. Each firm produces a variety and faces a downward sloping demand curve. The typical $MR = MC$ condition for a monopolistically competitive firm, indexed by i, implies that:

$$P_i\left(1 - \frac{1}{\delta}\right) = Wa \tag{1}$$

where P_i denotes the price of variety i, W and a are the nominal wage and unit labor coefficient, and δ is the elasticity of demand which, if the number of product varieties is large enough, also approximates the elasticity of consumer substitution between varieties. I have assumed to help avoid aggregation issues that the elasticity of demand and technology are identical across firms.

Now suppose that these products are traded with the rest of the world. What determines the mark-up factor? One issue that is likely to be important is the extent of close substitutes available domestically and abroad. To see this, consider the following simple specification:

$$\delta_i = \delta = \frac{1}{1 - \Lambda\left(\frac{P_i}{P}\right)^{\lambda_1}\left(\frac{P_i}{EP^*}\right)^{\lambda_2}} \tag{2}$$

where P and P^* denote the domestic and foreign aggregate price levels. Notice that, (1) the higher the individual firm price relative to the aggregate domestic or foreign prices, the greater the elasticity of demand, and (2) the higher the parameters λ_i are, the greater the elasticity of demand. The presence of close (domestic and foreign) substitutes tend to make the latter parameters high. Plugging equation (2) into (1), and recalling that, from equation (1), $P_i = P$:

[2] A detailed discussion of these policy issues is beyond the scope of this paper but see, for example, the fear of floating literature emanating from Calvo and Reinhart (2002), who show that, in the aftermath of the Asian crises, developing countries have systematically intervened in the foreign exchange market to manage the behavior of exchange rates. Levy-Yeyati *et al.* (2013) find evidence that in the 2000s such interventions have aimed to maintain competitive exchange rates or to avoid overvaluations.

[3] The discussion here borrows from Rødseth (2000).

$$P = \left(\frac{1}{\Lambda}Wa\right)^{\frac{1}{1+\lambda_2}} (EP^*)^{\frac{\lambda_2}{1+\lambda_2}}$$

If most of the substitutes for domestic tradables are produced in the rest of the world, then λ_2 will be high. In the limit, when it approaches infinity, we get:

$$P = EP^* \quad (3)$$

In the opposite case, on the other hand, where an economy specializes in a narrow range of differentiated varieties whose substitutes are also mostly produced domestically, λ_2 will be low, and in the extreme, approach zero.

$$P = \frac{1}{\Lambda}Wa \quad (4)$$

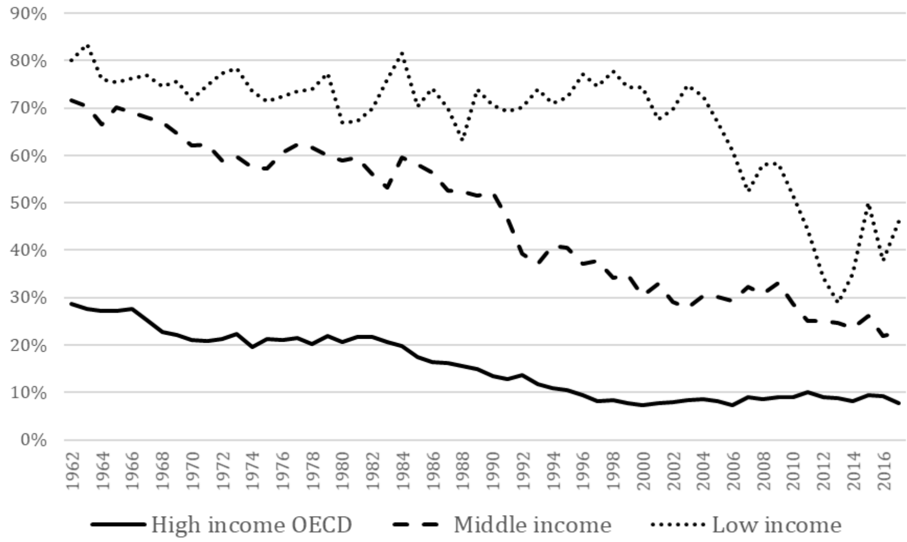
Needless to add it is hard to think of cases which would satisfy the latter criteria in a small open developing economy.

Empirical studies generally find that the price elasticities of export and import demand in developed countries are sufficiently high for the Marshall-Lerner condition to be satisfied (Bussiére *et al*., 2020). However estimated magnitudes vary and, for reasons identified originally by Orcutt (1950), aggregate estimates of trade elasticities are likely to be biased downwards and misleading. Moreover, given the underlying assumptions, crucially that the supply elasticities of exports and imports are infinite, the Marshall-Lerner condition is not the most relevant for developing economies with capacity constraints. This issue is much better explored at the sectoral level. For example, in general one would expect the degree of market power to be greater for economically large countries and the degree of substitutability to be greater for homogeneous goods than for differentiated goods. The latter observation suggests a closer look at the relative composition of developing and developed country exports. Fortunately, wider availability of data makes it a less daunting task to collect disaggregated information.

Figure 1 plots the share of primary goods in total exports for different categories of countries as reported by Lall (2000). Lall distinguishes between the technology and skill intensity of exports and classifies them into five product categories: high-skill intensive manufactures (High-skill), medium-skill intensive manufactures (Medium-skill), low-skill intensive manufactures (Low-skill), natural-resource-intensive manufactures (Resource), and primary products (Primary). The figure shows that, not surprisingly, this share is much higher for developing countries. A higher percentage of developing country exports are homogeneous primary goods.

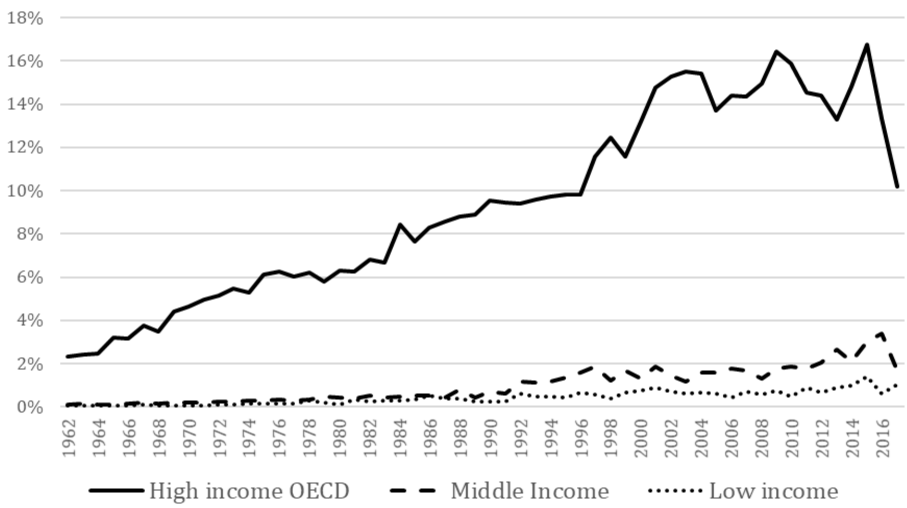
To illustrate this point further, Figure 2, shows the distribution of the median share of high skill-intensive goods. This share was only 1% for low income, 2% for middle income and 10% for high income OECD countries in 2017.

Figure 1 | The median share of primary good exports in total exports of a given country within each group



Note: Primary good classification is based on Lall (2000) and income classifications are from World Bank (2020).

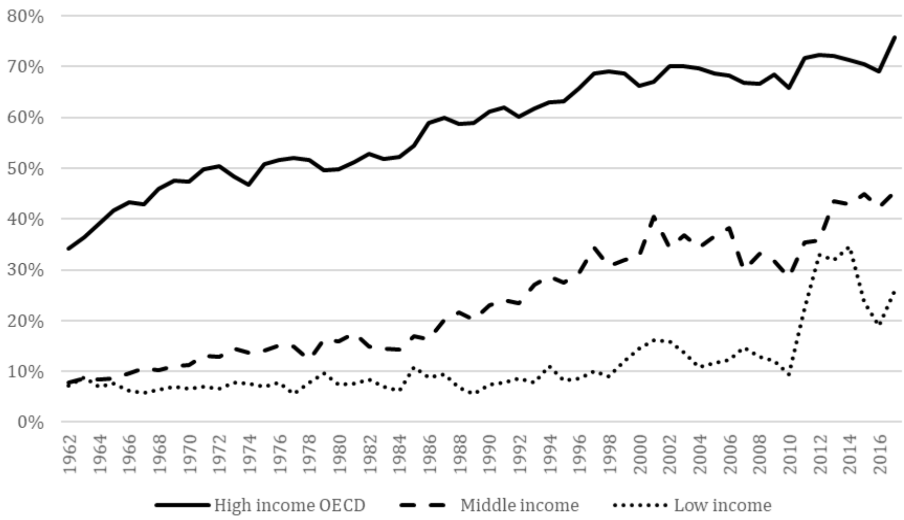
Figure 2 | The median share of high-skill exports in total exports of a given country within each group



Note: High-skill good classification is based on Lall (2000) and income classifications are from World Bank (2020).

In order to further explore how closely substitutable a country's exports are for exports from other countries, we can use the Rauch classification. By definition, differentiated products tend to have fewer substitutes than homogeneous goods. Figure 3 shows the median export shares of differentiated products (using the Rauch, 1999 *conservative* definition). In 2017, the median share of differentiated goods in high income OECD countries' export baskets was 76% while the numbers for middle-income and low-income countries were 45% and 26%, respectively.

Figure 3 | The median share of differentiated goods in total exports of a given country within each country group



Note: The classification for differentiated goods is based on Rauch (1999)'s conservative definition and income classifications are from the World Bank (2020).

Employing the Rauch (1999) classification, Broda and Weinstein (2006) and Soderbery (2018) find that the average elasticities of substitution are much higher for commodities than for reference-priced goods, which in turn are higher than those for differentiated goods. Likewise, Fontagne *et al.* (2019) shows that trade volume responses to bilateral tariffs are larger for homogeneous than for differentiated products. Finally, turning to market power, Soderbery (2018) derives inverse export supply elasticities for disaggregated trade flows and finds that importing countries that are larger in terms of GDP tend to have greater market power. Moreover, their estimates show that supply elasticities for differentiated goods are around three times larger than for homogeneous goods.

Taken together, the existing body of evidence provides good reason to treat the typical developing economy as a small open economy at the aggregate level, at least for long-run analysis. This is consistent with the earlier finding of Goldstein and Khan (1985) who showed that smaller open economies tend to experience greater effects on price setting of competitor prices than of domestic costs. Equation (3), in other words, is a more plausible assumption for traded sector output than equation (4).

4. Interactions between relative prices and quantities

4.1. A simple two-sector framework with surplus labor and infinitely elastic labor supply

Let's now turn to more general equilibrium considerations. The broader framework here is largely based on Razmi *et al.* (2012) and Razmi (2015), modified to allow for a closer analysis of key issues. It has the flavor of the dependent economy model with a traded goods sector (or T-sector) and a non-traded goods one (or N-sector).[4] Table 1 provides a summarized description of the variables employed.

Table 1 | Definitions of key variables

Variable	Definition
C_i, Y_i	Consumption and output of good i, respectively $(i = N, T)$
R	Total rents in the non-tradable sector
$\Pi, r, \bar{r}, r^*$	Profit share of output and the domestic, benchmark, and world profit rates
ω_i	Real wage in terms of non-tradables in sector $i, (i = N, T)$
υ	Worker share of marginal product in N-sector
$\breve{\omega}_N$	Shared wage in the N-sector (also the fallback position)
I	Investment
K	Stock of capital
L_i	Employment in sector $i, (i = N, T)$
TB	Trade balance
s_π	Worker and capitalist saving rates
e, q	Nominal and real exchange rates
p	Price of exported primary commodity in terms of non-tradables $(\equiv P_X/P_N)$
P_i	Price of good $i, (i = N, T)$
λ	Share of domestic consumption expenditure devoted to non-tradables

The benchmark stylized economy under consideration is characterized by sizable underemployment in the rural/traditional/non-tradable sector (in a later section, I'll consider how things change if we introduce supply-side bottlenecks and labor supply elasticity considerations). Various barriers such as quality standards, transaction barriers, transportation costs, and lack of infrastructure prevent exchange of the non-tradable good across international borders. Production requires a fixed factor (land) and labor (L_N), which earns an "effective" real wage (ω_N) determined by the productivity of labor at the margin. Specifically, labor gets a constant proportion (υ) of its marginal contribution that is determined by norms, institutions, etc. The rents are captured by the owners of the fixed factor (*i.e.*, the landlords), whose share in output is denoted by R. To summarize:

$$Y_N = AL_N^\gamma;\ \gamma \leq 1 \tag{5}$$

$$\omega_N = \upsilon\gamma AL_N^{\gamma-1} \tag{6}$$

$$R = 1 - \upsilon\gamma \tag{7}$$

where A is a technological constant and the parameter $\gamma \in (0,1)$ captures the presence of diminishing returns in this sector.[5]

[4] See Swan (1960) for an early exposition.
[5] One should note here that none of the later results regarding steady state accumulation and growth depend on this assumption of diminishing returns, although modifying it will affect the real wage and distribution in the non-tradable sector. The product must be less than one to ensure a positive share of rents.

Developing economies with underemployment are characterized often by work sharing in the absence of public unemployment insurance coverage. The rural/informal/traditional sector acts as a fallback provider of employment. It is, therefore, practical at the aggregate level, for workers employed in the formal/modern/industrial sector, where wages are generally higher, to see income in the traditional sector as their fallback position. A useful measure of nontraded sector worker income, therefore, takes the empirically measured wage in the traditional sector as an average remuneration, that is, total labor income divided by the number of workers not employed in the modern sector. This "shared wage" ($\breve{\omega}_N$) is given by:

$$\breve{\omega}_N = \frac{\omega_N L_N}{L - L_T} \leq \omega_N \tag{8}$$

where L_T is employment in the tradable sector, while L is the total size of the labor force.[6] Depending on institutional and social characteristics, the measured wage in the non-tradable sector may fall anywhere between the shared wage $\breve{\omega}_N$ and the effective wage ω_N.

The modern sector of the economy, the tradable sector or T-sector, produces internationally tradable output using labor (L_T) and an accumulable factor of production, capital, (K), in fixed proportions. In line with traditional structuralist models for the South, the output of the sector is capital constrained.

$$Y_T = \min\left(K, \frac{L_T}{a}\right) \tag{9}$$

In line with our discussion in section 3, the price of the tradable good, P_T, measured in foreign currency terms, is internationally given. Workers have some bargaining power in the T-sector, and the real wage ω_T is assumed to be proportional to a benchmark level of worker purchasing power in terms of non-tradables, $\overline{\omega}_T$.[7] This benchmark level captures labor market institutions and one would expect it to be high enough so as to cover the transaction costs for workers to move from the traditional sector to the urban modern sector, so that $\overline{\omega}_T \geq \breve{\omega}_N$. One would also expect a premium over this benchmark in the modern sector that depends on the extent of principal-agent problems (efficiency wages) and bargaining in the presence of costly search and relationship-specific investment.

$$\omega_T = \phi \overline{\omega}_T; \phi \geq 1 \tag{10}$$

Given labor mobility between sectors, there are likely to be forces of convergence between wages in the two sectors. Moreover, given skill differentials and labor market frictions, and contrary to the assumption made in standard trade models of the Heckscher-Ohlin and Ricardian variety, one

[6] The total labor force includes the sum of employment in the two sectors as well as the unemployed. It is widely recognized that the terms unemployment and/or underemployment are much less well-defined in a low-income economy context. Many workers who are unable to find a job in the modern sector may either remain unemployed, or work in the non-tradable sector, often sharing work with family members. Some of these features were highlighted in the seminal contribution of Lewis (1954).

[7] It may be more accurate to think of the real wage as being negotiated in terms of both goods in the expenditure basket, but since the price of tradables is given, this is a qualitatively innocuous simplification.

would expect this adjustment to be gradual. The factor of proportionality ϕ is an assumed here to be a pre-determined variable that evolves over time depending on the actual real wage relative to the T-sector workers' fallback position. The partial lagged adjustment mechanism can be specified as follows:

$$\dot{\phi} = f(\breve{\omega}_N - \theta\phi\bar{\varpi}_T);\ \theta \in (0,1] \tag{11}$$

Equation (11) indicates that distributional dynamics will play a key role in the later analysis. Denoting the real exchange rate (the relative price of tradables in terms of non-tradables) by q, and utilizing equations (9) and (10), the profit share of tradable output π is given by:

$$\pi = \frac{eP_TY_T - W_TL_T}{eP_TY_T} = 1 - \frac{\omega_T}{q} = 1 - \frac{a\phi\bar{\varpi}_T}{q} \tag{12}$$

Given full capacity utilization, the expression above also defines the profit rate, r. In line with standard structuralist and neo-Kaleckian literature, capitalists and landlords are assumed to save a constant proportion s_π of their income. For simplicity, assume no saving out of wages, government spending or taxation.[8]

Consumer preferences reflect substitutability between tradables and non-tradables, with the consumption of non-tradables, C_N, equaling a proportion λ of total capitalist, landlord, and worker consumption:

$$C_N = \lambda\left[(\omega_N L_N + \omega_T L_T) + (1 - s_\pi)\left(RAL_N^\gamma + q\Pi K\right)\right]$$

and,[9]

$$\lambda = \lambda(q);\quad \lambda' > 0 \tag{13}$$

The first half of the expression in the square brackets on the right-hand side captures consumption by workers, while the second half represents consumption by landlords and owners of capital. Employing eqs. (5), (6), (7), (9), (10), and (12) allows us to consolidate the above expression, so that:

$$C_N = \lambda\left\{[1 - s_\pi(1 - \upsilon\gamma)]AL_N^\gamma + [(1 - s_\pi)q + s_\pi a\phi\bar{\varpi}_T]K\right\} \tag{14}$$

A similar expression can be derived for domestic consumption of the tradable good:

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[8] These assumptions about saving rates can be relaxed without affecting the qualitative nature of the analysis, as long as $s_\pi > s_\omega$, *i.e.*, a greater proportion of income out of profits is saved than that out of wages.

[9] The sign of the partial below indicates that the two goods are substitutes in consumption, with an elasticity of substitution greater than unity. This is likely at the aggregate level. Ostry and Reinhart (1992), for example, find the intra-temporal elasticity of substitution between tradables and non-tradables to range within 1.22-1.27 for developing countries.

$$qC_T = (1-\lambda)\{[1-s_\pi(1-\upsilon\gamma)]AL_N^\gamma + [(1-s_\pi)q + s_\pi a\phi\overline{\omega}_T]K\} \tag{15}$$

Let's next turn to investment behavior. As mentioned in Section 1, the typical developing country imports a high proportion of its capital goods so that structuralist literature often simplifies by assuming that *all* capital goods are imported. This means that periods of accelerated investment can generate pressure on the external account. Also, for reasons mentioned earlier, the typical developing economy is likely to be a price-taker in the international market for capital goods. Let's suppose that all capital goods are tradable and imported. A plausible specification of investment behavior would make it depend on expected and actual profitability which, if we assume static expectations and a baseline minimum profit rate, would take the form:

$$\frac{I}{K} = g(r-\bar{r}) = g\left(1-\phi\frac{a\overline{\omega}_T}{q}-\bar{r}\right);\ g' > 0 \tag{16}$$

where r captures the baseline profit rate which places a floor on positive investment.[10] The tradable good can, of course, be exported or consumed domestically, with the trade balance (TB), expressed in terms of tradables, soaking up any differences between income and expenditure.

$$\frac{TB}{K} = \frac{Y_T}{K} - \frac{C_T}{K} - \frac{I}{K} \tag{17}$$

where the trade balance is normalized by the capital stock for convenience.

Equations (5)-(17) contain 14 endogenous variables (Y_N, L_N, ω_N, $\breve{\omega}_N$, ω_T, C_N, C_T, R, Y_T, π, λ, ϕ, TB, I/K). The N-sector clearing condition completes the framework for our short-run analysis.

$$Y_N = C_N \tag{18}$$

The real exchange rate q and the level of capital stock K are pre-determined in the short run. We are now in a position to explore the short-run reduced form solutions for the endogenous variables of interest.

Substituting from eqs. (5) and (14), yields, after some manipulation:

$$L_N = \left\{\frac{\lambda[(1-s_\pi)q + s_\pi a\phi\overline{\omega}_T]}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]}\frac{K}{A}\right\}^{\frac{1}{\gamma}} \tag{19}$$

[10] Or alternatively, the returns to investing abroad, which can be taken as exogenously determined for a small financially open economy. I return to this aspect later. Alternatively, one could treat these this as the user cost of capital that is kept stable by the central bank.
One issue that the formulation above ignores is that of capacity utilization and demand-side influences on investment. While undoubtedly there are periods of time when such factors dominate, it is hard to think of demand, as opposed to capacity, being the typical binding constraint for rms producing labor-intensive manufactures in an *open* developing economy.

Non-tradable output at any instant is determined by the amount of effective employment which is in turn ultimately determined by demand from the tradable sector. An expansion of the tradable sector (a rise in K), a shift in demand towards non-tradables (a rise in λ) or a decline in the saving rate expands employment in the non-tradable sector. Redistribution of income towards workers in either sector -that is, a rise in ω_T or υ- too expands non-tradable employment, as long as $s_\pi > s_\omega$ $(= 0)$. In brief, short-run equilibrium in the non-tradable sector presents a picture consistent with demand-led output growth.

Once L_N has been pinned down, N-sector output and wages can be determined using eqs. (5), (6), (8), and (19).

$$C_N = Y_N = \frac{\lambda[(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T]}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]}K \qquad (20)$$

$$\omega_N = \upsilon\gamma A\left\{\frac{\lambda[(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T]}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]}\frac{K}{A}\right\}^{\frac{\gamma-1}{\gamma}} \qquad (21)$$

$$\breve{\omega}_N = \frac{1}{L-aK}\upsilon\gamma\left\{\frac{(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]}K\right\} \qquad (22)$$

Non-tradable output and the sharing wage are increasing in K, q, and λ and declining in s_π (eqs. 20 and 22). Changes in these variables have the opposite impact on the effective N-sector real wage in the presence of diminishing returns (*i.e.*, as long as $\gamma < 1$ in equation 21). Intuitively, a real depreciation (a rise in q) causes increased spending on non-tradables, due to both income and substitution effects. Since output and employment in the N-sector are demand-led, these move upward, as does the sharing wage. Lower saving by either group has the same impact, as does, a higher tradable sector real wage. Due to diminishing returns, however, higher employment corresponds to a lower real effective wage. Increased employment in the modern tradable sector raises the shared wage but leaves the effective real wage unaffected. The former effect follows from the fact that more income is being distributed among fewer people outside the T-sector.

Domestic consumption of the tradable good can be derived from eqs. (15) and (19).

$$C_T = \frac{(1-\lambda)}{q}\frac{(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]}K \qquad (23)$$

Thus, substituting from equations (9), (16), (17) and (23), yields the following expression for the trade balance:

$$\frac{TB}{K} = 1-(1-\lambda)\frac{(1-s_\pi)q + s_\pi a\theta\phi\bar{\omega}_T}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]} - g\left(1-\phi\frac{a\bar{\omega}_T}{q} - \bar{r}\right) \qquad (24)$$

A higher saving rate generates a trade surplus. A rise in the labor share of output in the N-sector has the opposite effect. A real appreciation (*i.e.*, a decline in q) or an increased real wage in the T-sector have ambiguous effects on the trade balance. Consumption of tradables rises on the one hand while investment declines on the other. Intuitively, a real appreciation makes nontradables relatively expensive, switching expenditure towards tradables. This would negatively affect the trade balance. Tradable sector profitability declines, however, and the resulting decline in profitability would tend to generate a trade surplus. Stability of the long-run system requires the satisfaction of the famous Marshall-Lerner-Bickerdike-Robinson (MLRB) condition so that the spending effect dominates the investment effect and $\partial TB/\partial q > 0$. As mentioned earlier in section 3, a significant body of literature finds that this condition is satisfied.[11]

4.2. Dilemmas of real exchange rate policy

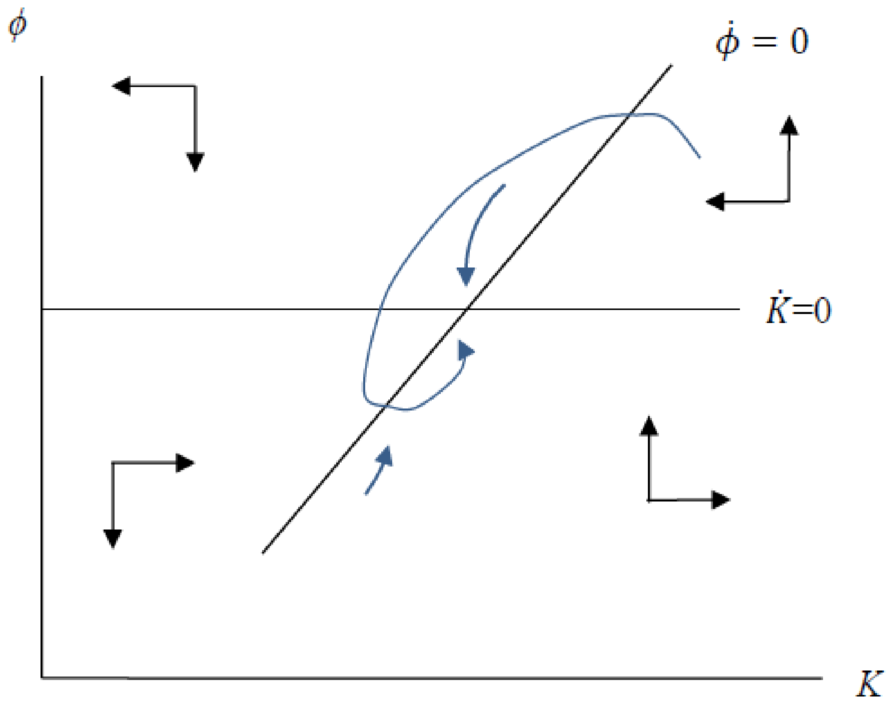
Equations (11) and (16) define the evolution of the state variables (K and ϕ) over time. A first glance at the latter equation may suggest that policy makers, who have sufficiently effective tools to manage the real exchange rate (*i.e.*, the main relative price) are able to pursue any accumulation and growth target. Interactions with the labor market, however, generate dynamics that complicate policy, ensure convergence to a steady state rate of growth over time, and impede the achievement of a higher steady state level of output. To see why, let's discuss the graphical representation of the dynamic system as captured by Figure 4.

Consider first the slopes of the isoclines starting with the $\dot{\phi} = 0$ one. A higher level of the capital stock is associated with a higher shared wage in the non-tradable sector (see equation 22), improving the fallback position of tradable sector workers. A higher T-sector real wage, specifically a higher ϕ, is now consistent with $\dot{\phi} = 0$. To the left of the $\dot{\phi} = 0$ isocline, the shared real wage ($\breve{\omega}_N$), and hence the fallback position of the T-sector workers is below their real wage, putting downward pressure on the latter. The $\dot{K} = 0$ isocline, on the other hand, is horizontal since, as we know from equation (16), the change in capital stock at any instant is independent of the level of capital stock at that instant. At any point below this isocline, the real wage is low and profit rate is higher than the benchmark level, leading to positive investment.

As shown mathematically in the Appendix, the system is locally stable (the trace of the Jacobian matrix of endogenous variables is negative while the determinant is positive). The underlying intuition is simple. Consider, for example, a shock that improves the fallback position of T-sector workers. The resulting rise in their real wage reduces investment, which then has the effect of dampening the initial improvement in the fallback position through a decline in employment and demand for non-tradables.

[11] Note that the MLRB condition is less stringent than the ML condition since it does not assume infinite export and import supply elasticities.

Figure 4 | The baseline dynamic system



The equilibrium could be a stable *node* or *focus*. It can be seen from the expression for the discriminant in the appendix that the lower the initial gap between the benchmark real wage ($\overline{\omega}_T$) and the fallback position ($\widetilde{\omega}_N$) of the workers, the more likely the system is to be a stable node with monotonic, acyclical adjustment.

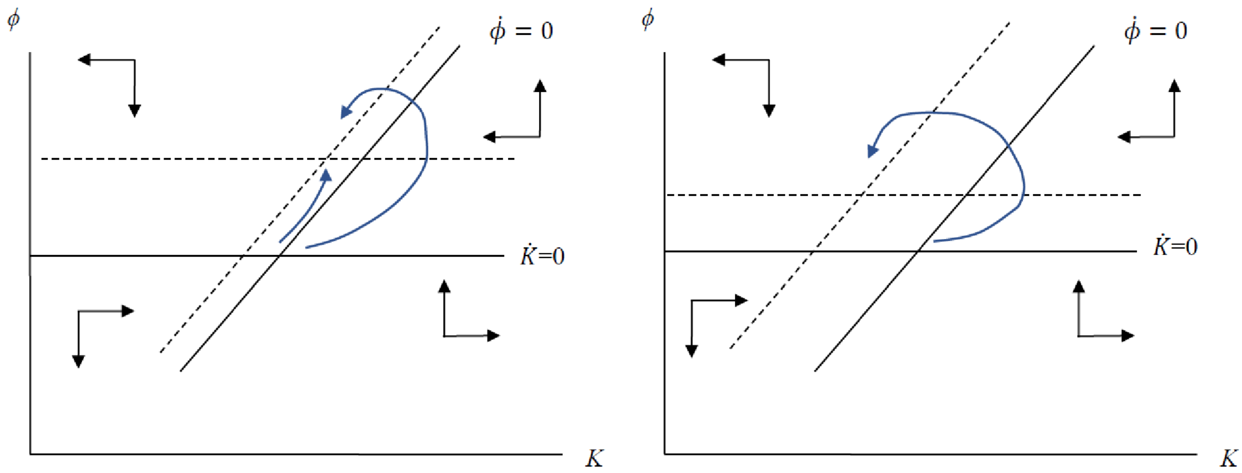
As can be seen from the slope of the $\dot{K} = 0$ isocline, and unlike the case of the traditional neoclassical constant returns to scale production function with factor substitution, there are no diminishing returns to capital accumulation. Interactions with the labor market nevertheless pose constraints on sustained capital accumulation, making policy management of relative prices challenging in practical terms. To see why, let's consider the comparative dynamics of a real devaluation aimed at facilitating expansion of the tradable sector.

Distributional conflict and wage inflation

The rise in profitability caused by an increase in q leads to an immediate rise in investment. Simultaneously, the shift in demand towards non-tradables improves the fallback position of tradable sector workers so that their real wage starts rising. As explained earlier, these two developments tend to dampen each other.

Whether or not the economy ends up at a higher level of capital stock in the new steady state depends partly in this simple set-up on how sensitive the shares of consumption are to relative price changes (*i.e.*, the magnitude of λ'). The left-hand panel in Figure 5, shows the case where this elasticity is sufficiently low so that, by the time rising wages have neutralized the initial impact on profitability, both the real wage and the level of capital stock are higher in the new steady state. But the system could easily end up in a new steady state where the steady state capital stock is lower and in spite of the initial impulse, the modern tradable sector has shrunk. Why? If consumers are sensitive to relative price changes, or if the T-sector is large enough, the resulting immediate increase in demand for non-tradables and the accompanying improvement in the shared wage in the N-sector could be adequately large so that T-sector workers are able to gain a significantly higher real wage in the new steady state. In terms of Figure 5, the relative vertical shift of the $\dot{\phi} = 0$ is greater. The wage inflation resulting from distributional conflict generated by real devaluation can undermine the initial impetus behind that policy action.

Figure 5 | Comparative dynamics of a real devaluation



Note: The left- and right-hand side panels illustrate the cases where λ′ is low and high, respectively.

This sub-section has underlined the potential role of distributional conflict in complicating policy. The next sub-section turns to another source of complications.

4.3. Applying an external account constraint

The previous section specified a steady state rate of capital accumulation and growth but did not impose any restrictions on the current account. Countries do not typically run expanding trade surpluses or deficits for long periods of time. This is particularly true for developing economies that often issue debt in foreign currency and rely on other economies for sophisticated imports. Let's now consider the implications of a trade balance constraint. Also, since the focus here is on distribution and the trade balance, I ignore the international exchange of financial assets.[12] Also, the steady state growth rate will now be treated as endogenous.

The system of equations (5)-(18) continues to apply, as do the short-run solutions (19)-(24). The new element is an equation for the evolution of the real exchange rate, which is specified so that q adjusts to maintain a constant trade balance (as a proportion of the capital stock) over time. There is a target for the trade balance ($\overline{TB}$), which could (but doesn't have to) be zero, and real exchange

[12] See the next section, however, for a rather crude treatment of financial flows.

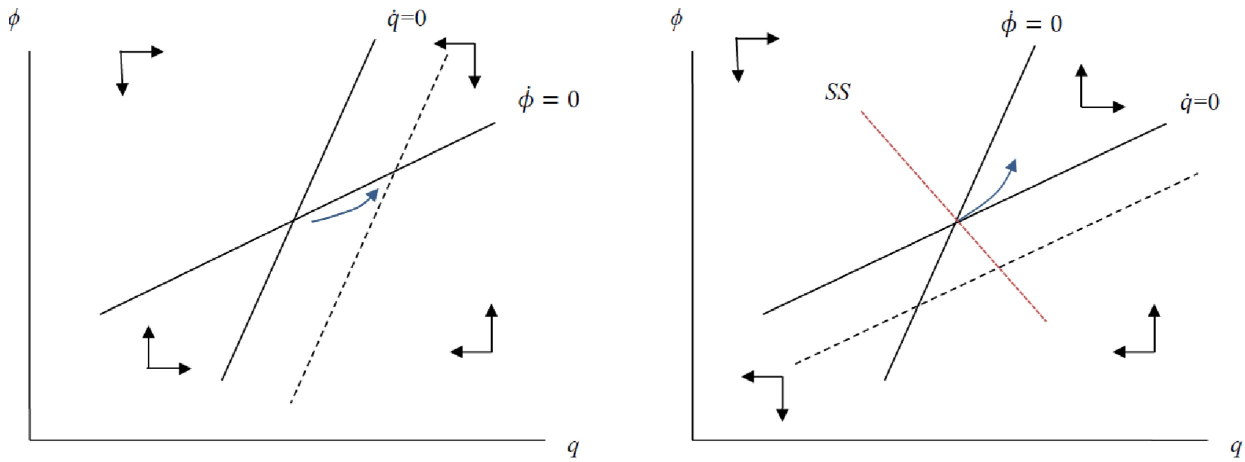
rate policy responds to deviations from the target (specifically, a trade deficit (surplus) is countered with a devaluation (revaluation)).

$$\dot{q} = h\left(\frac{\overline{TB}}{K} - \frac{TB}{K}\right) \qquad (25)$$

Equations (11) and (25) constitute the new system of simultaneous differential equations. The $\dot{q}$ =0 isocline in Figure 6 represents the locus of points along which the trade balance is at its target level. To understand the intuition underlying the positive slope, recall that an increase in the T-sector real wage (through a rise in ϕ) generates a trade deficit relative to the target, thanks to higher consumption. The corresponding level of q that maintains the trade balance at the target level has to be higher (because a higher q diverts domestic consumption towards non-tradables).

As shown in the Appendix, the equilibrium could be a stable focus (or node), or it could be a saddle point. The former case occurs when the trade balance is relatively more sensitive to changes in the real exchange rate while the evolution of the tradable sector real wage is relatively more sensitive to distributional changes in that sector (*i.e.*, the $\dot{q}$ =0 isocline is steeper than the $\dot{\phi}$ =0 isocline).

Figure 6 | A change in the targeted trade balance due to a capital flow reversal



Let's consider the stable case, as illustrated by the left panel in Figure 6 and brie y explore how a change in the trade balance target plays out. Perhaps there has been an international turnaround of capital flows making it necessary to run smaller trade deficits (or greater trade surpluses). The $\dot{q}$ =0 isocline shifts to the right in Figure 6. Not surprisingly, the steady state is now associated with the higher real exchange rate.

Is investment higher or lower in the new steady state? A look at equation (16) should convince the reader that the answer depends on the new steady state ratio of ϕ to q. Furthermore, one can see by looking at the left-hand panel in Figure 6 that this ratio, in turn, depends on the slope of the $\dot{\phi}$ =0 isocline. The steeper this isocline, the higher the new steady state product wage in the T-sector, and the greater the likelihood that investment is lower.
Formally, as shown in the Appendix, the slope of the $\dot{\phi}$ =0 isocline is given by:

$$\left.\frac{\partial\phi}{\partial q}\right|_{\dot{\phi}=0} = \frac{\lambda(1-s_\pi)\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}+\lambda'[(1-s_\pi)q+s_\pi a\phi\overline{\omega}_T]}{\lambda(1-s_\pi)q\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}}\frac{\breve{\omega}_N}{\overline{\omega}_T}$$

In the event that the $\dot{\phi} = 0$ isocline is steeper than the other one, we get saddle path instability. This path is captured by the right panel in the figure. The stable arm (represented by SS) is negatively sloped. The intuition behind the instability is interesting. The key is to recall that the T-sector real wage is highly sensitive to the wage gap. A higher trade balance target means that the real exchange rate has to start rising. But since the labor market in this case highly sensitive to the resulting improvement in the worker fallback position, this leads to a rapid increase in the real T-sector wage, which means that the trade balance is moving further away from the new target level, which requires further real depreciation. Of course, the presence of forward-looking rational expectations or an omniscient social planner could generate solutions where the real exchange rate jumps to the new saddle path (which has moved to the left), and following this step appreciation that hurts the fallback position of tradable sector workers allow for gradual depreciation accompanied by falling *T*-sector wages to guide the economy to its steady state. Such an induced recession in the non-tradable sector (see equation 19) comes with its own problems, needless to add.

In sum, a highly responsive formal sector labor market can generate instability in the face of trade balance problems, as we know from the macroeconomic history of Latin American economies.

4.4. Capital account considerations

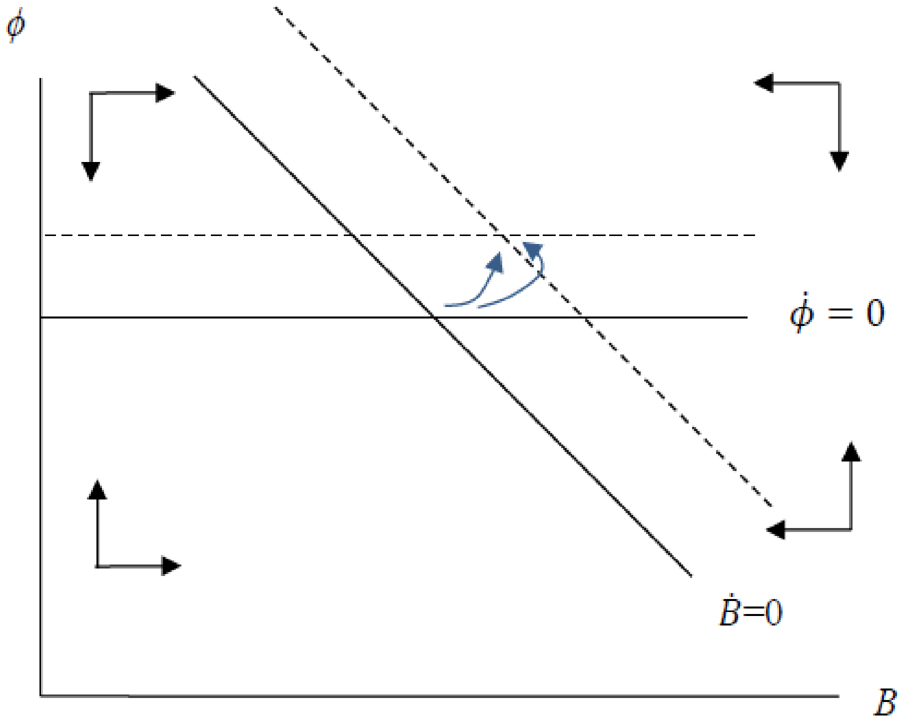
Incorporating international trade in financial assets significantly complicates the analysis and is beyond the scope of this paper. One could, however, introduce capital account-related *flow* considerations in a simple manner by borrowing from the traditional Mundell-Fleming treatment. Suppose that claims on capital are imperfect substitutes for bonds, so that capital inflows are a positive function of the gap between the domestic profit rate and the international interest rate (r^*). Let's use B to denote the *net* stock of international assets and ignore the interactions over time between asset accumulation and the current account. Developing country asset returns often incorporate a risk premium in international markets. Let's use x to represent this risk premium and plausibly assume that it is a positive function of the country's international indebtedness, so that $x = x(B)$ and $x' < 0$.

$$\dot{B} = k(r - x(B) - r^*) = g\left(1 - \phi\frac{a\overline{\omega}_T}{q} - x(B) - r^*\right) \quad (26)$$

Equations (11) and (26) define the new dynamic system. The equilibrium has the nature of a stable node or focus. How does a change in relative prices now affect the labor market, capital accumulation, and the external account?

Let's consider the effect of a real devaluation (see Figure 7). By increasing the domestic profit rate (and through arbitrage between domestic financial assets, the domestic interest rate), this development initially leads to greater investment and capital inflows. Without going into too much detail, both isoclines shift up, the real wage in the tradable sector is higher, and the new steady state rate of capital accumulation could be higher or lower depending on the relative vertical shift of the isoclines. The more muted the consumer response to relative price changes, the less the initial improvement in the fallback position due to expenditure-switching, and therefore, the higher the likelihood that ϕ/q is lower in the new steady state, and that the steady state investment is higher.

Figure 7 | The effects of a real devaluation



4.5. Terms of trade shocks and the Dutch disease

A significant number of developing economies remain dependent on the export of a narrow range of primary commodities such as oil and natural gas. A careful treatment of this issue would require a three-good framework (exportables, importables, and non-tradables). Here I take a simpler route by considering a natural resource that appears in the form of manna and is then exported. This bounty is not consumed directly at home although proceeds from it do of course influence domestic income and consumption of the other tradable and non-tradable goods. For simplicity, let's suppose that all proceeds from the export of the natural resource X, extraction of which grows proportionately with the size of the economy, are consumed.[13]

[13] The results discussed below do not qualitatively depend on this assumption and would pass through if we assume instead that a constant proportion is saved. In a representative agent interporal optimization framework, the trajectory of consumption will rise in light of the increased discounted value of lifetime income. The rise will, of course, depend on whether the shock is expected to be transitory or permanent.

How does our basic setup in Section 4.1 change? Equations (5)-(13) and the investment equation (16) are unaffected while eqs. (14) and (15) now need to be slightly modified:

$$C_N = \lambda\{[1 - s_\pi(1 - \upsilon\gamma)]AL_N^\gamma + [(1 - s_\pi)q + s_\pi a\phi\bar{\varpi}_T]K + pXK\} \quad (27)$$

$$qC_T = (1 - \lambda)\{[1 - s_\pi(1 - \upsilon\gamma)]AL_N^\gamma + [(1 - s_\pi)q + s_\pi a\phi\bar{\varpi}_T]K + pXK\} \quad (28)$$

where p is the (internationally determined) export price of the natural resource per unit relative to that of non-tradables. The trade balance equation becomes:

$$\frac{TB}{K} = \frac{Y_T}{K} - \frac{C_T}{K} - \frac{I}{K} + X \quad (29)$$

Again, the non-tradable sector clearing condition closes the model. The modified reduced form solutions are as follows:

$$L_N = \left\{\frac{\lambda[(1 - s_\pi)q + s_\pi a\phi\bar{\varpi}_T] + pX}{1 - \lambda[1 - s_\pi(1 - \upsilon\gamma)]}\frac{K}{A}\right\}^{\frac{1}{\gamma}} \quad (30)$$

$$C_N = Y_N = \frac{\lambda[(1 - s_\pi)q + s_\pi a\phi\bar{\varpi}_T + pX]}{1 - \lambda[1 - s_\pi(1 - \upsilon\gamma)]}K \quad (31)$$

$$\omega_N = \upsilon\gamma A\left\{\frac{\lambda[(1 - s_\pi)q + s_\pi a\phi\bar{\varpi}_T] + pX}{1 - \lambda[1 - s_\pi(1 - \upsilon\gamma)]}\frac{K}{A}\right\}^{\frac{\gamma-1}{\gamma}} \quad (32)$$

$$\breve{\omega}_N = \frac{1}{L - K}\upsilon\gamma\left\{\frac{(1 - s_\pi)q + s_\pi a\phi\bar{\varpi}_T + pX}{1 - \lambda[1 - s_\pi(1 - \upsilon\gamma)]}K\right\} \quad (33)$$

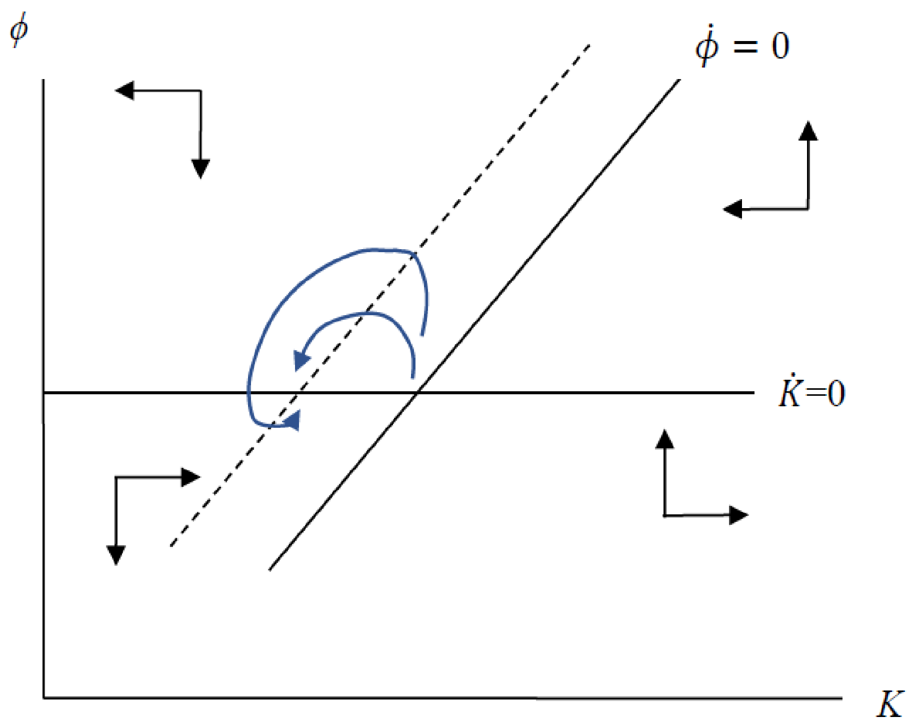
$$C_T = \frac{(1 - \lambda)}{q}\frac{(1 - s_\pi)q + s_\pi a\phi\bar{\varpi}_T + pX}{1 - \lambda[1 - s_\pi(1 - \upsilon\gamma)]}K \quad (34)$$

$$\frac{TB}{K} = 1 - (1 - \lambda)\frac{(1 - s_\pi)q + s_\pi a\phi\bar{\varpi}_T + pX}{1 - \lambda[1 - s_\pi(1 - \upsilon\gamma)]} - g\left(1 - \phi\frac{a\bar{\varpi}_T}{q} - r^*\right) \quad (35)$$

We can now analyze the dynamic effects of a terms of trade shock (change in p) or, symmetrically, that of an increase in the manna available as a proportion of the capital stock (a rise in X) using the baseline system from section 4.2. Recall that the system consists of eqs. (11) and (16), with the level of the capital stock and the real wage in the tradable sector (or more precisely, ϕ) as the predetermined variables.

Once again, the mathematical solutions are provided in the Appendix. Here I will discuss the effects of the above-mentioned shock with the help of Figure 8. Given the specification of the system, *i.e.*, the incorporation of an exogenous bounty, the stability properties are unchanged from section 4.2. A positive terms of trade (*i.e.*, a rise in P_x or p) shock shifts the $\dot{\phi} = 0$ up and to the left. The discovery of a natural resource means that consumption of non-tradables is initially higher, which improves the fallback position of T-sector workers. The resulting wage inflation affects investment in the modern tradable sector negatively. As employment declines in the tradable sector, so does demand for non-tradables, and eventually the T-sector wage catches up with the fallback position, but the capital stock continues to shrink. Beyond this point, the falling level of K means an accompanying decline in the fallback position, putting downward pressure on the T-sector wage. In the most direct approach to the new steady state both w_T and K are declining, although cycles are possible. The steady state level of the capital stock is lower while the real T-sector wage is unchanged. Initial wage inflation has been followed by deflation in the face of declining T-sector employment. Consistent with the Dutch disease phenomenon, the composition of the economy has moved away from the nonprimary tradable sector. If the relative resource cost of extraction of the natural resource remains low, other more labor- or capital-intensive tradable sectors are the ones likely to shrink. Thinking in terms of the Dornbusch *et al.* (1977) framework, it is the sectors that the country has the strongest static comparative advantage in that will thrive.

Figure 8 | A terms of trade shock



A factor that could relieve the negative effects of real appreciation in the face of the initial rise in demand for non-tradables is the possibility of productivity improvements or movement down average cost curves as a consequence of increased output. Such a development is precluded by assumption in this simple set-up. Considering that we are analyzing a small developing economy, this does not seem to be a major limitation.

4.6. Production bottlenecks

I have ignored potential supply-side constraints in the nontradable sector so far. This was reasonable, I think, considering that I was focusing on an economy with large amounts of surplus labor and where the policy makers have sufficient tools to manage the real exchange rate. It is not uncommon, however, for low and middle-income economies to run into supply-side bottlenecks and experience real appreciation following episodes of excess demand. Let's, therefore, relax these two strong assumptions, and introduce supply-side considerations more explicitly in the non-tradable sector.

To accommodate the possibility of supply-side constraints, let's modify the basic framework in section 4.2 so that N-sector output responds to relative price changes. To frame things in simple, albeit stylized terms, let's specify non-tradable output behavior as follows:

$$Y_N = DL_N(q);\ L'_N < 0 \tag{36}$$

$$\omega_N = D \tag{37}$$

$$\breve{\omega}_N = \frac{DL_N}{L - L_T}$$

Labor is the only factor utilized in the non-tradable sector and production is subject to constant returns to scale. Non-tradable output is a function of labor employed in that sector, which declines in response to a relative price shift in favor of tradables. Moreover, the real wage in this sector equals the average product of labor. Again, there is surplus labor that shares the non-tradable sector income and could be utilized in the tradable sector without affecting non-tradable output.

The production and factor income specifications for the tradable sector roll over from the previous section, as do the trade balance and investment specifications. The consumption expressions for the two goods need to be slightly modified and become:[14]

$$C_N = \lambda\{DL_N + [(1 - s_\pi)q + s_\pi a\phi\overline{\omega}_T + qX]K\} \tag{38}$$

$$qC_T = (1 - \lambda)\{DL_N + [(1 - s_\pi)q + s_\pi a\phi\overline{\omega}_T + qX]K\} \tag{39}$$

[14] Notice that one difference from the previous section is that I have consolidated the price of all tradables (including the natural resource) into one price, the real exchange rate *q*. In this section, I do not explore terms of trade shocks, so the distinction is no longer important.

Once again, the N-sector clearing condition closes the model. Using (36) and (38), we get:

$$DL_N(q) = \lambda(q)\{DL_N + [(1 - s_\pi)q + s_\pi a\phi\bar{\omega}_T + qX]K\}$$

so that,

$$L_N(q) = \lambda \frac{(1 - s_\pi)q + s_\pi a\phi\bar{\omega}_T + qX}{1 - \lambda} \frac{K}{D} \quad (40)$$

Since the real exchange rate now is endogenous, the equation above is not a reduced form solution for L_N. We can, however, utilize the implicit function theorem to derive partial solutions for q.

$$q = q(K, \phi, X, \bar{\omega}_T);\ q_K, q_\phi, q_X, q_{\bar{\omega}_T} < 0 \quad (41)$$

Where:

$$q_K = \frac{\partial q}{\partial K} = \frac{\lambda}{1 - \lambda} \frac{(1 - s_\pi)q + s_\pi a\phi\bar{\omega}_T + X}{\Lambda D} < 0,$$

$$q_\phi = \frac{\partial q}{\partial \phi} = \frac{\lambda}{1 - \lambda} s_\pi a\bar{\omega}_T \frac{K}{\Lambda D} < 0,$$

$$q_X = \frac{\partial q}{\partial X} = \frac{\lambda}{1 - \lambda} \frac{K}{\Lambda D} < 0,$$

$$q_{\bar{\omega}_T} = \frac{\partial q}{\partial \bar{\omega}_T} = \frac{\lambda}{1 - \lambda} s_\pi a\phi \frac{K}{\Lambda D} < 0,$$

and:

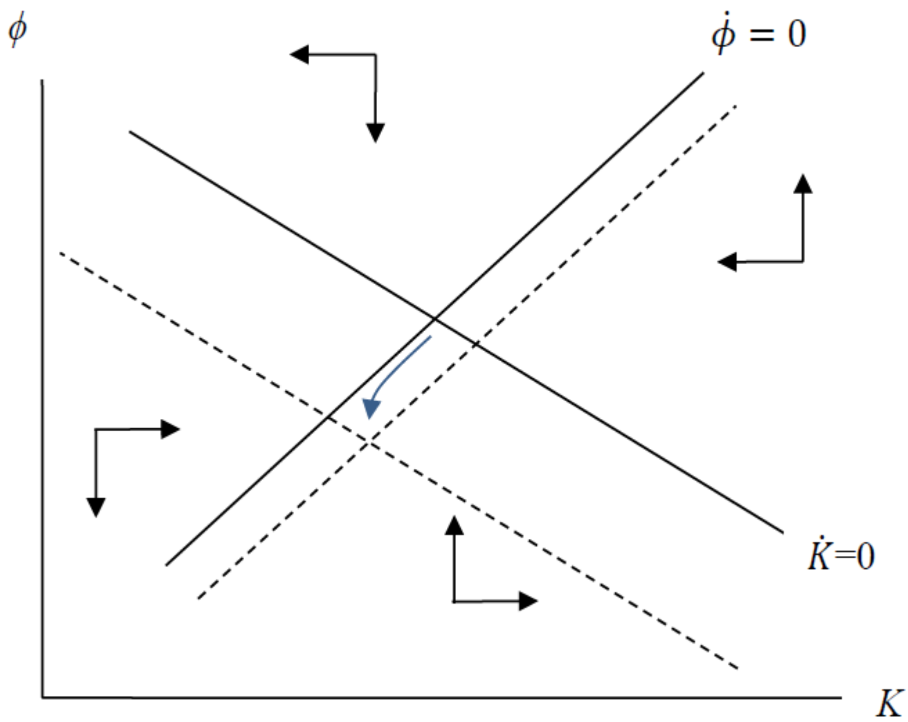
$$\Lambda \equiv L_N' - \frac{\lambda'[(1 - s_\pi)q + s_\pi a\phi\bar{\omega}_T + X] + \lambda(1 - \lambda)(1 - s_\pi)}{(1 - \lambda)^2} \frac{K}{D} < 0$$

To understand the intuition underlying the signs above, notice that a rise in q affects output and consumption of non-tradables in opposite directions, therefore generating excess demand for this good. This means that, if K rises, for example, the excess demand for non-tradables must be eliminated by real appreciation. This (partial) positive correlation between q and K is consistent with the Balassa-Samuelson effect.

We can also employ (38), (39), and (41) to solve for consumption of the two goods as a function of the pre-determined and exogenous variables. From the perspective of this section, a key result that carries over from previous sections is that the domestic consumption of both goods rises with the level of the capital stock, improving the fallback position of T-sector workers.

Let’s turn once more to the dynamic system as captured by eqs. (16) and (11). Figure 9, which illustrates the system, shows the effect of a new natural resource discovery. The change shifts both isoclines downwards. As formally shown in the Appendix, the $K = 0$ isocline shifts more than the other one in the horizontal direction so that the steady level of both the capital stock and the T-sector real wage drop to lower values. Recall from the previous section that, with no supply-side constraints in the non-tradable sector, it was only the size of, but not the real wage in, the tradable sector that declined. Why the difference? Unlike the case without a supply bottleneck, the newly arrived bounty leads to real appreciation. A look at equation (16) will convince the reader that this means that the real wage must be lower for investment to be non-negative in the new steady state. Intuitively, the initial appreciation raises the real product wage in the T-sector while simultaneously putting downward pressure on the fallback position. Investment and the real wage decline as a result.

Figure 9 | Natural resource discovery in the presence of supply-side bottlenecks



In sum, the presence of supply-side bottlenecks exacerbates the negative effect of a natural resource discovery on real wages in the tradable sector.

5. Concluding thoughts

Development economics as a distinct academic field has been in existence for more than half a century now but some of the original insights of the pioneers remain relevant. Indeed, one could go further back in time and draw on Ricardo and the classical economists to understand some of the features and constraints that appear much more prominently in developing economies such as the dual structure of labor markets, the presence of a traditional sector alongside a modern one, balance of payments issues, and distributional conflict over scarce resources.

I have attempted to present a series of stylized models built around a baseline framework that incorporate some of these issues in a parsimonious manner. This allowed me to carry out a series of thought exercises focused on issues that lie at the intersection of development and international economics, and that have been considered important over the years, both among academics and policy makers. As always, some of the different broad mechanisms may be more or less important over different time horizons and for different types of countries. For example, populous countries such as India with scarce land may have more surplus labor than sparsely populated land-abundant countries such as Argentina. Some countries may be heavily abundant in natural resources while others may not. Real wage flexibility will be higher in some countries compared to others. Static comparative advantage, either due to Ricardian technological differences or due to relative factor endowments, as in the Heckscher-Ohlin or specific factors frameworks, may well make it easier to influence industrialization and structural change in some cases compared to others. The main thrust of analysis should be to identify the salient structural features in each context in order to explore them in a formal and insightful manner.

The tradable sector that I have analyzed in this paper is special in the sense that it's the part of the economy where production takes place and capital is utilized under modern conditions. The goal here was simplicity and clarity. A less barebones structure would incorporate the possibility of economies of scale (Ros and Skott, 1998; Rapetti, 2012), dynamically evolving comparative advantage (Krugman, 1987), market imperfections (Rodrik, 2008), structural diversification (Razmi, 2013), and learning-by-exporting (Guzman et al., 2018), among other important aspects. Obviously monetary considerations are important too, especially on the balance of payments front.

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Appendix

This section provides the formal algebraic expressions underlying the discussion in each section.

Section 4.1

Consider the dynamic system based on equations (11) and (16). The elements of the endogenous variable Jacobian are:

$$\mathbf{J} = \begin{vmatrix} \dot{K}_K & \dot{K}_\phi \\ \dot{\phi}_K & \dot{\phi}_\phi \end{vmatrix}$$

Where:

$$\dot{K}_K = -g'\frac{a\bar{\omega}_T}{q}K < 0,$$

$$\dot{K}_\phi = 0,$$

$$\dot{\phi}_K = f'\frac{L}{(L-aK)K}\breve{\omega}_N > 0,$$

$$\dot{\phi}_\phi = -f'\frac{(1-\lambda)(L-aK)+\lambda s_\pi(1-\upsilon\gamma)L}{(L-aK)\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}}\bar{\omega}_T < 0$$

Trace $= -f'\bar{\omega}_T < 0$, $|\mathbf{J}| = f'g'\frac{a\bar{\omega}_T}{q}\frac{L}{(L-aK)K}\breve{\omega}_N > 0$

Denoting the discriminant by Δ:

$$\Delta = f'\bar{\omega}_T\left[\bar{\omega}_T - 4g'\frac{a}{q}\frac{L}{(L-aK)K}\breve{\omega}_N\right] <> 0$$

Section 4.2

Using "~" to denote steady state values of variables:

$$\frac{d\tilde{K}}{dq} = -\frac{\upsilon\gamma}{\breve{\omega}_N}\frac{\lambda(1-s_\pi)\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}+\lambda'[(1-s_\pi)q+s_\pi a\phi\bar{\omega}_T]}{\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}^2}+\frac{\phi}{q}\frac{L-aK}{K}\frac{1}{\breve{\omega}_N} <> 0$$

$$\frac{d\tilde{\phi}}{dq} = \frac{\phi}{q} > 0$$

Notice that a high value of λ' and limited availability of workers from outside the T-sector (*i.e.*, low $L - aK$) tend to make $\frac{d\tilde{K}}{dq}$ negative.

Section 4.3

Consider the dynamic system based on equations (11) and (25). The elements of the endogenous variable Jacobian are:

$$\mathbf{J} = \begin{vmatrix} \dot{q}_q & \dot{q}_\phi \\ \dot{\phi}_q & \dot{\phi}_\phi \end{vmatrix}$$

Where:

$$\dot{q}_q = -h' \left\{ \frac{\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}(1-\lambda)\frac{a\bar{\omega}_T}{q^2} + \lambda'[(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T](1-\upsilon\gamma)}{\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}^2} s_\pi - g' \frac{a\phi\bar{\omega}_T}{q^2} \right\} < 0,$$

$$\dot{q}_\phi = -h' \left\{ -\frac{1-\lambda}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]} s_\pi + g' \right\} \frac{a\bar{\omega}_T}{q} > 0,$$

$$\dot{\phi}_q = f' \frac{\lambda(1-s_\pi)\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\} + \lambda'[(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T]}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]} \frac{\breve{\omega}_N}{\lambda[(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T]} > 0,$$

$\dot{\phi}_\phi = -f' \frac{(1-s_\pi)q}{[(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T]} \bar{\omega}_T < 0$, (given that $\breve{\omega}_N - \phi\bar{\omega}_T \approx 0$ around the steady state).

Trace = $\dot{q}_q + \dot{\phi}_\phi < 0$, $|\mathbf{J}| <> 0$

$|\mathbf{J}| > 0$ if $-\frac{\dot{q}_q}{\dot{q}_\phi} > -\frac{\dot{\phi}_q}{\dot{\phi}_\phi}$, *i.e.* if the $\dot{q} = 0$ isocline is the steeper one.

The slopes of the two isoclines are:

$$\left.\frac{\partial\phi}{\partial q}\right|_{\dot{\phi}=0} = \frac{\lambda(1-s_\pi)\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\} + \lambda'[(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T]}{(1-s_\pi)q\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}} \frac{\breve{\omega}_N}{\bar{\omega}_T}$$

$$\left.\frac{\partial\phi}{\partial q}\right|_{\dot{q}=0} = \frac{\dfrac{\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}(1-\lambda)\dfrac{a\bar{\omega}_T}{q^2} + \lambda'[(1-s_\pi)q + s_\pi a\phi\bar{\omega}_T](1-\upsilon\gamma)}{\{1-\lambda[1-s_\pi(1-\upsilon\gamma)]\}^2} s_\pi \dfrac{q}{a\bar{\omega}_T} - g' \dfrac{\phi}{q}}{\dfrac{1-\lambda}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]} s_\pi - g'}$$

Section 4.4

The vertical shifts of the two isoclines are given by:

$$\left.\frac{\partial\phi}{\partial q}\right|_{\dot{B}=0}=\frac{\phi}{q}>0$$

$$\left.\frac{\partial\phi}{\partial q}\right|_{\dot{q}=0}=\frac{\frac{1-s_\pi}{(1-s_\pi)q+s_\pi a\phi\bar{\omega}_T}+\frac{\lambda'}{\lambda}\frac{1}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]}\frac{\breve{\omega}_N}{\bar{\omega}_T}K}{\frac{1}{1-\lambda[1-s_\pi(1-\upsilon\gamma)]}\left[(1-\lambda)+\frac{\lambda s_\pi(1-\upsilon\gamma)L}{(L-aK)}\right]}>0$$

Notice that the higher λ' is, the greater the vertical shift of the $\dot{q}=0$ isocline.

Section 4.5

The comparative dynamic outcomes as a result of an increase in X are as follows:

$$\frac{d\tilde{K}}{dX}=-\frac{p}{\frac{L}{L-aK}[(1-s_\pi)q+s_\pi a\phi\bar{\omega}_T+pX]}K<0$$

$$\frac{d\tilde{\phi}}{dX}=0$$

Section 4.6

The slopes of the two isoclines are as follows:

$$\left.\frac{\partial\phi}{\partial K}\right|_{\dot{K}=0}=\frac{1}{q}\frac{\lambda}{1-\lambda}\frac{(1-s_\pi)q+s_\pi a\phi\bar{\omega}_T+pX}{\Lambda D}>0$$

$$\left.\frac{\partial\phi}{\partial K}\right|_{\dot{\phi}=0}=\left[\frac{DL_N}{L-K}+L'_N q_K\right]\frac{D}{(L-K)\bar{\omega}_T}>0$$

The horizontal shifts of the 2 isoclines are given by:

$$\left.\frac{\partial K}{\partial X}\right|_{\dot{K}=0}=-\frac{K}{(1-s_\pi)q+s_\pi a\phi\bar{\omega}_T+pX}<0$$

$$\left.\frac{\partial K}{\partial X}\right|_{\dot{\phi}=0}=-\frac{\frac{L'_N}{L-K}\frac{\lambda}{1-\lambda}\frac{K}{\Lambda}}{\frac{DL_N}{(L-K)^2}+\frac{L'_N}{L-K}\frac{\lambda}{1-\lambda}\frac{[(1-s_\pi)q+s_\pi a\phi\bar{\omega}_T+pX]}{\Lambda}}>0$$

Notice that, if $\frac{DL_N}{(L-K)^2}=0$ in the denominator of the second line, then the shift of the two curves is identical in magnitude. Since $\frac{DL_N}{(L-K)^2}>0$, this proves that $\dot{\phi}=0$ isocline will shift by less.

Un modelo dinámico stock flujo para la Argentina: una aplicación al escenario económico post pandemia

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Resumen

El presente documento desarrolla un modelo de Stock-Flujo Consistente (SFC) para el análisis de las variables macroeconómicas de la Argentina. La principal utilidad de los modelos SFC está asociada a la posibilidad de realizar ejercicios contrafactuales para evaluar diferentes modificaciones de la política fiscal, tributaria, monetaria y comercial. Estos modelos están caracterizados por la utilización de matrices de contabilidad social (SAM), lo que permite realizar una desagregación de la cuenta capital y de los instrumentos financieros de cada sector institucional. Esto le otorga consistencia contable, ya que la SAM contiene las principales transacciones del sector real, así como los flujos monetarios entre las distintas instituciones: hogares, empresas, bancos, gobierno, banco central y el resto del mundo. Este modelo fue elaborado con el objetivo de realizar proyecciones de mediano plazo sobre los principales flujos y *stocks* de la economía argentina, complementando los resultados de otros modelos existentes en la literatura.

Clasificación JEL: C54, E16, E58.

Palabras claves: modelo *stock*-flujo, política monetaria, simulaciones.

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A Dynamic Stock-Flow Model for Argentina: an Application to the Post-Pandemic Economic Scenario

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Abstract

This document develops a Consistent Stock-Flow (SFC) model for the analysis of macroeconomic variables in Argentina. The main utility of SFC models is associated with the possibility of performing counterfactual exercises to evaluate different modifications of fiscal, tax, monetary and commercial policy. These models are characterized by the use of social accounting matrices (SAM), which allows a breakdown of the capital account and financial instruments of each institutional sector. This gives accounting consistency, since the SAM contains the main transactions of the real sector, as well as the monetary flows between the different institutions: households, companies, banks, government, central bank and the rest of the world. This model was developed with the objective of making medium-term projections on the main flows and stocks of the Argentine economy, complementing the results of other existing models in the literature.

JEL Classification: C54, E16, E58.

Keywords: monetary policy, simulations, stock-flow models.

1. Introducción

El análisis cuantitativo de las políticas públicas es fundamental a la hora de su diseño e implementación. Una de las herramientas utilizadas para este tipo de trabajo son los modelos SFC (*Stock Flow Consistent*), en conjunto con una gama amplia de modelos macroeconómicos. Los modelos SFC fueron desarrollados en forma pionera por Godley (1976) en la década del setenta para analizar el ajuste de la economía del Reino Unido ante diversos problemas de balance de pagos que enfrentaba. Si bien su uso ha crecido exponencialmente a partir del trabajo de Lavoie y Godley (2007), el mismo ha estado concentrado principalmente en el estudio teórico de diversos problemas macroeconómicos y financieros (Godin *et al.*, 2013). Sin embargo, tal como lo documentan Zezza y Zezza (2019), progresivamente han comenzado a surgir versiones empíricas aplicadas a diversos países. Entre las primeras aplicaciones encontramos los trabajos de Papadimitriu *et al*. (2009) para la economía de Grecia y Papadimitriu *et al*. (2013) para los Estados Unidos. Recientemente han aparecido dos nuevos modelos empíricos aplicados a la economía de Italia (Zezza, 2020) y Dinamarca (Byrialsen y Raza, 2020). Uno de los hechos más destacados en este sentido, ha sido la incorporación de un SFC por parte del Banco de Inglaterra (Burgess *et al*., 2016) para la evaluación de sus políticas.

En lo que respecta a la Argentina, prácticamente no existen modelos empíricos SFC hasta la fecha. Una de las pocas excepciones es el trabajo de Michelena y Guaita (2019), el cual constituye la versión previa de este estudio. A diferencia del modelo actual, la versión previa describe en detalle a la economía real, dejando incompleto o poco desarrollado al bloque financiero de la economía. Adicionalmente, está el trabajo reciente de Valdecantos (2020), uno de los referentes a nivel internacional en la literatura SFC, quien elabora un modelo empírico para estudiar la crisis de balanza de pagos de la economía argentina durante las últimas décadas. El autor también considera diferentes escenarios de política, alternativos a los que fueron tomados durante 2016, para resolver los desequilibrios externos.

La principal utilidad de los modelos SFC, al igual que otros macro modelos, reside en la posibilidad de realizar ejercicios contrafactuales para evaluar diferentes modificaciones de la política fiscal, tributaria, monetaria y comercial. La posibilidad de realizar estimaciones cuantitativas es una herramienta clave a la hora de analizar escenarios y de evaluar las políticas en términos de costos y beneficios potenciales. Por tal motivo, estos modelos permiten a los investigadores utilizar datos duros y transparentes, tanto en el análisis como en la toma de decisiones. Los modelos *stock*-flujo constituyen una base para entender los efectos de distintos *shocks* sobre un conjunto relevante de variables, tales como: el empleo, la producción, el balance de pagos y la distribución del ingreso, entre otros. Es importante resaltar que este enfoque permite obtener resultados no solo con respecto a la dirección de los efectos, sino también a su magnitud. Tal como lo destaca Zezza y Zezza (2019), existen cinco elementos principales que caracterizan al enfoque SFC:

- Consistencia horizontal: los pagos deben ser registrados como un ingreso para un determinado sector institucional y un egreso para otro.

- Consistencia vertical: refiere a la restricción presupuestaria de cada sector.

- Consistencia *stock*-flujo: el *stock* al final del período debe ser igual al *stock* inicial, sumado a los flujos y a las ganancias de capital, tal que:

$$S_t = S_{t-1} + F_t + CG_t$$

- Consistencia de hoja de balance: los activos finales de un sector, al final del período, deben ser iguales a la suma de los pasivos de uno o más sectores. Este punto resalta la relación existente entre deudores y acreedores en la economía.

- Retroalimentación entre los flujos y *stocks*: La inclusión de los *stocks* no solo es relevante en términos contables, sino que además tienen un impacto sobre la economía real. Por ejemplo, si las empresas tienen un elevado *stock* de deuda en moneda extranjera y ocurre un aumento del tipo de cambio, pueden verse afectadas sus decisiones de inversión.

Las primeras cuatro propiedades del enfoque SFC son el resultado de la utilización de matrices de contabilidad social financieras (FSAM), empleando la contabilidad propuesta por Stone y Brown (1962). Por otra parte, el último de los puntos es el resultado de la adopción del enfoque teórico post-keynesiano sobre el funcionamiento de la economía, en donde el dinero y las finanzas juegan un papel central dentro del sistema económico (Lavoie, 2014). Si bien esto puede parecer una obviedad *a priori*, la mayoría de los modelos introducen al dinero en forma *ad hoc* y no incorporan una interacción detallada y precisa entre la esfera real y financiera.

El modelo SFC desarrollado en este documento fue pensando como una herramienta para la generación de escenarios y simulaciones sobre la economía argentina. Su principal contribución reside en la generación de proyecciones sobre los principales *stocks* a lo largo del tiempo, así como en la medición de los balances de cada sector institucional. De esta forma, resulta posible detectar y advertir posibles trayectorias explosivas o insostenibles a lo largo del tiempo y determinar cuáles son sus implicancias en términos de la política monetaria y fiscal (Burgess *et al*., 2016).

La estructura de este documento es la siguiente. En la próxima sección revisamos brevemente la implementación práctica de los modelos SFC. La tercera sección presenta todos los bloques de ecuaciones del modelo, mientras que la cuarta sección explica la metodología utilizada para la calibración y reproducción del año base. La quinta sección desarrolla un conjunto de simulaciones relevantes para estudiar el comportamiento de la economía ante diversos *shocks* y respuestas de política. La última sección concluye y presenta los próximos pasos pensados dentro de esta línea de investigación.

2. El Modelo SFC

2.1. Convenciones

A lo largo del documento adoptamos una serie de convenciones sobre los nombres de las variables y los parámetros que constituyen al modelo. Estas convenciones tienen como objetivo hacer la lectura lo más accesible posible para aquellos lectores que no trabajan regularmente con este tipo de modelos.

- Todos los parámetros y variables exógenas son presentados en letras minúsculas.
- Las variables endógenas son expuestas en letras mayúsculas.
- El subíndice t refiere al período actual.
- Los siguientes superíndices corresponden a los sectores institucionales:
  - K: sector privado no financiero.
  - G: sector público no financiero.
  - H: hogares.
  - B: bancos comerciales.
  - F: resto del mundo.
  - Z: banco central.
- Los prefijos comúnmente usados para el nombre de las variables son:
  - P: para precios
  - Q: para cantidades
  - Y: para el ingreso
  - V: para las variables nominales

2.2. Ecuaciones

En la sección actual describimos el modelo completo. Para una lograr una mejor comprensión de los lectores, la ordenamos en ocho bloques de ecuaciones. Sucesivamente, consideramos los bloques de producción, comercio internacional, precios, hogares, gobierno, mercado laboral, portafolio y, finalmente, el cierre.

Bloque de la Producción

Asumimos una economía pequeña y abierta que produce un bien homogéneo, en condiciones de competencia imperfecta y con capacidad instalada ociosa, utilizando una función de producción con coeficientes fijos del tipo Leontief. Por lo tanto, no hay sustitución entre el capital K, el trabajo L y los insumos intermedios $QINT$:[1]

$$QX = min\left(\frac{L}{\alpha_L}; \frac{K}{\alpha_K}; \frac{QINT}{ica}\right) \tag{X.1}$$

donde α_L es la inversa de la productividad laboral, α_K es la relación capital-producto y ica es el conocido coeficiente insumo-producto.

[1] Esto supone que existe una única técnica dada y que, por lo tanto, existe complementariedad en la producción.

Dada la función de producción adoptada, la demanda de mano de obra e insumos intermedios son una función lineal del nivel de producción:

$$L_t = \alpha_L \cdot QX_t \tag{X.2}$$

$$QINT_t = ica \cdot QX_t \tag{X.3}$$

Las variables anteriores también son expresadas en términos nominales multiplicando precios por cantidades:

$$VX_t = P_t^X \cdot QX_t \tag{X.4}$$

$$VINT_t = P_t^Q \cdot QINT_t \tag{X.5}$$

Bloque de Oferta, demanda y comercio internacional

Por el lado de la oferta, el bien producido por las empresas locales puede destinarse al mercado doméstico, QD, o puede exportarse a otros países, QE:

$$QX_t = QD_t + QE_t \tag{T.1}$$

De acuerdo con la especificación comúnmente utilizada en la literatura, la demanda de exportaciones depende del ingreso del resto del mundo, GDP^F, y del tipo de cambio real, RER. Siguiendo los resultados empíricos de Zack y Dalle (2014), las estimaciones econométricas para Argentina sugieren que la elasticidad ingreso de las exportaciones, ϵ_F, es mayor que la elasticidad precio, ϵ_r:

$$log(QE_t) = \epsilon_0 + \epsilon_r \cdot log(RER_t) + \epsilon_F \cdot log(GDP_t^F) \tag{T.2}$$

La demanda doméstica de bienes es igual a la discrepancia entre la absorción QQ y las importaciones QM:

$$QD_t = QQ_t - QM_t \tag{T.3}$$

Como es habitual, la demanda de importaciones depende del PBI doméstico, GDP, y del tipo de cambio real, RER. De igual forma que en el caso de las exportaciones, las estimaciones para Argentina (Berretoni y Castresana, 2009) confirman que la elasticidad del ingreso, μ_y, es mayor que la elasticidad del precio, μ_r. Este resultado no es sorprendente, dado que más del 80% de las importaciones argentinas están compuestas por insumos intermedios, bienes de capital y energía. Estos elementos dependen en gran medida del ciclo económico y tienden a ser muy inelásticos en lo que respecta a los precios.

$$log(QM_t) = \mu_0 + \mu_r \cdot log(RER_t) + \mu_y \cdot log(GDP_t) \tag{T.4}$$

La absorción, QQ, es igual a la suma del consumo de los hogares, QH, la inversión pública, QI^G, la inversión privada, QI^K, el consumo del gobierno, QG, y la demanda de insumos intermedios, $QINT$:

$$QQ_t = QH_t + QI_t^G + QI_t^K + QINT_t + QG_t \quad (T.5)$$

Nuevamente, reescribimos las variables anteriores a precios corrientes:

$$VE_t = P_t^E \cdot QE_t \quad (T.6)$$

$$VD_t = P_t^D \cdot QD_t \quad (T.7)$$

$$VQ_t = P_t^Q \cdot QQ_t \quad (T.8)$$

$$VH_t = P_t^Q \cdot QH_t \quad (T.9)$$

$$VI_t^G = P_t^Q \cdot QI_t^G \quad (T.10)$$

$$VI_t^K = P_t^Q \cdot QI_t^K \quad (T.11)$$

$$VG_t = P_t^Q \cdot QG_t \quad (T.12)$$

En línea con la definición de las cuentas nacionales, el PBI a precios constantes es igual a la diferencia entre la absorción y las importaciones, medida a precios del año base:

$$GDP_t = QH_t + QG_t + QI_t^G + QI_t^K + QE_t - QM_t \quad (T.13)$$

El ahorro externo, SAV^F, o la cuenta corriente con signo negativo, es igual a la inversa de la balanza comercial, más los flujos netos de las remesas, $TR_{F,L,t}$, y los dividendos, $TR_{F,K,t}$, sumado a los intereses pagados por las empresas y el gobierno a los inversionistas extranjeros, y restando los retornos del banco central sobre las reservas internacionales, FF.

$$\begin{aligned} SAV_t^F &= pm_t^W \cdot QM_t - pe_t^W \cdot QE_t + TR_{F,L,t} + TR_{F,K,t} \\ &+ \textstyle\sum_i I_t^{LF} \cdot LF_{i,t-1} - I_t^{DF} \cdot FF_{t-1} \end{aligned} \quad (T.14)$$

Por simplicidad, suponemos que el PBI del resto del mundo crece a una tasa exógena g_F:

$$GDP_t^F = GDP_{t-1}^F \cdot (1 + g_F) \quad (T.15)$$

Bloque de precios y salarios

En las economías emergentes, debido al uso de políticas industriales y comerciales activas, los precios internos de la mayoría de los bienes no están regulados por la ley del precio único (Taylor, 1990a). A corto plazo, la dinámica inflacionaria depende del crecimiento de los salarios, W, y del tipo de cambio, EXR, sumado a la inercia heredada de los períodos anteriores (Rowthorn, 1977).

$$\widehat{P_t^D} = \lambda_P \cdot \widehat{P_{t-1}^D} + \lambda_W \cdot \widehat{W_t} + \lambda_E \cdot \widehat{EXR_t} \quad \text{(P.1)}$$

en donde el símbolo $\left(\hat{x} = \frac{dlog(x)}{x}\right)$ refiere a la diferencia del logaritmo de la variable.

Una versión ampliada de la ecuación (P.1) puede contener algunos términos adicionales como pueden ser los precios regulados y la tasa de interés.

La dinámica del salario nominal, *W*, depende del nivel de indexación de la economía y es el resultado de la puja distributiva sobre los ingresos de los trabajadores y las empresas. En cada período, el salario es ajustado parcialmente por la evolución de la inflación. Suponemos que los sindicatos tienen un nivel objetivo de salario igual a ω_l^T, y ajustan sus demandas de acuerdo con la evolución de la inflación pasada. Si el salario real del período anterior está por debajo del salario objetivo, los trabajadores exigirán un salario más alto.

$$W_t = W_{t-1} \cdot \left(1 + \varphi_w \cdot \left(\omega_l^T - \frac{W_{t-1}}{P_{t-1}^D}\right)\right) \quad \text{(P.2)}$$

donde $\varphi_w > 0$ es el parámetro de indexación.

Con respecto a la evolución del tipo de cambio, por el momento solo podemos decir que la misma depende del cierre elegido, el cuál desarrollaremos en detalle posteriormente.

El precio local que reciben los productores de los bienes exportables es igual al precio internacional, pe^W, ajustado por el pago de impuestos a la exportación y el tipo de cambio nominal, EXR:

$$P_t^E = \frac{pe^W \cdot EXR_t}{(1+t^E)} \quad \text{(P.3)}$$

El precio doméstico que deben pagar los consumidores de los productos y servicios importados es equivalente al precio internacional, pm^W, ajustado por el pago de los derechos a la importación:

$$P_t^M = pm^W \cdot EXR_t \cdot (1 + t^M) \quad \text{(P.4)}$$

A partir de las ecuaciones previas para el comercio exterior, podemos derivar el precio de la oferta y de la absorción, respectivamente:

$$P_t^X = P_t^D \cdot \phi + P^E \cdot (1 - \phi) \quad \text{(P.5)}$$

donde $0 < \phi < 1$.

$$P_t^Q = \left(P_t^D \cdot \gamma + P^M \cdot (1 - \gamma)\right) \cdot (1 + t^Q) \quad \text{(P.6)}$$

con $0 < \gamma < 1$.

En la ecuación (P.7) el tipo de cambio real es igual a la relación entre el tipo de cambio nominal y los precios internos:

$$RER_t = \frac{EXR_t}{P_t^Q} \quad \text{(P.7)}$$

Finalmente, la tasa de inflación la definimos como el cambio porcentual en los precios entre dos períodos consecutivos de tiempo:

$$\sigma_t = 100 \cdot \left(\frac{P_t^Q}{P_{t-1}^Q} - 1\right) \quad \text{(P.8)}$$

Bloque del mercado laboral

El salario real es el cociente de la relación entre el salario nominal obtenido por los trabajadores y el nivel de precios:

$$\omega_t = \frac{W_t}{P_t^Q} \quad \text{(L.1)}$$

La oferta de trabajo evoluciona exógenamente a una tasa g_L. Suponiendo una tasa de actividad constante, la oferta de trabajo varía en la misma proporción que la población económicamente activa:

$$N_t = N_{t-1} \cdot (1 + g_L) \quad \text{(L.2)}$$

En consecuencia, combinando las ecuaciones (L.2) y (X.2), podemos derivar la tasa de desempleo de la economía:

$$U_t^L = 1 - \frac{L_t}{N_t} \quad \text{(L.3)}$$

Bloque Hogares

La proporción del ingreso de los hogares correspondiente al trabajo, YHL, resulta del producto entre los salarios nominales y el nivel de empleo. Debemos agregar a esta fuente de ingresos las transferencias netas (positivas o negativas) provenientes del resto del mundo. Asumimos que estas transferencias siempre son ajustadas automáticamente por el valor del tipo de cambio nominal:

$$YHL_t = W_t \cdot L_t + TR_{F,L,t} \cdot EXR_t \quad \text{(H.1)}$$

Los beneficios que las empresas distribuirán en cada período, YHK, son una fracción ψ de las ganancias brutas:

$$YHK_t = (1 - \psi) \cdot PROF_t \quad \text{(H.2)}$$

Finalmente, los hogares reciben sus ingresos de cinco fuentes principales: compensaciones laborales, YHL, ganancias distribuidas, YHK, transferencias de ingresos efectuadas por el gobierno, $TR_{H,G,t}$, flujos de intereses provenientes de la tenencia depósitos bancarios, DD_{t-1}, y externos, DF_{t-1}. Las transferencias del gobierno incluyen a la seguridad social, el subsidio al desempleo y las pensiones.

$$YH_t = YHL_t + YHK_t + TR_{H,G} \cdot P^Q + I_t^{DF} \cdot DF_{t-1} + I_t^{DD} \cdot DD_{t-1} \quad \text{(H.3)}$$

El ingreso disponible de los hogares es igual a su ingreso personal menos los impuestos sobre la renta t^Y:

$$YD_t = YH_t \cdot (1 - t^Y) \quad \text{(H.4)}$$

El ahorro de los hogares, SAV^H, es una fracción Υ del ingreso disponible:

$$SAV_t^H = \Upsilon \cdot YD_t \quad \text{(H.5)}$$

El consumo surge como un residuo entre el ingreso disponible de los hogares y su ahorro del período:

$$VH_t = YD_t - SAV_t^H \quad \text{(H.6)}$$

Por último, para modelar la relación inversa entre el consumo agregado y el tipo de cambio real, suponemos que la tasa de ahorro, Υ, depende positivamente del tipo de cambio real, RER. Aquí podemos encontrar varias justificaciones dentro de la teoría económica. Por ejemplo, en la versión de Alejandro (1963) y Taylor (1978), la devaluación reduce el ingreso real de los asalariados y aumenta el de los rentistas. Como los primeros tienen una propensión marginal a consumir mayor a los últimos, la redistribución del ingreso tiene un efecto contractivo siempre que el modelo tenga una regla de cierre keynesiana.[2]

$$log(\Upsilon_t) = \kappa_0 + \kappa_\Upsilon \cdot log(RER_t) \quad \text{(H.7)}$$

Bloque de las Firmas

Las ganancias brutas de las empresas no financieras son iguales a una porción fija de π de la producción:

$$PROF_t = \pi \cdot VX \quad \text{(K.1)}$$

El ahorro neto de las firmas, SAV^K, es igual a las ganancias retenidas, que son una fracción ψ de la inversión realizada, menos los intereses que deben abonar en concepto del endeudamiento que mantienen con los bancos domésticos, LD, y con el resto del mundo, LF:

[2] Para una discusión más detallada sobre las reglas de cierre ver Rattso (1982).

$$SAV_t^K = \psi \cdot PROF_t - I_t^{LF} \cdot LF_{K,t-1} \cdot EXR_t - I_t^{LD} \cdot LD_{K,t} \quad \text{(K.2)}$$

Bloque del sector Gobierno

El primer conjunto de ecuaciones del bloque gubernamental determina su demanda de bienes y servicios. Las ecuaciones (G.1) y (G.2) definen respectivamente el gasto y la inversión pública, mientras que (G.3) establece las transferencias a los hogares. En (G.4), el gasto agregado del gobierno es igual a la suma de los gastos en bienes y servicios, las transferencias realizadas a los hogares y los intereses pagados. En todos los casos asumimos que estas tasas de crecimiento son fijadas exógenamente de acuerdo con el escenario planteado.

$$QG_t = QG_{t-1} \cdot (1 + g_c) \quad \text{(G.1)}$$

$$QI_t^G = QI_{t-1}^G \cdot (1 + g_i) \quad \text{(G.2)}$$

$$TR_{H,G,t} = TR_{H,G,t-1} \cdot (1 + g_h) \quad \text{(G.3)}$$

$$EG_t = VG_t + TR_{H,G} + I_t^{LF} \cdot LF_{G,t-1} \cdot EXR_t + I_t^{LD} \cdot LD_{G,t} \quad \text{(G.4)}$$

El segundo conjunto de ecuaciones del bloque de gobierno estima la recaudación de impuestos. Las ecuaciones (G.5) - (G.10) estiman los impuestos, netos de subsidios, correspondientes a los impuestos indirectos (G.5), impuestos a la importación (G.6), impuesto al trabajo y capital (G.7) y (G.8), impuestos específicos a las actividades productivas (G.9), impuestos a la exportación (G.10), e impuestos sobre la renta (G.11). El ingreso general del gobierno es igual a la suma de todos los impuestos anteriores (G.12).

$$TIQ_t = t^Q \cdot \left(VD + VM \cdot (1 + t^M)\right) \quad \text{(G.5)}$$

$$TIM_t = t^M \cdot VM_t \quad \text{(G.6)}$$

$$TIL_t = t^L \cdot W_t \cdot L_t \quad \text{(G.7)}$$

$$TIK_t = t^K \cdot PROF_t \quad \text{(G.8)}$$

$$TIA_t = t^A \cdot VX_t \quad \text{(G.9)}$$

$$TIE_t = t^X \cdot VE_t \quad \text{(G.10)}$$

$$TIY_t = t^Y \cdot YH_t \quad \text{(G.11)}$$

$$YG_t = TIY_t + TIQ_t + TIM_t + TIL_t + TIK_t + TIE_t + TIA_t \quad \text{(G.12)}$$

El ahorro del gobierno, SAV^G, es la diferencia entre sus ingresos y gastos:

$$SAV_t^G = YG_t - EG_t \tag{G.13}$$

Finalmente, considerando la inversión pública, el saldo presupuestario total del gobierno es:

$$SF_t^G = SAV_t^G - VI_t^G \tag{G.14}$$

Bloque de la dinámica del modelo

La dinámica de acumulación del capital en el modelo está basada en el super multiplicador (Serrano, 1995) en el que la evolución de la capacidad productiva de la economía sigue el nivel y el crecimiento de los diversos componentes autónomos de la demanda agregada, a través de efectos multiplicadores y aceleradores en el contexto de una economía abierta.

En consecuencia, la inversión privada, QI^K, es igual al nivel de producción multiplicado por la propensión media a invertir, h:

$$QI_t^K = h_t \cdot QX_t \tag{D.1}$$

Además, otro rasgo importante del modelo es el ajuste de la propensión media a invertir a lo largo del ciclo, de acuerdo a la diferencia entre la tasa de utilización efectiva, U^K, y la normal, U^N, tal que:

$$h_t = h_{t-1} \cdot \left(1 + \beta_H \cdot ({U^K}_{t-1} - U^N)\right) \tag{D.2}$$

Una alternativa a la ecuación anterior, fundada en un análisis empírico, consiste en definir a la tasa de acumulación como una función de cuatro factores relevantes.

$$\frac{QI_t^K}{K_{t-1}^K} = \phi_{inv} \cdot (U_t^K)^{\gamma_1} \cdot \left(\frac{QI_t^G}{K_t^G}\right)^{\gamma_2} \cdot \left(\frac{PROF_t}{P_t^Q \cdot K_t^K}\right)^{\gamma_3} \cdot \left(\frac{(1+I^{LD})}{(1+\sigma_t)}\right)^{\gamma_4} \tag{D.2'}$$

donde $\gamma_1\ \gamma_2, , \gamma_3 > 0$,y $\gamma_4 < 0$.

El primer factor captura el efecto acelerador de la inversión (Clark, 1917), en línea con los modelos postkeynesianos, considerando la tasa de utilización de la capacidad instalada. Además, suponemos que existe un efecto *crowding-in* con la inversión pública capturado por γ_2. Un estudio reciente, realizado por el FMI (Izquierdo *et al*., 2019), encuentra un efecto multiplicador alto al estudiar la inversión pública en las provincias argentinas. El tercer elemento de la ecuación captura el impacto positivo que tiene la tasa de ganancia sobre los incentivos a invertir de las empresas.

El último elemento de la ecuación (D.2') refiere al efecto negativo que teóricamente debería ejercer la tasa de interés sobre el ritmo de acumulación. Si revisamos la literatura acerca de los factores explicativos de la inversión para la economía argentina, no encontramos evidencia que sea concluyente. Por ejemplo, Bebczuk (1994) y Acosta y Loza (2005) no incorporan a la tasa de interés debido a que consideran que la misma, en términos reales, es negativa durante largos períodos del siglo XX, lo que afecta su relevancia. Otros trabajos que utilizan paneles de empresas (Panigo *et* *al*., 2007) tampoco la emplean, ya que ponen el foco en variables asociadas a las características individuales de las unidades. Por último, encontramos el trabajo de Coremberg *et al*. (2007), en el que se realiza un estudio exhaustivo de la inversión privada durante el período 1950-2000. Los autores encuentran que existe un efecto significativo solo de corto plazo, mientras que en el largo plazo la tasa real no tiene ningún efecto sobre la inversión.

El valor tomado por el *stock* de capital en cada período consiste en su valor en el pasado más la nueva inversión, descontando la depreciación correspondiente:

$$K_t^K = K_{t-1}^K \cdot (1 - \delta_K) + QI_t^K \quad \text{(D.3)}$$

donde $0 < \delta_K < 1$ es la tasa de depreciación.

Además, el *stock* de capital del gobierno, K^G, es igual al valor del período anterior más la inversión pública del período actual, descontando la depreciación:

$$K_t^G = K_{t-1}^G \cdot (1 - \delta_G) + QI_t^G \quad \text{(D.4)}$$

donde $0 < \delta_G < 1$ es la tasa de depreciación.

La tasa de utilización es estimada mediante la relación entre el nivel de producción y el *stock* de capital privado del período anterior:

$$U_t^K = \frac{QX_t}{K_{t-1}^K} \quad \text{(D.5)}$$

El bloque financiero del modelo

La primera ecuación expone las opciones que tiene el gobierno para financiar sus necesidades del período, que surgen de adicionar la inversión y el resultado fiscal. Las fuentes del financiamiento son los préstamos domésticos, LD, los préstamos externos, LF, y los adelantos transitorios o préstamos del banco central, AT. También, el gobierno puede reducir su tenencia de depósitos en los bancos comerciales, DD. Debido a que en este trabajo vamos a analizar diferentes políticas públicas, el financiamiento del sector público es introducido en forma *ad hoc* según los distintos escenarios planteados. Por tal motivo, vamos a suponer exógenos a todos los instrumentos, con excepción de los préstamos domésticos que funcionan como una suerte de *buffer-stock*:[3]

$$VI_t^G - SAV_t^G = \Delta LD_{G,t} + \Delta LF_{G,t} \cdot EXR_t + \Delta AT_t - \Delta DD_{G,t} \quad \text{(GF.1)}$$

Las empresas, a diferencia del gobierno, solo tienen dos instrumentos financieros para apalancar sus decisiones de inversión. Además de los recursos propios, pueden pedir préstamos a los bancos comerciales domésticos, o demandar préstamos externos al resto del mundo. Nuevamente,

[3] *Stock* de amortiguación.

el crédito externo es considerado exógeno y los préstamos domésticos completan las necesidades del período:

$$VI_t^K - SAV_t^K = \Delta LD_{K,t} + \Delta LF_{K,t} \cdot EXR_t \qquad \text{(FF.1)}$$

Adicionalmente a las relaciones de endeudamiento planteadas previamente, añadimos una ecuación optativa para el endeudamiento externo, en caso de que decidamos considerarlo endógeno en los ejercicios. Aquí, suponemos que los flujos de deuda desde el resto del mundo toman una forma similar al de la paridad de interés descubierta. En consecuencia, la demanda de préstamos externos aumenta toda vez que la tasa de interés doméstica supera a la tasa internacional y a las expectativas de devaluación. Este último factor otorga a la decisión de tomar créditos en el exterior cierto carácter especulativo, ya que por el principio de incertidumbre no podemos conocer cuál será el valor del tipo de cambio en el futuro.

$$LF_{i,t} = LF_{i,t-1} \cdot \left(1 + \upsilon_t \cdot \left(I_t^{LD} - I_t^{LF} - E(\widehat{e_t})\right)\right) \qquad \text{(FF.2')}$$

Los hogares ahorran parte de sus ingresos al final de cada período, mientras que el excedente es traducido en una variación de su riqueza financiera neta, NW^H. A esto, debemos sumarle las ganancias de capital producidas por los cambios en la valuación de sus tenencias de activos externos:

$$NW_t^H = SAV_t^H + DF_{t-1} \cdot (\Delta EXR_t) \qquad \text{(FH.1)}$$

A continuación, vamos a desarrollar como los hogares toman sus decisiones financieras. La ley del Walras juega un papel fundamental dentro de la teoría de decisión de cartera (Tobin, 1958) y sus propiedades son resumidas en las llamadas restricciones de agregación (*adding-up constraints*).

$$\begin{pmatrix} \frac{HP}{NW^H} \\ \frac{DF}{NW^H} \\ \frac{DD}{NW^H} \end{pmatrix} = \begin{pmatrix} \Omega_{10} \\ \Omega_{20} \\ \Omega_{30} \end{pmatrix} \cdot \begin{pmatrix} \Omega_{11} & \Omega_{12} & \Omega_{13} \\ \Omega_{21} & \Omega_{22} & \Omega_{23} \\ \Omega_{31} & \Omega_{32} & \Omega_{33} \end{pmatrix} \cdot \begin{pmatrix} 0 \\ I^{DF} \\ I^{DD} \end{pmatrix} + \begin{pmatrix} \Omega_{14} \\ \Omega_{24} \\ \Omega_{34} \end{pmatrix} \cdot \frac{YD}{NW^H} \qquad \text{(FH.2)}$$

El primer vector da cuenta de los activos financieros que pueden demandar los hogares, que en este caso son el dinero en efectivo (HP^D), los depósitos externos (DF) y los depósitos bancarios (DD). El primer vector a la derecha señala la porción Ω_{i0} de su riqueza neta (NW) que los agentes mantienen en cada activo financiero. En la columna de las tasas de retorno resalta el hecho de que una de ellas toma el valor de cero. Esto sucede debido a que el primer activo, el circulante, no arroja ningún retorno al ser mantenido en la cartera. Por otra parte, los depósitos a plazo si generan periódicamente una rentabilidad determinada, lo cual está reflejado en el mismo vector. Aquí, los agentes buscan diversificar el riesgo, por lo que ante cambios en las tasas relativas de rendimientos modificarán su demanda de activos, aunque en forma parcial. Esto implica que los distintos activos son sustitutos imperfectos entre sí.

Al sistema de ecuaciones precedente le falta un pequeño elemento, el cual es sumamente importante a la hora de analizar la demanda de activos financieros. Debido a la naturaleza especulativa de las decisiones de cartera, vamos a incorporar nuevamente las expectativas en el modelo, esta vez a través de la tasa de rendimiento asociada a la demanda relativa de activos externos. Entonces, debemos reemplazar el vector de rendimientos por:

$$(I^{DF} + E(\hat{e}_t)) \qquad \text{(FH. 2')}$$

En donde $\hat{e}$ es la tasa de variación del tipo de cambio nominal, tal que:

$$\widehat{e_t} = \left(\frac{\Delta EXR_t}{EXR_{t-1}}\right) \qquad \text{(FH.3)}$$

La siguiente ecuación detalla el comportamiento de las expectativas sobre el tipo de cambio. Suponemos que una porción χ son del tipo *backward looking*, es decir que dependen de la información pasada que es relevante para los agentes. Por otra parte, asumimos que otra porción de las expectativas depende del período actual.

$$E(\widehat{e_t}) = \chi \cdot \hat{e}_{t-1} + (1-\chi) \cdot \widehat{e_t} \qquad \text{(FH.4)}$$

Los bancos, por su parte, deben constituir las reservas en el banco central con relación a los depósitos captados de los hogares y del gobierno.

$$RR_t = \rho \cdot \textstyle\sum_i DD_{i,t} \qquad \text{(FBK.1)}$$

El exceso de liquidez que resulta de la diferencia entre los depósitos, por un lado, y los encajes y préstamos, por el otro, lo colocan en letras ofrecidas por el banco central, *BB*. Estas letras son utilizadas por el banco central para fijar su tasa de política monetaria.

$$\Delta BB_t = SAV_t^B + \textstyle\sum_i \Delta DD_{i,t} - \sum_i \Delta LD_{i,t} - \Delta RR_t \qquad \text{(FBK.2)}$$

El ahorro de los bancos, como sector institucional, está determinado por el saldo neto de los intereses recibidos y pagados en cada período:

$$SAV_t^B = I_t^{LD} \cdot \textstyle\sum_i LD_{i,t-1} + I_t^{BB} \cdot BB_{t-1} - I_t^{DD} \cdot \sum_i DD_{i,t-1} \qquad \text{(FB.3)}$$

El banco central por su parte emite circulante de acuerdo con la ecuación (FC.1). Asumimos que la cantidad de dinero aumenta con la monetización del déficit cuasifiscal, los préstamos al gobierno y la variación en las reservas internacionales. En el sentido inverso, el banco central retira pesos del mercado aumentando la absorción de liquidez vía letras a los bancos o, bien, aumentando los encajes.

$$\Delta HP_t^S = -SAV_t^Z + \Delta AT_t + \Delta FF_t \cdot EXR_t - \Delta BB_t - \Delta RR_t \quad \text{(FC.1)}$$

La variación en las reservas internacionales es igual al resultado en la cuenta corriente, llamado aquí ahorro del resto del mundo, más el saldo neto de la demanda y oferta de activos externos en la economía. Este último factor está influenciando por la composición del endeudamiento que tomen el sector público y privado, así como de las decisiones de cartera de los hogares. Por ejemplo, entre 2016 y 2018, la economía argentina sostuvo un sustantivo déficit de cuenta corriente con una considerable dolarización del sector privado, al tiempo que aumentaron las reservas internacionales. Esto fue posible gracias al excepcional endeudamiento en dólares del sector público y privado durante dicho período.

$$\Delta FF_t = -SAV_t^F + \sum_i \Delta LF_{i,t} - \sum_h \Delta DF_{h,t} \quad \text{(FC.2)}$$

El resultado operativo del período viene dado por el saldo entre lo que paga por las letras emitidas y lo que recibe de intereses por las reservas internacionales.

$$SAV_t^Z = I_t^{DF} \cdot FF_{t-1} - I_t^{BB} \cdot BB_{t-1} \quad \text{(FC.3)}$$

A continuación, vamos a desarrollar el mecanismo de determinación de las tasas de interés en la economía, comenzando por las tasas bancarias. Los bancos comerciales fijan su tasa activa considerando la tasa de política, I^{BB}, la tasa de encajes, ρ, y añadiendo un *mark-up*, PR.

$$I_t^{LD} = \left(\frac{I_t^{BB}}{1-\rho}\right) \cdot (1 + PR_t) \quad \text{(IR.1)}$$

Si bien en la literatura no existe un consenso sobre cómo evoluciona el margen de beneficios en el ciclo económico, algunos trabajos empíricos realizados para la Argentina la ubican como procíclica (Aguirre *et al.*, 2015). Por simplicidad, aquí asumimos que es exógena.

La tasa pasiva fijada por el sistema financiero, nuevamente toma como referencia a la tasa de política, I^{BB}, y a la tasa de encajes, ρ, aplicando el margen correspondiente:

$$I_t^{DD} = \frac{I_t^{BB} \cdot (1-\rho)}{(1+PR_t)} \quad \text{(IR.2)}$$

En el caso del banco central, debemos definir como conducirá la política monetaria en los límites del modelo. En línea con lo que hoy es el consenso dentro de la macroeconomía, suponemos que la entidad monetaria lleva a cabo su política fijando la tasa de interés. En base a lo que ha sido la experiencia argentina en la post convertibilidad, los activos elegidos para llevarla a cabo son las letras del propio banco central. Así, la autoridad monetaria fija una tasa de referencia y su demanda y oferta de letras es completamente endógena, es decir que compra o vende todos los bonos necesarios para mantener su objetivo (Godley y Lavoie, 2007). Como resultado, la oferta monetaria ajusta en última instancia a las decisiones de cartera de los agentes, ya que, ante un aumento en la tasa de interés de referencia, los bancos incrementarán la tasa pasiva, lo que a su vez aumentará la demanda de depósitos, creando un exceso de liquidez en el sistema financiero. Por último, los bancos comerciales colocarán estos excedentes en letras emitidas por la autoridad monetaria.

En términos del modelo, suponemos que el banco central fija su tasa de política de acuerdo con una regla de *Taylor* ampliada (Taylor, 1993), que considera la evolución de la actividad, el tipo de cambio y la estabilidad en los precios. En este sentido, la función adoptada presenta la suficiente flexibilidad como para suponer distintos valores para los parámetros, de acuerdo con cuál variable pese más dentro de las decisiones sobre la política monetaria. En consecuencia, podemos tener un banco central más preocupado por contener la inflación o, bien, uno más enfocado en evitar la volatilidad del tipo de cambio.

$$I_t^{BB} = I_{t-1}^{BB} + \zeta_y \cdot (\widetilde{y}_t) + \zeta_p \cdot (\Delta\sigma_t) + \zeta_e \cdot (\Delta\widehat{e}_t) \quad \text{(IR.3)}$$

donde ζ_y, ζ_p y ζ_e > 0, mientras que $\widetilde{y}_t = U_t^K - U_t^N$ es una *proxy* de la brecha de producto.

La última ecuación del modelo es lo que Godley y Lavoie (2007) denominan como ecuación redundante, ya que está determinada por todas las restantes. En nuestro modelo, existen dos ecuaciones que determinan la demanda de dinero por parte de los hogares (FH.2) y la oferta provista por el banco central (FC.1), aunque no hemos incorporado ninguna que asegure la igualdad entre ambas. Sin embargo, el cambio entre la oferta y demanda de dinero debe ser el mismo una vez que el modelo es resuelto computacionalmente y su consistencia está asegurada contablemente por el uso de la SAM.

$$HP_t^D = HP_t^S \quad \text{(walras)}$$

3. Datos y calibración del modelo

La base para el armado de la matriz de contabilidad social, utilizada para la calibración del modelo y para la posterior reproducción del escenario base, fue tomada del trabajo de Michelena (2019) y tiene como año base al 2018. Resulta importante destacar que el trabajo citado desarrolla una SAM real, es decir, una matriz que solamente contiene las transacciones del sector real de la economía excluyendo tanto la cuenta capital como los activos financieros. En una SAM financiera, cada sector institucional tiene dos tipos de cuentas: una cuenta corriente como en la SAM real, y una cuenta capital. Si bien todos los agentes poseen una cuenta que captura el ahorro en la matriz original, al no estar incluidos los instrumentos financieros no pueden ser desarrolladas las decisiones de inversión ni los cambios de activos y pasivos al final de cada período.

Para este trabajo, la SAM financiera (FSAM) fue construida con los niveles de desagregación y detalle permitidos por la disponibilidad y calidad de la información necesaria. El trabajo de construcción de la FSAM sigue las recomendaciones metodológicas contenidas en los trabajos de Hubic (2012) y Jellema *et al*. (2004), al tiempo que sigue las sugerencias de compilación presentadas por Tsujimura (2003). Uno de los inconvenientes más importantes a la hora de su construcción fue el tratamiento del cambio de valuación de los activos nominados en moneda extranjera, ya que en 2018 ocurrió un aumento del tipo nominal cercano al 100%. En este punto seguimos las recomendaciones realizadas por el FMI (Cartas y Harutyunyan, 2017) con respecto a la valuación de los *stocks* entre períodos. Dicho manual recomienda compilar los datos correspondientes a los *stocks* y a los flujos en tres componentes separados: transacciones, revaluaciones y OCVA (*other changes in the volume of assets*).

En esta versión de la matriz fueron incorporados cinco sectores institucionales, al tiempo que fueron añadidos los principales instrumentos financieros de la economía. A continuación, presentamos el detalle de las cuentas añadidas a la matriz,

Tabla 1 | Instituciones e instrumentos financieros en la FSAM

Instituciones (6)	Instrumentos financieros (8)
Hogares	Circulante
Gobierno	Depósitos domésticos
Banco Central	Depósitos externos
Firmas	Préstamos domésticos
Bancos comerciales	Préstamos externos
Resto del Mundo	Letras del BC
	Reservas internacionales
	Reservas requeridas

Fuente: elaboración propia.

La técnica de calibración fue utilizada en la determinación de todas las tasas impositivas y en aquellos casos en donde no dispusimos de series de tiempo lo suficientemente extensas como para obtener estimaciones econométricas consistentes. Finalmente, en aquellos casos en donde no fue posible estimar a los parámetros mediante la calibración o la econometría, los valores fueron tomados directamente de la literatura.[4]

Tabla 2 | Parámetros exógenos del modelo

Ecuación	Parámetros	Ecuación	Parámetros
(T.2)	ϵ_r =0,05; ϵ_F =1,14	(T.4)	μ_r = -0,5; μ_y = 2,96
(P.1)	α_p =0,62; α_e =0,15; α_w =0,22	(P.2)	φ =1,1
(H.2)	ψ =0,40;	(H.6)	Υ = 0,11
(H.8)	κ_Υ = 0,14	(D.3)	β_H = 2
(FF.2)	υ = 0,5	(FH.2)	Ω_{13} =-0,1; Ω_{14} =0,5
(FH.2)	Ω_{22} =0,7; Ω_{23} =-0,45	(FH.2)	Ω_{32} =-0,7; Ω_{33} =0,7
(FH.9)	χ =0,6	(IR.4)	ζ_y =0,8; ζ_e =0,6; ζ_p =0

Fuente: elaboración propia.

[4] Esta técnica es conocida habitualmente como *best-guess*.

4. Simulaciones

En esta sección utilizamos el modelo para llevar a cabo algunas simulaciones relevantes de política. En este punto es importante destacar que la frecuencia de los datos utilizados es anual, por lo que nuestras estimaciones están pensadas para proyectar escenarios de mediano plazo. Comenzamos con un escenario BAU (*business as usual*). Debido a que la SAM contiene toda la información relevante para el año 2018, podemos utilizar los datos posteriores disponibles al momento de realizar la estimación, debiendo proyectar hacia adelante las principales variables exógenas del modelo.

Con respecto a la demanda agregada, necesitamos proyectar los gastos autónomos desde el año 2021 en adelante, mientras que para el 2019-2020 utilizamos los valores observados. En este sentido, nuestro escenario inicial incorpora el impacto de la pandemia, la cual tuvo un efecto significativo sobre la producción, el ingreso y el empleo de la economía doméstica. Para simular el *shock* negativo de 2020, ajustamos al alza el parámetro que representa la propensión a ahorrar en los hogares, Υ. Adicionalmente, ajustamos a la baja la demanda internacional que afecta negativamente a las exportaciones.

Debajo presentamos los supuestos más importantes de este escenario.

- El Gobierno aumenta el gasto, la inversión y las transferencias en 2020/2021 para atender a los hogares, pero después las deja constantes en términos reales.
- La financiación es realizada mediante la emisión de deuda en el mercado local y la toma de préstamos del BC, aunque reduciéndola progresivamente (sin recurrir al endeudamiento externo).
- Incorporamos el escenario de reestructuración de la deuda pública, que relaja los pagos de intereses hacia el resto del mundo durante 2020-2027.
- Con respecto al cierre externo, el Banco Central mantiene el tipo de cambio fijo (con una regla de "crawling peg") para la balanza comercial, con controles de capital que resultan en un tipo de cambio financiero diferenciado para las operaciones de cartera.

Para simular este último supuesto debemos agregar algunas ecuaciones al modelo. Al liberar una variable, debemos fijar otra para cumplir con la condición de cuadratura y que el modelo tenga solución. El candidato obvio es la demanda de activos externos por parte de los hogares, por lo que incorporamos una ecuación adicional para el tipo de cambio:

$$FXR_t = \frac{DF_t^D}{\overline{DF}_t} \quad \text{(ALT.1)}$$

Ahora, FXR es el tipo de cambio relevante para las decisiones de cartera, mientras que EXR es el tipo de cambio que afecta la dinámica del comercio exterior.

La dinámica de las reservas, FF_t, viene dada por el *stock* previo más el saldo de cuenta corriente y los ingresos de capital, y reemplaza a FF en la ecuación (FC.2).

$$\Delta FF_t = -SAV_t^F + \sum_i \Delta LF_{i,t} \quad \text{(ALT.2)}$$

Para determinar el crecimiento externo, elaboramos un índice ponderado de los principales socios comerciales, teniendo en cuenta los pronósticos de la Organización para la Cooperación y el Desarrollo Económicos (OCDE). Además, utilizamos la información provista por el INDEC, para determinar el desempleo y trazar una proyección del crecimiento de la población activa a mediano plazo.[5]

Adicionalmente, elaboramos tres escenarios alternativos, con el objetivo de proyectar la recuperación económica hacia adelante. El primer escenario presenta un ajuste del gasto público, con el objetivo de analizar el impacto de una agenda más contractiva en lo fiscal. El resto de los escenarios, presentan una dinámica más expansiva:

- Disciplina fiscal (*fiscal*): base + el Gobierno recorta el gasto para lograr un déficit fiscal primario de menos del 1% en 2023 (antes del pago de intereses).

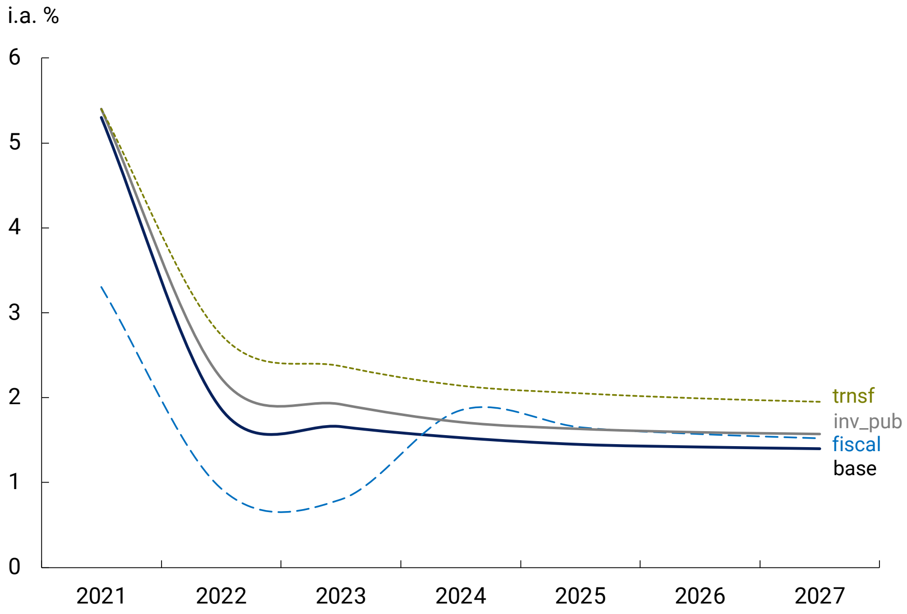
- Inversión pública (*inv_pub*): base + el Gobierno aumenta el gasto de capital progresivamente hasta alcanzar un 3% en relación con el PIB en 2025.

- Transferencia a los hogares (*trnsf*): anterior + el Gobierno mantiene también el aumento de las transferencias a los hogares para promover una recuperación más rápida del PIB y del empleo.

El impacto de los distintos escenarios sobre la actividad económica lo medimos utilizando dos variables: la tasa de crecimiento del PBI y la tasa de desempleo. En el caso del PBI, existe un fuerte incremento en los primeros años producto de la recuperación en el consumo de los hogares y las exportaciones, sumado al gasto extraordinario del gobierno (ver Gráfico 1). La recuperación de la actividad resulta en una caída gradual del desempleo, que progresivamente retorna a los niveles previos a la crisis (ver Gráfico 2). Merece la pena resaltar que, dado el crecimiento anual constante en la población activa, la economía necesita crecer por encima del 1,2% para reducir el desempleo (dado los parámetros utilizados).

[5] Utilizamos la Encuesta Permanente de Hogares (EPH) y las proyecciones demográficas.

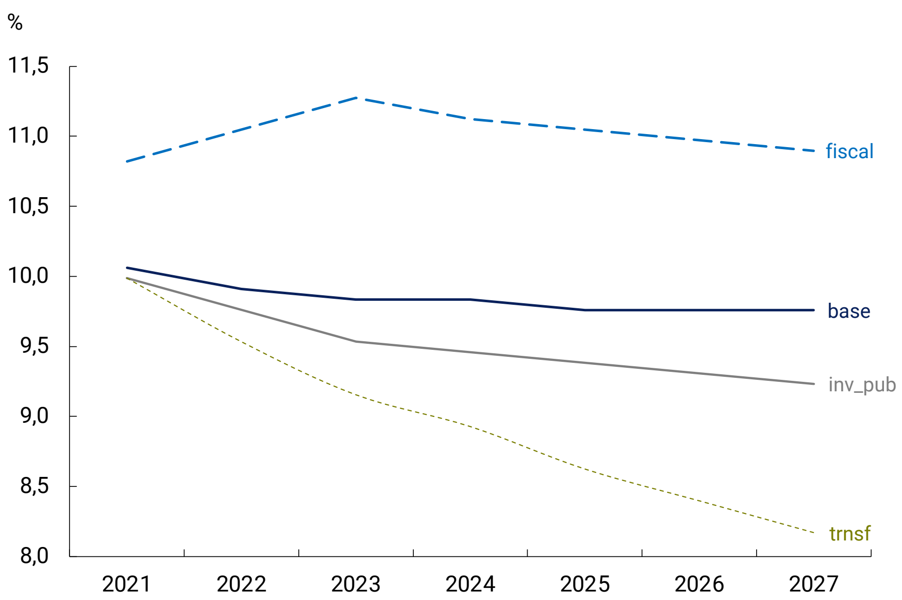
Gráfico 1 | Tasa de crecimiento del PBI estimada. Variación % anual



Fuente: elaboración propia.

En los extremos podemos observar que el escenario expansivo (con aumento en los gastos de capital y en transferencias a los hogares) permite una recuperación más acelerada, mientras que el ajuste del gasto aplicado en los primeros años causa una recuperación más lenta, y en un principio incluso genera un aumento del desempleo. En el escenario base, la baja del desempleo es muy gradual, debido a que el crecimiento apenas alcanza para absorber a la población que ingresa al mercado laboral.

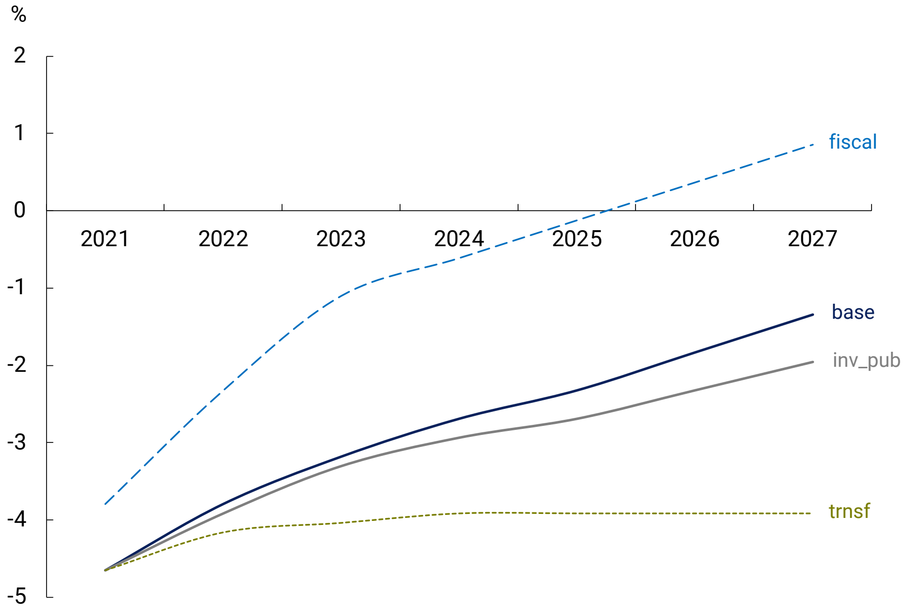
Gráfico 2 | Tasa de desempleo estimada. En %



Fuente: elaboración propia.

Los resultados asociados al sector público muestran la primera de las contradicciones, entre las necesidades de mejorar las cuentas fiscales y conducir los niveles de endeudamiento a niveles más sostenibles, con la necesidad de impulsar el crecimiento y acelerar la recuperación (ver Gráfico 3). A excepción del caso expansivo, en el resto de los escenarios el déficit va reduciéndose gradualmente, convergiendo a niveles cercanos al 2% del PBI para el año 2027. En el escenario del ajuste, el equilibrio fiscal es alcanzado mucho antes, mientras que, en el expansivo, el déficit logra estabilizarse en el mediano plazo en torno al 4% del PBI.

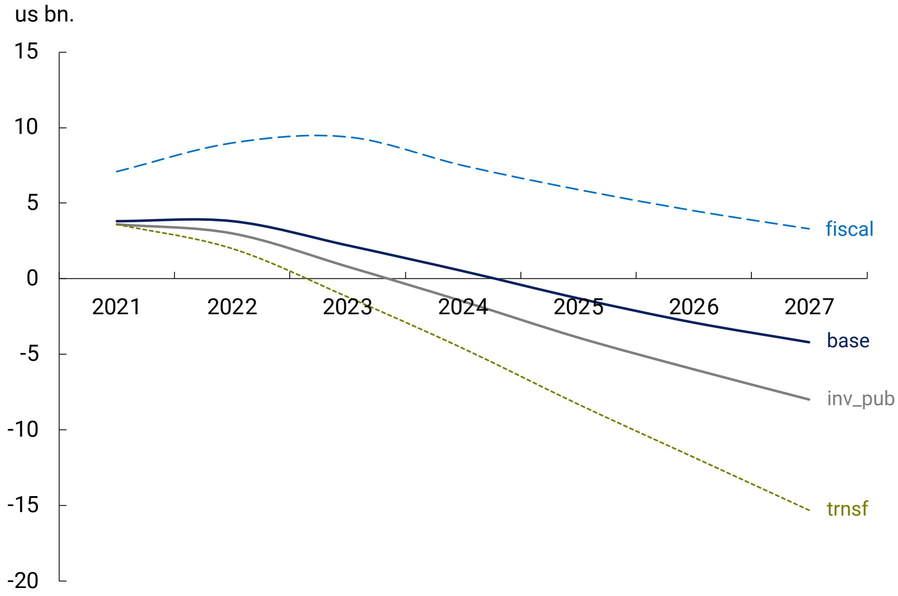
Gráfico 3 | Resultado fiscal simulado. En % del PBI



Fuente: elaboración propia.

El Gráfico 4 muestra la contracara de los escenarios anteriormente citados. En los escenarios más expansivos, la cuenta corriente sufre un rápido deterioro y pasa a un resultado negativo entre 2023 y 2025, dependiendo del caso. Esto es el resultado del aumento vigoroso de las importaciones, las cuales están muy ligadas a la dinámica de la actividad económica, dada la elevada elasticidad ingreso existente.

Gráfico 4 | Saldo comercial simulado. En USD miles de millones



Fuente: elaboración propia.

Este hecho pone ciertas luces de alerta con respecto a una política fiscal muy expansiva, ya que, en un esquema como el actual, sin ingreso de capitales que financien los desequilibrios y con presiones a la dolarización de cartera, un deterioro acelerado en la cuenta corriente tiene como correlato la pérdida de reservas. Una vez más, aparecen las tensiones entre la velocidad de la recuperación y la estabilidad del sector externo, ya que el superávit de cuenta corriente mantiene un resultado positivo solamente en el escenario del ajuste.

5. Conclusiones

El principal aporte de este documento fue el desarrollo de un modelo SFC empírico para la Argentina, el cual que nos permite realizar proyecciones de mediano plazo sobre las principales variables reales y financieras. En líneas generales, el SF complementa a otros modelos existentes, como los DSGE y macroeconométricos, generando proyecciones y simulaciones para los principales flujos y *stocks* de la economía argentina. Como característica específica, el modelo SF proporciona estimaciones de los *stocks* y flujos de los diferentes sectores institucionales, permitiendo detectar dinámicas explosivas o inconsistentes a lo largo del tiempo a partir de distintas políticas fiscales, monetarias o ciertos *shocks* internos y externos. Las simulaciones presentadas sirvieron para mostrar las características principales del modelo y destacar las posibilidades que ofrece para poder emular diferentes escenarios contrafactuales para los próximos años.

Los resultados obtenidos señalan un conflicto evidente entre la velocidad de la recuperación requerida, y la estabilidad del balance de pagos. En aquellos escenarios simulados en donde la expansión es muy significativa, la economía requiere de otras fuentes de financiamiento externo, o de un proceso signado por la desdolarización de cartera del sector privado, para evitar entrar en un espiral de inestabilidad.

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