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Foreign debt, distribution, inflation, and growth in an SFC model*

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We present an open economy growth model, using Stock-Flow Consistent (SFC) methodology. Our contribution is to add the possibility of one country issuing debt denominated in another country's currency, as well as allowing its firms to borrow from foreign banks. We investigate the effects and interactions that these features have on trade and financial flows, income distribution, foreign debt, and fiscal and monetary policy. Our results point towards the dismissal of the 'twin deficit' view, and support an active management of the exchange rate, in light of contradictory effects of fixed and flexible exchange rate regimes, according to the circumstances.

Keywords: *Stock-Flow Consistent models, exchange rate policy, income distribution, twin deficits, external debt*

JEL codes: *E12, E24, E31, E44, F32, F43*

1 INTRODUCTION

This paper develops a Stock-Flow Consistent (SFC, from now on) open-economy model, with capital accumulation and financial transactions between two countries. SFC models draw on the tradition of Wynne Godley and Marc Lavoie (Godley/Lavoie 2007, G/L from now on), meaning that income accounting has no 'black holes' (Taylor 2008: 639). An income or financial inflow to an institutional sector (household, government, banks, and the rest of the world) is made up of outflow(s) from other sectors. The flows are cumulated over time so that the model is 'stock-flow consistent.' The effects on wealth of gains or losses in asset prices are carefully accounted for, and so are differential inflation rates in prices for goods and services. About the origin of SFC modeling and its main characteristics, the interested reader can consult Dos Santos (2003; 2005; 2006) and G/L (2007, in the preface, and chs 1, 2, and 13), while for a state-of-the-art analysis we recommend a reading of Caverzasi/Godin (2013).

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In this paper we extend the model of ch. 12 of G/L, adding some other features related to exchange rate expectations which were introduced in Lavoie/Daigle (2011). We add an investment function based on the accelerator principle; a Phillips curve with a flat middle segment; a productivity growth function based on the change in real wages; and mark-up pricing rules that take into account the behavior of the exchange rate, among other characteristics. We also introduce the possibility of one country issuing debt denominated in both currencies, a typical feature of developing economies, therefore the names we assign to the countries in our model are 'USA' and 'Argentina.' In addition, we include foreign lending to firms in a foreign currency.

This type of modeling and these assumptions seem quite adequate at a time when financial assets represent an increasing multiple of world GDP (Palma 2009: 834). While most financial flows occur between industrialized countries, the share that goes and comes from developing countries has a substantial effect on these economies owing to their relatively small size, their immature financial development, and the important financial liberalization process they have been through over the last decades.

Because of past misconceived arguments, it also seems imperative to develop the implications and constraints of the different exchange rate regimes. The purpose of the paper is to shed some light on this discussion and to propose measures that will improve the wellbeing of the population without disregarding the budget constraints and stock-flow norms that need to be respected.

The focus of this model will be on what happens to the developing country, Argentina, leaving aside the effects on the USA as long as they are not necessary for the presentation of the argument. The rest of the paper is as follows. Section 2 outlines the model. Section 3 presents and interprets the results of our simulation experiments. Section 4 draws out the main conclusions, both with a theoretical and a policy view of current developments in the world economy.

But before we proceed, we must make a qualification. The core of this work is to analyse the interactions between two economies, one financially dependent and the other financially dominant (Vernengo 2006; Medeiros 2008), in a very specific sense of the words financial 'dependency' and 'domination': by 'financial dependency' we refer to countries that are forced to borrow in a foreign currency; by 'financial dominance' we refer to the country that issues the international money. In line with the tradition of SFC modeling (G/L, ch. 11; Lavoie/Zhao 2010), we use the name of actual countries (Argentina, country of origin of this author, and the USA) to identify the countries of the model. This does not imply that the model is calibrated to closely resemble the actual features of the Argentinean and US economies. The point is that the model highlights the consequences of this particular key difference.

2 THE MODEL

2.1 Accounting structure

The model presents a world composed of two countries ('USA' and 'Argentina'), with five sectors in each: households, firms (which are vertically integrated, so that their inputs are wages and imports), banks, government, and the central bank, split from the government sector for exposition purposes. Each country produces one good, apt for consumption, investment, and export purposes. They trade that good, and also financial assets. Table 1 presents the balance sheet of each sector in each country.

Table 1 Balance sheet of 'USA' and 'Argentina'

| | USA | | | | | Argentina | | | | |
|------------------|------------------------------|-------------|-------------|-------------|--------------|---------------------------|------------------------|-------------|-------------------------|----------------------------|
| | Households | Firms | Banks | Gov. | CB | Households | Firms | Banks | Gov. | CB |
| Capital stock | - | $+K_u$ | - | - | - | - | $+K_a$ | - | - | - |
| Cash | $+H_u$ | - | - | - | $-H_u$ | $+H_a$ | - | - | - | $-H_a$ |
| Deposits | $+M_u$ | - | $-M_u$ | - | - | $+M_a$ | - | $-M_a$ | - | - |
| Advances | - | - | $-A_u$ | - | $+A_u$ | - | - | $-A_a$ | - | $+A_a$ |
| Bills USA | $+B_{hu}^u$ | - | $+B_{bu}^u$ | $-B^u$ | $+B_{cbu}^u$ | $+B_{ha}^u \cdot x\tau a$ | - | - | - | $+B_{cba}^u \cdot x\tau a$ |
| Bills Arg. '\$a' | $+B_{hu}^{Sa} \cdot x\tau u$ | - | - | - | - | $+B_{ha}^a$ | - | $+B_{ba}^a$ | $-B^{Sa}$ | $+B_{cba}^a$ |
| Bills Arg. '\$u' | $+B_{hu}^{Su}$ | - | - | - | - | - | - | - | $-B^{Su} \cdot x\tau a$ | - |
| Loans '\$a' | - | - | - | - | - | - | $-L_a^a$ | $+L^a$ | - | - |
| Loans '\$u' | - | $-L_u^u$ | $+L^u$ | - | - | - | $-L_a^u \cdot x\tau a$ | - | - | - |
| Wealth | $-V_{hu}$ | $-V_{fu}^u$ | $-V_{bu}^u$ | $+V_{gu}^u$ | $-V_{cbu}^u$ | $-V_{ha}$ | $-V_{fa}^a$ | $-V_{ba}^a$ | $+V_{ga}^a$ | $-V_{cba}^a$ |
| Σ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Households allocate their wealth in deposits (M), cash (H), and short-term bills. There are three types of bills: the American government issues bills denominated in dollars (B^u); the Argentinean government issues bills denominated in pesos (B^{sa}), that can be acquired by households of both countries, *and* it also issues bills denominated in dollars (B^{su}) that can only be acquired by residents in the US. All holdings are expressed in the domestic currency, so for instance $B_{hu}^{sa} \cdot xru$ represents the holdings of Argentinean bills denominated in pesos (the upper-script sa) by American households (the lower script hu), translated into dollars by multiplying it by the American exchange rate. The same happens with the investment of Argentinean households in US bills ($B_{ha}^u \cdot xra$).

The sole asset of firms is their capital stock; their sole liability, the loans they take from banks (Argentinean firms can borrow from Argentinean banks in pesos and from American banks in dollars; loans have a one-period lifespan); and the difference is their net wealth. Banks, in turn, lend to firms, take deposits, invest in bills, and take advances from the central bank according to circumstances. Their profits accumulate to make their net wealth. Neither banks nor firms have equity on which they should pay dividends.

The central bank issues cash (its liability), grants advances to banks, and buys government bills. In the case of the Argentinean central bank, it also holds American bills ($B_{cba}^u \cdot xra$), which constitute its reserves, and a sort of net wealth.

Tables 2a and 2b track all the flows that occur in the period, one for each country. A plus sign represents an income or a source of funds, and a minus sign represents an expenditure or the use of funds. For instance, the purchase of bills is represented by $-\Delta B$, while the proceeds of that sale are represented by $+\Delta B$, and so forth. We also split the columns of firms and banks in order to highlight the difference between current transactions (which do not affect the capital of the firm) and capital transactions (which do).

The first five rows of Tables 2a and 2b represent the components of the GDP: consumption, investment, government expenditure, exports, and imports. Investment is recorded with a plus sign in the current-account column (tracing the sale of the capital good) and a minus sign in the capital-account column (recording the use of funds to achieve an increase in tangible assets). The subsequent rows register wages payments, tax payments, and depreciation allowance, the latter being, from the point of view of the firm, a source of funds coming from its own capital, therefore carrying a positive sign. Then come interest payments on bills (to domestic and foreign residents, banks and central banks); on deposits, on loans, and on advances. Taking all these movements into account, we can compute profits of the firms, banks, and central banks. The latter are transferred to their respective government, while banks' and firms' profits are a source of funds that leads to an increase in their net wealth.

We can also compute household net wealth, but we just present, in the later rows, the net increment in their holdings of the above-mentioned financial assets, which from their point of view is a use of their money and thus are recorded with a minus sign. From the issuer's point of view, it is a source of funds, and it thus carries a plus sign. The same logic holds for banks' and central banks' holdings of bills. We also record the increase in firms' borrowing and banks' lending.

2.2 List of equations

We present first the equations related to national accounts. Upper-case letters denote nominal variables, lower-case ones reflect real variables. Equations (1) and (2) refer to real and nominal sales (the former, times sales prices) in each country; Equations (3) and (4) refer to real and nominal GDP; then we have the GDP price deflator, imports

Table 2a Transaction matrix of 'USA'

| | Households | Firms | | USA | | Government | Central Bank |
|----------|--|----------------------------------|------------------|-----------------------------------|----------------------|---------------------------------|------------------------------------|
| | | C | K | C | K | | |
| C | $-C_u$ | $+C_u$ | - | - | - | - | - |
| G | - | $+G_u$ | - | - | - | $-G_u$ | - |
| I | - | $+I_u$ | $-I_u$ | - | - | - | - |
| X | - | $+X_u$ | - | - | - | - | - |
| IM | - | $-IM_u$ | - | - | - | - | - |
| $[Y]$ | - | $[Y_u]$ | - | - | - | - | - |
| W | $+W_u \cdot N_u$ | $-W_u \cdot N_u$ | - | - | - | - | - |
| T | $-T_u$ | - | - | - | - | $+T_u$ | - |
| DA | - | $-DA_u$ | $+DA_u$ | - | - | - | - |
| $Int.$ | - | - | - | - | - | - | - |
| D | $+r_{mu}(-1) \cdot M_{us}(-1)$ | - | - | $-r_{mu}(-1) \cdot M_{us}(-1)$ | - | - | - |
| B^u | $+rb_{u(-1)} \cdot B^u_{hus}(-1)$ | - | - | $+rb_{u(-1)} \cdot B^u_{bus}(-1)$ | - | $-rb_{u(-1)} \cdot B^u_{s(-1)}$ | $+rb_{u(-1)} \cdot B^u_{cbus}(-1)$ |
| B^{Su} | $+rb_{u(-1)} \cdot B^{Su}_{hus}(-1) \cdot xru$ | - | - | - | - | - | - |
| B^{Su} | $+rb_{u(-1)} \cdot B^{Su}_{hud}(-1)$ | - | - | - | - | - | - |
| A | - | - | - | $-ra_u(-1) \cdot A_{us}(-1)$ | - | - | $+ra_{u(-1)} \cdot A_{us}(-1)$ |
| L^a | - | - | - | - | - | - | - |
| L^u | - | $-rl_{u(-1)} \cdot L^u_{us}(-1)$ | - | $+rl_{u(-1)} \cdot L^u_{us}(-1)$ | - | - | - |
| F_f | - | $-F_{fu}$ | $+F_{fu}$ | - | - | - | - |
| F_{cb} | - | - | - | - | - | $+F_{cbu}$ | $-F_{cbu}$ |
| F_b | - | - | - | $-F_{bu}$ | $+F_{bu}$ | - | - |
| $Ch.$ | - | - | - | - | - | - | $+ \Delta H_u$ |
| H | $- \Delta H_u$ | - | - | - | - | - | - |
| M | $- \Delta M_u$ | - | - | - | $+ \Delta M_u$ | - | - |
| B^u | $- \Delta B^u_{hus}$ | - | - | - | $- \Delta B^u_{bus}$ | $+ \Delta B^u$ | $- \Delta B^u_{cbus}$ |
| B^{Su} | $- \Delta B^{Su}_{hus}(-1) \cdot xru$ | - | - | - | - | - | - |
| B^{Su} | $- \Delta B^{Su}_{hud}$ | - | - | - | - | - | - |
| A | - | - | - | - | $+ \Delta A_{us}$ | - | $- \Delta A_{us}$ |
| L^a | - | - | - | - | - | - | - |
| L^u | - | - | $+ \Delta L^u_u$ | - | $- \Delta L^u_u$ | - | - |

Table 2b Transaction matrix of 'Argentina'

| Households | Firms | | Argentina Banks | | Government | Central Bank |
|-----------------|---|------------------------------|-----------------------------------|---------------------------------|---|--|
| | C | K | C | K | | |
| C | $-C_a$ | - | - | - | - | - |
| G | $+G_a$ | - | - | - | $-G_a$ | - |
| I | $+I_a$ | $-I_a$ | - | - | - | - |
| X | $-IM_a$ | - | - | - | - | - |
| IM | $+X_a$ | - | - | - | - | - |
| [Y] | $[Y_a]$ | - | - | - | - | - |
| W | $+W_a \cdot N_a$ | - | - | - | - | - |
| T | $-T_a$ | - | - | - | $+T_a$ | - |
| DA | $+DA_a$ | $+DA_a$ | - | - | - | - |
| Int. | - | - | - | - | - | - |
| D | $+r_{md(-1)} \cdot M_{as(-1)}$ | - | $-r_{md(-1)} \cdot M_{as(-1)}$ | - | - | - |
| B ^u | $+rb_{u(-1)} \cdot B_{has(-1)}^u \cdot xra$ | - | - | - | - | $+rb_{u(-1)} \cdot B_{chas(-1)}^u \cdot xra$ |
| B ^{sa} | $+rb_{a(-1)} \cdot B_{has(-1)}^a$ | - | $+rb_{a(-1)} \cdot B_{bas(-1)}^a$ | - | $-r_{ba(-1)} \cdot B_{s(-1)}^{sa}$ | $+rb_{a(-1)} \cdot B_{chas(-1)}^a$ |
| B ^{su} | - | - | - | - | $-B_{hud(-1)}^{su} \cdot r_{bud(-1)} \cdot xra$ | - |
| A | - | - | $-ra_{d(-1)} \cdot A_{as(-1)}$ | - | - | $+ra_{d(-1)} \cdot A_{as(-1)}$ |
| L ^a | - | - | $+rl_{d(-1)} \cdot L_{as(-1)}^a$ | $+rl_{d(-1)} \cdot L_{s(-1)}^a$ | - | - |
| L ^u | $-rl_{u(-1)} \cdot L_{as(-1)}^u \cdot xra$ | - | $+rl_{d(-1)} \cdot L_{as(-1)}^a$ | - | - | - |
| F _f | $-F_{fa}$ | $+F_{fa}$ | - | - | - | - |
| F _{cb} | - | - | - | - | $+F_{cha}$ | $-F_{cha}$ |
| F _b | - | - | $-F_{ba}$ | $+F_{ba}$ | - | - |
| Ch. | - | - | - | - | - | $+\Delta H_a$ |
| H | $-\Delta H_a$ | - | - | - | - | - |
| M | $-\Delta M_a$ | - | - | $+\Delta M_a$ | - | - |
| B ^u | $-\Delta B_{has}^u \cdot xra$ | - | - | - | - | $-\Delta B_{chas}^u \cdot xra$ |
| B ^{sa} | $-\Delta B_{has}^a$ | - | - | $-\Delta B_{bas}^a$ | $+\Delta B_{as}^{sa}$ | $-\Delta B_{chas}^a$ |
| B ^{su} | - | - | - | - | $+\Delta B_{hud}^{su} \cdot xra$ | - |
| A | - | - | - | $+\Delta A_{as}$ | - | $-\Delta A_{as}$ |
| L ^a | - | $+\Delta L_{as}^a$ | - | $-\Delta L_{as}^a$ | - | - |
| L ^u | - | $+\Delta L_{as}^u \cdot xra$ | - | - | - | - |

prices, and the nominal components of GDP. There are not many remarkable features in these equations; perhaps the most important is to note that the price of exports is determined in the export country (Equation (8)). Quantities will be determined in the import country, as we will show.

$$s_u = c_u + i_u + g_u + x_u \quad (1u)$$

$$s_a = c_a + i_a + g_a + x_a \quad (1a)$$

$$S_u = s_u \cdot p_{su} \quad (2u)$$

$$S_a = s_a \cdot p_{sa} \quad (2a)$$

$$y_u = s_u - im_u \quad (3u)$$

$$y_a = s_a - im_a \quad (3a)$$

$$Y_u = S_u - IM_u \quad (4u)$$

$$Y_a = S_a - IM_a \quad (4a)$$

$$p_{yu} = \frac{Y_u}{y_u} \quad (5u)$$

$$p_{ya} = \frac{Y_a}{y_a} \quad (5a)$$

$$p_{mu} = p_{sa} \cdot xr_u \quad (6u)$$

$$p_{ma} = p_{su} \cdot xr_a \quad (6a)$$

$$IM_u = im_u \cdot p_{mu} \quad (7u)$$

$$IM_a = im_a \cdot p_{ma} \quad (7a)$$

$$X_u = x_u \cdot p_{su} \quad (8u)$$

$$X_a = x_a \cdot p_{sa} \quad (8a)$$

$$C_u = c_u \cdot p_{su} \quad (9u)$$

$$C_a = c_a \cdot p_{sa} \quad (9a)$$

$$I_u = i_u \cdot p_{su} \quad (10u)$$

$$I_a = i_a \cdot p_{sa} \quad (10a)$$

$$G_u = g_u \cdot p_{su} \quad (11u)$$

$$G_a = g_a \cdot p_{sa} \quad (11a)$$

We postulate a rather simple mark-up pricing rule, in which firms price their products based on a mark-up on unitary cost including interest payments on loans borrowed last year, as shown in Equation (12). There are other, more elaborated formulations of

cost-based pricing, discussed in G/L (ch. 8), such as normal cost pricing, where costs are defined in reference to a *normal* level of output or capacity utilization. In this paper, however, given the complex nature of the model, we restrict ourselves to a simpler rule of pricing behavior. The mark up that enters in the pricing equation is exogenous, but it can vary according to a change in the exchange rate to reflect international competition. A higher coefficient π_{1u} , shown in Equation (13), would mean that the country is more exposed to international competition, so in case of an appreciation of the exchange rate (a *negative* change in the exchange rate) the mark-up absorbs part of the impact and prices do not rise to the extent that they should.¹ On the other hand, the only inputs firms use are labor and imports.

$$p_{su} = \frac{(1 + \pi_u) \cdot (W_u \cdot N_u + IM_u + r l_{u(-1)} \cdot L_{us(-1)}^u)}{s_u} \quad (12u)$$

$$p_{sa} = \frac{(1 + \pi_a) \cdot (W_a \cdot N_a + IM_a + r l_{a(-1)} \cdot L_{as(-1)}^a + r l_{u(-1)} \cdot L_{as(-1)}^u \cdot x r a)}{s_a} \quad (12a)$$

$$\pi_u = \pi_{0u} + \pi_{1u} \cdot \left(\frac{\Delta(x r_{u(-1)})}{x r_{u(-1)}} \right) \quad (13u)$$

$$\pi_a = \pi_{0a} + \pi_{1a} \cdot \left(\frac{\Delta(x r_{a(-1)})}{x r_{a(-1)}} \right) \quad (13a)$$

$$W_u = W_{u(-1)} + \omega_{0u} \cdot (w_{u(-1)}^T \cdot p_{su} - W_{u(-1)}) \quad (14u)$$

$$W_a = W_{a(-1)} + \omega_{0a} \cdot (w_{a(-1)}^T \cdot p_{sa} - W_{a(-1)}) \quad (14a)$$

$$w_u^T = \omega_{1u} + \omega_{2u} \cdot (EMP_u + z_{1u} \cdot [EMP_u - EMP_u] - z_{2u} \cdot b \text{ and } b_u + z_{3u} \cdot b \text{ and } t_u) \quad (15u)$$

$$w_a^T = \omega_{1a} + \omega_{2a} \cdot (EMP_a + z_{1a} \cdot [EMP_a - EMP_a] - z_{2a} \cdot b \text{ and } b_a + z_{3a} \cdot b \text{ and } t_a) \quad (15a)$$

$$z_{1u} = 1 \text{ if } b \text{ and } b_u < EMP_u < b \text{ and } t_u \quad (16ui)$$

$$z_{2u} = 1 \text{ if } b \text{ and } b_u > EMP_u \quad (16uii)$$

$$z_{3u} = 1 \text{ if } EMP_u > b \text{ and } t_u \quad (16uiii)$$

$$z_{1a} = 1 \text{ if } b \text{ and } b_a < EMP_a < b \text{ and } t_a \quad (16ai)$$

$$z_{2a} = 1 \text{ if } b \text{ and } b_a > EMP_a \quad (16aii)$$

$$z_{3a} = 1 \text{ if } EMP_a > b \text{ and } t_a \quad (16aiii)$$

¹ This is consistent with stylized facts that show that the pass-through from devaluations is smaller than one, so that the real exchange rate moves together with the nominal one, and usually it is the latter that has the most decisive influence on the former. See Taylor/Taylor (2004).

In our model, workers target a real wage when they negotiate their nominal wages. These are set at the beginning of the period, so that firms know their costs when they decide on their prices. Wage demands are backward-looking, and workers adjust a portion of the discrepancy between the nominal wage implied in the target (of the last period) and the actual nominal wage. What real wage do they target?

Here is where we introduce a somewhat unconventional Phillips curve. In our model, the wage demands of workers reflect the demand pressures from the labor market, proxied by the rate of change in the level of employment, but in a non-linear way. That is why we use the dummy variables of Equations (16). If the rate of change in the level of employment rate is within a certain range, workers will demand a given real wage. The range is determined by what workers judge to be a ‘reasonable’ rate of job creation, EMP , here equal to 3 percent, plus or minus a margin (of 0.3 percent in each direction). If jobs are created at a rate below 2.7 percent, or at a rate above 3.3 percent, there then exists a positive and linear relationship between real wage demands and the rate of change in employment. In words, our Phillips curve has a flat middle segment.² Its bands are determined by institutional factors, with scope for the influence of political actors.

The wage bill that enters in the price function is composed of the nominal wage times the employment volume. This is determined by the ratio of real GDP to labor productivity. The latter factor reacts to changes in the real wage, weighted by a coefficient q .³ The other input in the production process is imports. Equation (22) shows a typical import function, in which the independent variables are the ratio of domestic prices to import prices and real GDP, with ε_1 and μ_1 being the price elasticities and ε_2 and μ_2 the income elasticities of imports. ε_0 and μ_0 in turn represent the proportion of imports in domestic output, a coefficient liable to change due to development or industrial policies, such as import-substitution industrialization (we will make simulations to try to depict the latter). As mentioned earlier, quantities of exports are set by the import countries, as shown in Equation (23).

$$EMP_u = \Delta(N_{u(-1)}) / N_{u(-1)} \quad (17u)$$

$$EMP_a = \Delta(N_{a(-1)}) / N_{a(-1)} \quad (17a)$$

$$w_u = W_u / p_{su} \quad (18u)$$

$$w_a = W_a / p_{sa} \quad (18a)$$

$$N_u = y_u / pr_u \quad (19u)$$

2 Our equations draw heavily on G/L (2007), especially ch. 11 (pp. 386–388), even though in their model labor market pressure is captured by the employment rate. Empirical evidence about the existence of flat segments is found in Barnes/Olivei (2003), Lye/McDonald (2008), and Stock/Watson (2010), among others. See also IMF (2013, ch. 3).

3 This author is a firm believer in the relevance of the Kaldor–Verdoorn effect, by which aggregate demand has a substantive influence on the productivity growth rate. I can only offer a clumsy excuse for its omission in this model. The Kaldor–Verdoorn effect sets in motion a cumulative growth process, in demand-led growth models such as this one, by incorporating increasing returns to scale. In our model, that implies an unstable, explosive behavior, which deprives it from a steady state. Rowthorn (1981 [1989]) already noted that the introduction of such a feature severely restricts the stability conditions of Kaleckian models, and the same argument applies this time. A review of empirical support for the effect highlighted in this paper can be found in Storm/Naastepad (2012).

$$N_a = y_a / pr_a \quad (19a)$$

$$pr_u = pr_u \cdot (1 + g_{pru}) \quad (20u)$$

$$pr_a = pr_a \cdot (1 + g_{pra}) \quad (20a)$$

$$g_{pru} = q_u \cdot \left(\Delta(w_{u(-1)}) / w_{u(-1)} \right) \quad (21u)$$

$$g_{pra} = q_a \cdot \left(\Delta(w_{a(-1)}) / w_{a(-1)} \right) \quad (21a)$$

$$im_u = \varepsilon_o \cdot \left(\frac{p_{yu(-1)}}{p_{mu(-1)}} \right)^{e_1} \cdot y_u^{e_2} \quad (22u)$$

$$im_a = \mu_o \cdot \left(\frac{p_{ya(-1)}}{p_{ma(-1)}} \right)^{i_1} \cdot y_a^{i_2} \quad (22a)$$

$$x_u = im_a \quad (23u)$$

$$x_a = im_u \quad (23a)$$

We present next the equations relative to the (nominal and real) capital stock, investment decisions, depreciation allowance, borrowing, and profits. The capital stock depreciates at a constant rate δ , but this is always covered by investment. The rate of growth of the capital stock is determined by an accelerator effect, plus an exogenous term, as shown in Equation (28). Equation (29) presents the capacity utilization rate, and Equation (30) firms' net wealth. This is the difference between the nominal capital stock and loans.

$$K_u = k_u \cdot p_{su} \quad (24u)$$

$$K_a = k_a \cdot p_{sa} \quad (24a)$$

$$k_u = k_{u(-1)} \cdot (1 - \delta_u + gk_u) \quad (25u)$$

$$k_a = k_{a(-1)} \cdot (1 - \delta_a + gk_a) \quad (25a)$$

$$i_u = k_{u(-1)} \cdot (gk_u + \delta_u) \quad (26u)$$

$$i_a = k_{a(-1)} \cdot (gk_a + \delta_a) \quad (26a)$$

$$DA_u = \delta_u \cdot K_{u(-1)} \quad (27u)$$

$$DA_a = \delta_a \cdot K_{a(-1)} \quad (27a)$$

$$gk_u = \gamma_{0u} + \gamma_{1u} \cdot \left(\Delta y_{u(-1)} / y_{u(-1)} \right) \quad (28u)$$

$$gk_a = \gamma_{0a} + \delta_{1a} \cdot \left(\Delta y_{a(-1)} / y_{a(-1)} \right) \quad (28a)$$

$$z_u = \frac{y_u}{k_{u(-1)}} \quad (29u)$$

$$z_a = \frac{y_a}{k_{a(-1)}} \quad (29a)$$

$$V_{fu} = K_u - L_{us}^u \quad (30u)$$

$$V_{fa} = K_a - L_{as}^a - L_{as}^u \cdot xra \quad (30a)$$

Firms demand loans to cover their financial requirements (principal and interest of past loans, investments) not covered by the depreciation allowance and their past profits. A distinguishing feature of this model is that Argentinean firms can borrow in the Argentinean and American banking systems, in different currencies, as shown in Equations (31a iii) and (31a iii). Profits are the remnants of the GDP computing the wage bill, interest payments on loans, and the depreciation allowance. Loans borrowed from US banks (and the interest payments on them) are always registered at the supplied value (that is, in dollars) and translated into pesos at the current exchange rate.

$$L_{ud}^u = L_{us(-1)}^u \cdot (1 + rl_{u(-1)}) + I_u - DA_u - F_{fu(-1)} \quad (31u)$$

$$L_{ad} = L_{as(-1)}^a \cdot (1 + rl_{a(-1)}) + L_{as(-1)}^u \cdot (1 + rl_{u(-1)}) \cdot xra + I_a - DA_a - F_{fa(-1)} \quad (31ai)$$

$$L_{ad}^a = \nu \cdot L_{ad} \quad (31a iii)$$

$$L_{ad}^u = L_{ad} - L_{ad}^a \quad (31a iii)$$

$$F_{fu} = Y_u - W_u \cdot N_u - rl_{u(-1)} \cdot L_{us(-1)}^u - DA_u \quad (32u)$$

$$F_{fa} = Y_a - W_a \cdot N_a - rl_{a(-1)} \cdot L_{as(-1)}^a - rl_{u(-1)} \cdot L_{as(-1)}^u \cdot xra - DA_a \quad (32a)$$

It is time to describe the equations concerning households' regular income, households' disposable income (actual and expected), and their consumption decisions. These are taken in real terms, based on some expectations about disposable income and 'real' wealth. However, these expectations also have an effect on the allocation of wealth between different alternatives.

$$Yr_u = W_u \cdot N_u + r_{mu(-1)} \cdot M_{us(-1)} + rb_{u(-1)} \cdot B_{hus(-1)}^u + rb_{a(-1)} \cdot B_{hus(-1)}^{sa} \cdot xru + rb_{u(-1)} \cdot B_{hus(-1)}^{su} \quad (33u)$$

$$Yr_a = W_a \cdot N_a + r_{ma(-1)} \cdot M_{as(-1)} + rb_{a(-1)} \cdot B_{has(-1)}^a + rb_{u(-1)} \cdot B_{has(-1)}^u \cdot xra \quad (33a)$$

$$T_u = \theta_u \cdot Yr_u \quad (34u)$$

$$T_a = \theta_a \cdot Yr_a \quad (34a)$$

$$YD_u = Yr_u + \Delta xru \cdot B_{hus(-1)}^{sa} - T_u \quad (35u)$$

$$YD_a = Yr_a + \Delta xra \cdot B_{has(-1)}^u - T_a \quad (35a)$$

$$yd_u = \frac{YD_u}{p_{su}} \quad (36u)$$

$$yd_a = \frac{YD_a}{p_{sa}} \quad (36a)$$

$$yd_u^e = yd_{u(-1)} + \beta_u \cdot (yd_{u(-1)} - yd_{u(-1)}^e) \quad (37u)$$

$$yd_a^e = yd_{a(-1)} + \beta_a \cdot (yd_{a(-1)} - yd_{a(-1)}^e) \quad (37a)$$

$$YD_u^e = yd_u^e \cdot p_{su(-1)} \quad (38u)$$

$$YD_a^e = yd_a^e \cdot p_{sa(-1)} \quad (38a)$$

$$V_{hu} = V_{hu(-1)} + YD_u - C_u \quad (39u)$$

$$V_{ha} = V_{ha(-1)} + YD_a - C_a \quad (39a)$$

$$v_{hu} = \frac{V_{hu}}{p_{su}} \quad (40u)$$

$$v_{ha} = \frac{V_{ha}}{p_{sa}} \quad (40a)$$

$$V_{hu}^e = V_{hu(-1)} + YD_u^e - C_u \quad (41u)$$

$$V_{ha}^e = V_{ha(-1)} + YD_a^e - C_a \quad (41a)$$

$$c_u = \alpha_{1u} \cdot yd_u^e + \alpha_{2u} \cdot v_{hu(-1)} \quad (42u)$$

$$c_a = \alpha_{1a} \cdot yd_a^e + \alpha_{2a} \cdot v_{ha(-1)} \quad (42a)$$

Taxes are levied on regular income, and once deducted (and adding the capital gains due to exchange rate movements) we get the nominal disposable income. Notice that the holdings of Argentinean bills denominated in dollars do *not* generate a capital gain to American holders by exchange rate movements. Dividing it by the sales price index, we get real disposable income.⁴ However, households do not base their consumption decisions directly (and entirely) on it, but rather on the *expected* real disposable income. This is formed by the actual past value and a term that corrects past mistakes (with a certain speed of adjustment). They also consume a (low) proportion of their past real wealth. With expected disposable income and consumption, we can have an estimate of households' *expected wealth* that they will invest in different assets. But, before that, we want to highlight an important factor. In the steady state, with no mistaken expectations, there is a stable relation between wealth and disposable income, equal to: $V_h^* = \alpha_3 \cdot YD^*$, with $\alpha_3 = \frac{(1-\alpha_1)}{[1 - (\frac{1}{1+gr}) + (\frac{\alpha_2}{1+gr})]}$, where gr is the growth rate of disposable income and consumption. This long-run *norm* will have a substantial effect on *government*

4 For simplicity, we omit the effect of past inflation on real wealth.

debt, as we will show later in the simulations. A detailed analysis is found in G/L (2007, appendix 3.4).

Having decided how much they will consume, and how much they will save, households need to decide how to invest their wealth. Since all financial assets last one period, there is no impediment for them to reallocate their whole wealth, rather than just new savings. Portfolio allocation is done according to Tobinesque rules, in which agents compare different rates of return plus the relevant risk of the specific asset. In this case, there are two such risks: currency risk, which can cause capital gains or losses according to exchange rate movements; and sovereign risk, which questions directly the repayment capacity of the debtor (the government). Different risks apply to different assets. When a country issues debt denominated in its own currency, the corresponding asset faces currency (or depreciation) risk. Sovereign risk is relevant for countries that have debt denominated in another currency. In our model, sovereign risk is relevant only relative to Argentinean bills denominated in dollars. But we do not only distinguish different types of risk, we also distinguish different types of traders. However, a clarification regarding the notation is due. The variable $B_{hud}^{\$a}$ represents the demand of Argentinean bills denominated in pesos (' $\$a$ ') by American households (' hud '), while variable $B_{hud}^{\$u}$ represents the demand, by the same households, of Argentinean bills denominated in dollars (' $\$u$ '). It's just unfortunate that dollars and pesos share the same symbol.

$$M_{ud}^n = V_{bu}^e \cdot (\lambda_{10} + \lambda_{11} \cdot rm_u + \lambda_{12} \cdot rb_u + \lambda_{13} \cdot [rb_a + dxru^e] + \lambda_{14} \cdot [rb_u - \phi]) \quad (43ui)$$

$$B_{hud}^u = V_{bu}^e \cdot (\lambda_{20} + \lambda_{21} \cdot rm_u + \lambda_{22} \cdot rb_u + \lambda_{23} \cdot [rb_a + dxru^e] + \lambda_{24} \cdot [rb_u - \phi]) \quad (43uii)$$

$$B_{hud}^{\$a} = V_{bu}^e \cdot (\lambda_{30} + \lambda_{31} \cdot rm_u + \lambda_{32} \cdot rb_u + \lambda_{33} \cdot [rb_a + dxru^e] + \lambda_{34} \cdot [rb_u - \phi]) \quad (43uiii)$$

$$B_{hud}^{\$u} = V_{bu}^e \cdot (\lambda_{40} + \lambda_{41} \cdot rm_u + \lambda_{42} \cdot rb_u + \lambda_{43} \cdot [rb_a + dxru^e] + \lambda_{44} \cdot [rb_u - \phi]) \quad (43uiv)$$

$$H_{ud}^n = V_{bu} - M_{ud}^n - B_{hud}^u - B_{hud}^{\$a} - B_{hud}^{\$u} \quad (43uv)$$

$$M_{ad}^n = V_{ba}^e \cdot (\lambda_{50} + \lambda_{51} \cdot rm_a + \lambda_{52} \cdot rb_a + \lambda_{53} \cdot [rb_u + dxra^e]) \quad (43ai)$$

$$B_{had}^a = V_{ba}^e \cdot (\lambda_{60} + \lambda_{61} \cdot rm_a + \lambda_{62} \cdot rb_a + \lambda_{63} \cdot [rb_u + dxru^e]) \quad (43aii)$$

$$B_{had}^u = V_{ba}^e \cdot (\lambda_{70} + \lambda_{71} \cdot rm_a + \lambda_{72} \cdot rb_a + \lambda_{73} \cdot [rb_u + dxru^e]) \quad (43aiii)$$

$$H_{ad}^n = V_{ba} - M_{ad}^n - B_{had}^u - B_{had}^a \quad (43aiv)$$

$$H_{ud} = H_{ud}^n \cdot z_{4u} \quad (44u)$$

$$H_{ad} = H_{ad}^n \cdot z_{4a} \quad (44a)$$

$$z_{4u} = 1 \text{ if } H_{ud}^n > 0 \quad (45u)$$

$$z_{4a} = 1 \text{ if } H_{ad}^n > 0 \quad (45a)$$

$$M_{ud} = M_{ud}^n \cdot z_{4u} + (V_{bu} - B_{hud}^u - B_{hud}^{\$a} - B_{hud}^{\$u}) \cdot z_{5u} \quad (46u)$$

$$M_{ad} = M_{ad}^n \cdot z_{4a} + (V_{ba} - B_{had}^u - B_{had}^a) \cdot z_{5a} \quad (46a)$$

$$z_{5u} = 1 \text{ if } H_{ud}^n < 0 \quad (47u)$$

$$z_{5a} = 1 \text{ if } H_{ad}^n < 0 \quad (47a)$$

$$dxru^e = -dxra^e \quad (48u)$$

$$dxra^e = \chi^f \cdot dxra^{ef} + \chi^c \cdot dxra^{ec} \quad (48ai)$$

$$dxra^{ef} = \zeta \cdot \left(\frac{xra^\# - xra_{(-1)}}{xra_{(-1)}} \right) \quad (48aai)$$

$$dxra^{ec} = \xi \cdot \left(\Delta(xra_{(-1)}) / xra_{(-1)} \right) \quad (48aiii)$$

$$\rho = \left(B_{bud(-1)}^{\$u} / Ya(-1) \cdot xru_{(-1)} \right) \quad (49)$$

$$\phi = \kappa \cdot \left(\Delta(\rho) / \rho \right) \quad (50)$$

The numerous equations numbered (43) describe portfolio allocation. All the values of the λ coefficients must respect the adding-up constraints set in G/L (2007, pp. 328–329). And, just like G/L (*ibid.*, pp. 325–328), we also have an implicit demand for money which has a negative rate of return equal to the inflation rate, incorporated in the values assigned to the λ .

Equations (43ui), (43uv), (43ai), and (43aiv) show *notional* demands for cash and deposits; that's why they have a superscript '*n*.' Why do we consider both a *notional* and an *actual* demand for these two assets in particular? The explanation lies in the first term in the portfolio equations: households allocate their *expected* wealth, with cash demand being the buffer stock that absorbs mistaken expectations between actual and expected wealth. But, at times, these divergences can be so huge that the notional demand for cash becomes *negative*. In that case, Equations (44) to (47) ensure that families decrease their deposits to cover the difference. The second term in Equation (46) would be smaller than the value resulting from Equations (43ui) and (43ai).

Regarding expectations and risks, our modeling of expectation formation regarding the future movement of the exchange rate follows Lavoie/Daigle (2011). In the exchange markets, there is a proportion of 'fundamentalists' traders who act according to some rule, and a proportion of Chartist traders who follow past movements while trying to predict future ones.⁵ The former expect the exchange rate to move according to the divergence between its past value and some benchmark, $xra^\#$. We do not believe that this value arises from an equilibrium process; instead, we think it is a market convention. The separation between fundamentalists and Chartists is likely to create some cyclical behavior, together with the special Phillips curve we use.

Equations (49) and (50) represent risk associated with the holding of Argentinean bills denominated in dollars, a currency that the government does not print. In a simple fashion, we say that that risk moves in line with the rate of change in the ratio of (past) Argentina's foreign debt denominated in dollars to its nominal GDP also expressed in dollars. We believe this is a fairly realistic argument that explains better than others some facts of the European crisis: countries with lower debt may be riskier than ones with higher debt, if their position is speedily deteriorating.

5 Among the literature supporting this modeling of the exchange market, we can mention Harvey (1993), Moosa (2003, ch. 8), De Grauwe/Grimaldi (2006, ch. 2), and Rossi (2010).

The behavior of commercial banks in this model is pretty simple. They grant all the loans that firms demand from them (Equations (52)), and accept all the deposits households make (Equations (51)), charging a mark-up on the former and thus making a profit (Equations (58)). The difference between deposits plus accumulated profits (their net wealth) and loans is invested into bills, when this difference is positive; or is covered with advances from the central bank, when it is negative. In the latter case, the distinction between notional and actual demands is also relevant, and the mechanism is described in Equations (53) to (57). This institutional framework is more similar to the Anglo-Saxon banking system than to the European one.

$$M_{us} = M_{ud} \quad (51u)$$

$$M_{as} = M_{ad} \quad (51a)$$

$$L_{us}^u = L_{ud}^u \quad (52ui)$$

$$L_{as}^u = L_{ad}^u \cdot xru \quad (52uii)$$

$$L_{as}^a = L_{ad}^a \quad (52a)$$

$$B_{bud}^{nu} = M_{us} + V_{bu} - L_{as}^u - L_{us}^u \quad (53u)$$

$$B_{bad}^{na} = M_{as} + V_{ba} - L_{as}^a \quad (53a)$$

$$B_{bud}^u = B_{bud}^{nu} \cdot z_{6u} \quad (54u)$$

$$B_{bad}^a = B_{bad}^{na} \cdot z_{6a} \quad (54a)$$

$$z_{6u} = 1 \text{ if } B_{bud}^{nu} > 0 \quad (55u)$$

$$z_{6a} = 1 \text{ if } B_{bad}^{na} > 0 \quad (55a)$$

$$A_{ud} = (L_{as}^u + L_{us}^u - M_{us} - V_{bu}) \cdot z_{7u} \quad (56u)$$

$$A_{ad} = (L_{as}^a - M_{as} - V_{ba}) \cdot z_{7a} \quad (56a)$$

$$z_{7u} = 1 \text{ if } B_{bud}^{nu} < 0 \quad (57u)$$

$$z_{7a} = 1 \text{ if } B_{bad}^{na} < 0 \quad (57a)$$

$$F_{bu} = rl_{u(-1)} \cdot L_{us(-1)}^u + rl_{u(-1)} \cdot L_{as(-1)}^u + rb_{u(-1)} \cdot B_{bus(-1)}^u - rm_{u(-1)} \cdot M_{us(-1)} - ra_{u(-1)} \cdot A_{us(-1)} \quad (58u)$$

$$F_{ba} = rl_{a(-1)} \cdot L_{as(-1)}^a + rb_{a(-1)} \cdot B_{bas(-1)}^a - rm_{a(-1)} \cdot M_{as(-1)} - ra_{a(-1)} \cdot A_{as(-1)} \quad (58a)$$

$$V_{bu} = V_{bu(-1)} + F_{bu} \quad (59u)$$

$$V_{ba} = V_{ba(-1)} + F_{ba} \quad (59a)$$

This is a good moment to present the different interest rates of the model. The base rate on government bills is set by the central bank. Banks apply a mark-up over it to set the interest rate on loans. The interest rate on central bank advances carries

a penalty, though smaller than the banks' mark-up. The deposit rate is equal to the bill rate.

$$rl_u = rb_u \cdot (1 + \iota_u) \quad (60u)$$

$$rl_a = rb_a \cdot (1 + \iota_a) \quad (60a)$$

$$r_{mu} = r_{bu} \quad (61u)$$

$$r_{ma} = r_{ba} \quad (61a)$$

$$ra_u = r_{bu} \cdot (1 + \mathfrak{v}_u) \quad (62u)$$

$$ra_a = r_{ba} \cdot (1 + \mathfrak{v}_a) \quad (62a)$$

We have already mentioned nominal government expenditure in Equation (11). Real government expenditure grows at a fixed rate σ . Central banks' profits are distributed back to their respective governments. We present next the equations showing this and bills supplied to households and banks. Equation (66u) has a special mark (*FX*), as it will be one of the equations defining a fixed exchange rate closure. When we talk about flexible exchange rates and the central bank, these equations will take another form.

$$g_u = g_{u(-1)} \cdot (1 + \sigma_u) \quad (63u)$$

$$g_a = g_{a(-1)} \cdot (1 + \sigma_a) \quad (63a)$$

$$B_s^u = B_{s(-1)}^u + G_u - T_u + r_{bu(-1)} \cdot B_{s(-1)}^u - F_{cbu} \quad (64u)$$

$$B_s^a = B_{s(-1)}^{s_a} \cdot (1 + r_{ba(-1)}) + B_{hud(-1)}^{s_u} \cdot (1 + r_{bu(-1)}) \cdot xra + G_a - T_a - F_{cba} \quad (64ai)$$

$$B_s^{s_a} = B_{has}^a + B_{hus}^{s_a} + B_{bas}^a + B_{cbas}^{s_a} \quad (64aii)$$

$$B_{hus}^u = B_{hud}^u \quad (65u)$$

$$B_{has}^a = B_{bad}^a \quad (65a)$$

$$B_{has}^u = B_{bad}^u \cdot xru \quad (66uFX)$$

$$B_{hus}^{s_a} = B_{hud}^{s_a} \cdot xra \quad (66ai)$$

$$B_{hus}^{s_u} = B_{hud}^{s_u} \cdot xra \quad (66aii)$$

$$B_{bus}^u = B_{bud}^u \quad (67u)$$

$$B_{bas}^a = B_{bad}^a \quad (67a)$$

The following equations present the demand and supply functions related to the central bank. We follow the presentation of G/L (2007, ch. 12).

$$H_{us} = H_{ud} \quad (68u)$$

$$H_{as} = H_{ad} \quad (68a)$$

$$A_{us} = A_{us} \quad (69u)$$

$$A_{ad} = A_{ad} \quad (69a)$$

$$B_{cbud}^u = H_{us} - A_{us} \quad (70u)$$

$$B_{cbad}^a = B_{cbad(-1)}^a + \Delta(H_{as}) - \Delta(B_{cbas}^u) \cdot xra \quad (70a)$$

$$B_{cbus}^u = B_{cbud}^u \quad (71u)$$

$$B_{cbas}^a = B_{cbad}^a \quad (71a)$$

$$B_{cbas}^u = B_s^u - B_{bus}^u - B_{bus}^u - B_{cbus}^u - B_{bas}^u \quad (72uFX)$$

$$B_{cbad}^u = B_{cbas}^u \cdot xra \quad (72a)$$

$$xru = constant \quad (73uFX)$$

$$xra = 1/xru \quad (73a)$$

$$F_{cbu} = rb_{u(-1)} \cdot B_{cbus(-1)}^u + ra_{u(-1)} \cdot A_{us(-1)} \quad (74u)$$

$$F_{cba} = rb_{a(-1)} \cdot B_{cbas(-1)}^a + ra_{a(-1)} \cdot A_{as(-1)} + rb_{u(-1)} \cdot B_{cbas(-1)}^u \cdot xra \quad (74a)$$

One needs to take note of the following equations: in Equation (70a), the demand for bills is presented in differences, instead of levels, because there exists the possibility of capital gains due to exchange rate movement (G/L: 461). Equation (72u) shows the essence of a fixed exchange rate: the Argentinean central bank must buy all the American bills left on the market if it wants to sustain a given exchange rate. That is why its demand is determined by its supply. There is a redundant equation, however: the Argentinean government supplies the residual bills in pesos (those not bought by banks or households) to the central bank. But there is already one such equation: equation (71a). Since the same variable cannot appear twice in the LHS of the equation, it becomes redundant in the model, but its fulfillment is assured by the tight accounting that we went through: there is no other way. However, these equations do not remain the same if we want to model a flexible exchange rate. For that, we need the following closure:

$$B_{has}^u = B_s^u - B_{bus}^u - B_{bus}^u - B_{cbus}^u - B_{cbas}^u \quad (66uFL)$$

$$B_{cbas}^u = constant \quad (72uFL)$$

$$xru = B_{has}^u / B_{bad}^u \quad (73uFL)$$

In this closure, the demand for and the supply of American bills to Argentinean households are determined independently, and it is the role of the exchange rate to adjust in order to equalize them. We have inverted Equation (66uFX). However, this does not mean that these two variables are the sole factor in the determination of the exchange rate: all the variables play a role here. Imports and exports affect income, GDP growth affects investment and loans, and interest rate payments. That is the beauty of stock-flow models: they are macroeconomic structural models, with no accounting holes, and with a simultaneous and consistent determination of flows, stocks, and prices.

The disadvantage is that, in models this large, stability analysis becomes almost impossible analytically. To sum up, we present the current account and the capital account of the balance of payments, which includes foreign reserve movements (what G/L call ‘KABOSA,’ a capital account that includes the Official Settlement Account, and what is now called the ‘financial account’ of the balance of payments).

$$CA_u = X_u - IM_u + r_{ba(-1)} \cdot B_{hus(-1)}^{sa} \cdot xru + r_{bu(-1)} \cdot B_{hud(-1)}^{su} + r_{lu(-1)} \cdot L_{as(-1)}^u - r_{bu(-1)} \cdot B_{bas(-1)}^u - r_{bu(-1)} \cdot B_{cbas(-1)}^u \quad (75u)$$

$$CA_a = X_a - IM_a + r_{bu(-1)} \cdot \left(B_{bas(-1)}^u + B_{cbas(-1)}^u \right) \cdot xra - r_{ba(-1)} \cdot B_{hus(-1)}^{sa} - r_{bu(-1)} \cdot B_{hud(-1)}^{su} \cdot xra - r_{lu(-1)} \cdot L_{as(-1)}^u \cdot xra \quad (75a)$$

$$KA_u = \Delta B_{bas}^u + \Delta B_{cbas}^u - \Delta B_{hus}^{sa} \cdot xru - \Delta B_{hud}^{su} - \Delta L_{as}^u \quad (76u)$$

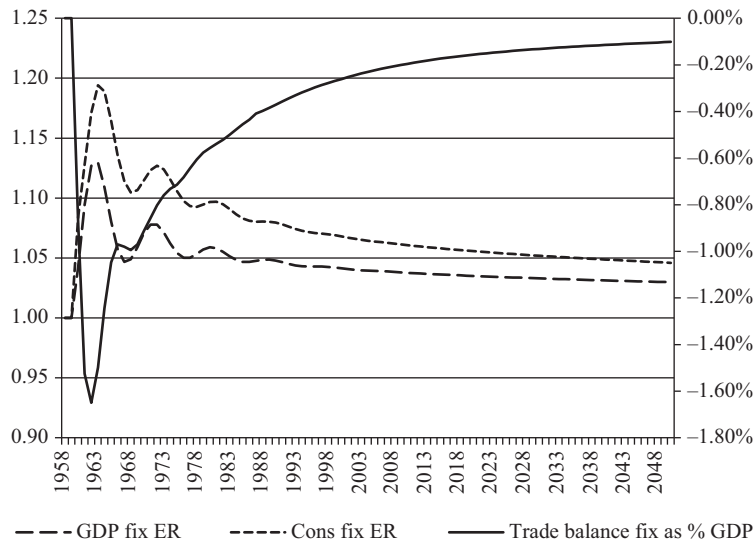
$$KA_a = \Delta B_{bas}^{sa} + \Delta B_{hud}^{su} \cdot xra - \Delta B_{bas}^u \cdot xra - \Delta B_{cbas}^u \cdot xra - \Delta L_{as}^u \cdot xra \quad (76a)$$

Finally, we present a brief description of the baseline used as a benchmark to compare the effects of the different shocks we simulated. We simulated the model for 100 periods, and at the end of those periods GDP was increasing, in the flexible exchange rate regime, at 3.04 percent in Argentina and 3.03 percent in the USA, with the Argentinean peso slightly depreciating around 0.08 percent annually, real wages going up by 0.03 percent in Argentina and 0.04 percent in the USA; there is also some price deflation at around 0.4 percent per period, while the accumulation rate (Equation (28)) proceeds at 2.9 percent. In the fixed exchange rate regime, in turn, GDP grows in both countries at 3.03 percent, the real wage rate grows at 0.04 percent, deflation is also at 0.04 percent, and accumulation moves at 2.9 percent per period. The debt-to-GDP ratio grows but at a decreasing trend in both regimes, rising by less than 0.1 percent per period and stabilizing asymptotically. In our opinion, however, these values should not be given much importance. What matters in our view is the impact of the shocks relative to the baseline, the baseline in itself being of secondary importance. The parameters used to reach the baseline are presented in the appendix, and a script of the model is available on request, or in the website <http://sfc-models.net/>.

3 SIMULATIONS

3.1 Consumption, savings, and fiscal policy

The model is simulated during 100 periods, called years between 1950 and 2050. The shocks are imposed on the 10th period, that is, the ‘year’ 1960. In the first experiment, we increase by 10 percent the coefficient a_{1a} , which represents the propensity to consume out of disposable income of Argentinean households. As expected in a Keynesian model that imposes no constraint on the supply side, we observe that real GDP is higher after the change. The long-term impact is smaller than the short-term impact, but it is still positive. The paradox of thrift holds both in the short and in the long run. However, we do observe a fall in real and nominal household wealth, which slightly counteracts the increased propensity to consume. In other words, the coefficient \hat{a}_3 becomes smaller. But that is not the only implication.



Notes: GDP, real consumption and trade balance after a 10% increase in the propensity to consume out of disposable income in Argentina, in a fixed ER regime.

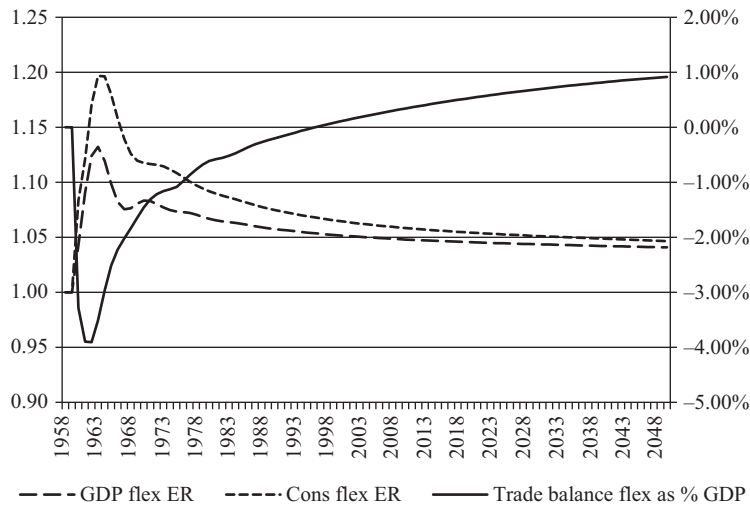
Figure 1a Paradox of thrift in a fixed exchange rate regime

Higher consumption and less saving is matched, *ceteris paribus*, by two features: one is a change in the external performance due to higher imports, and we do observe initially the deterioration in the trade and current accounts of Argentina in both exchange rate regimes. However, in the flexible exchange rate regime, the trade balance ends up making a positive contribution to GDP, due to the deterioration of the peso (though this does not mean that the exchange rate moves necessarily in the same direction as the current account, as we will show later). This difference is shown in Figure 1a (which represents the case of the fixed exchange rate regime) and Figure 1b (which represents the flexible exchange rate regime). The straight line in both cases, representing the evolution of the trade balance as a share of GDP, is measured on the right-hand vertical axis. As can be seen, the trade balance becomes positive for Argentina, contributing to a higher level of economic activity. This already gives us some hint about the relative influence of price competitiveness in this model (and with the parameter values that we chose), something that will be explored below.

The other important feature is the fall in public sector borrowing requirements of the Argentinean government. The economy therefore achieves a lower debt-to-GDP ratio (though foreign debt denominated in dollars is a higher proportion of total debt). This is shown in Figure 2.

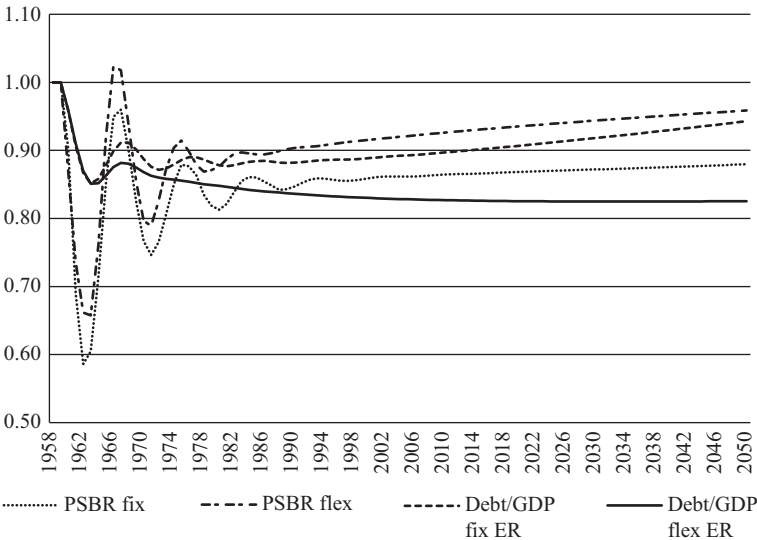
We now look at the effects of a higher rate of growth of public expenditure. The model is very sensitive to changes in this parameter. We increase the coefficients σ_a and σ_u from 3 percent to 3.15 percent in the case of a fixed exchange rate regime and to 3.12 percent in the case of the flexible regime, and even in the latter case, in what refers to the American coefficient, we did not have values for the last 15 years, although the sample was big enough to draw some conclusions.

Both increases are expansionary for the country that implements them and for the other one as well, due to the stimulus to export. However the net impact on the balance of trade depends on the exchange rate regime. The flexible exchange rate regime reflects higher



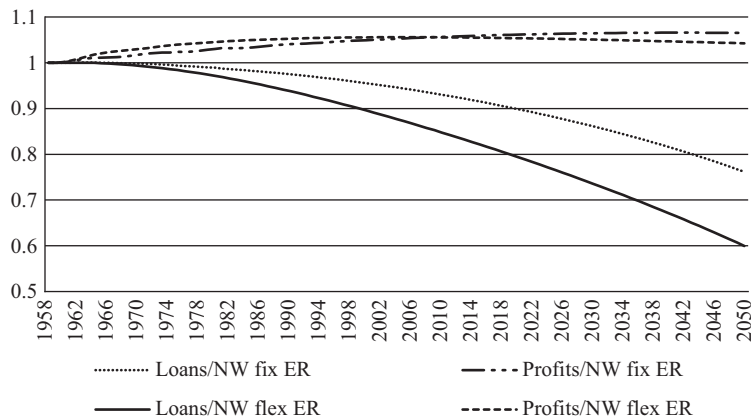
Notes: GDP, real consumption and trade balance after a 10% increase in the propensity to consume out of disposable income in Argentina, in a flexible ER regime.

Figure 1b Paradox of thrift in a flexible exchange rate regime



Notes: Public Sector Borrowing Requirements and Debt/Nominal GDP ratio in Argentina after an increase in the propensity to consume out of disposable income.

Figure 2 Fiscal performance with higher propensity to consume



Notes: Loans to net wealth and profit to net wealth ratios of Argentinean firms after an increase in the rate of growth of public expenditures.

Figure 3 Higher growth rate of public expenditures

output due to an improved balance of trade, which in turn is caused by a depreciation of the exchange rate. The rate of growth of the capital stock also has the same behavior: in both cases it is positive, but it is greater in the flexible exchange rate regime. By contrast, real consumption is slightly higher in the fixed exchange rate than in the other. The reason is that a sustained depreciation increases the mark-up and lowers real wages, something ruled out in our fixed exchange rate model. However, given the parameters of our simulations and the magnitude of the changes, the fall in the real wage is very small and the trade balance impact prevails over consumption. The opposite of a depreciation, in the fixed exchange rate case, is a loss of foreign reserves in Argentina. But more can be said.

In recent times, financial blogs have started to use the 'Kaleckian equation' as a guide to estimate the future movements of corporate profits. That equation basically says that profits are equal to corporate investment minus households' saving plus the budget deficit plus the current account surplus (Kalecki 1971). Can we observe something like that here? Yes, we can. Figure 3 shows the evolution of the loans to firms' net wealth ratio, and the (net of depreciation allowance) profits to net wealth ratio. Compared to the baseline, we observe the expected result: the first ratio goes down, the second ratio goes up. Also, the former ratio falls even more in the flexible exchange rate regime than in the fixed regime, even though the magnitude of the change was lower. We attribute this to the increase in the mark-up and the higher price level observed when the exchange rate is allowed to float.

3.2 Interest rates, portfolios, devaluations, and expectations

Moving now to monetary policy, we conducted three experiments: we raised the interest rate on American bills (and Argentinean bills denominated in dollars), we raised the interest rate on bills denominated in pesos, and we raised both at the same time. In the first stage, we will present the results on the second experiment (an increase of 50 bps in r_{ba} from 3 percent to 3.5 percent). The very short-run movements are as expected, the medium-to-longer-run not, but they do offer a lot of insight and we will focus our

presentation on the reaction in the first five periods or years, even though we obtained results for the whole length of the simulations. It is a supply and demand story. Let us start with the fixed exchange rate regime. Since there are many variables involved in the explanation, a literary description seems more appropriate than a graphical presentation. We beg the reader to stay with us during the explanation.

The Argentinean public sector borrowing requirements (PSBR) increase, although slightly less in the second period, as interest rates take a greater toll in the government budget. The demand for bills in pesos, from American and Argentinean households, increases slightly, except for the latter in 1961. The American demand for US bills also decreases initially, though later it will grow together with household wealth. What is steadily declining is the US PSBR. Greater interest payments to USA households imply greater income and smaller deficits (this effect is actually small: the American debt is barely 2 percent lower in the last period of the simulation compared to the baseline). The supply of American bills goes down, and the supply of Argentinean bills goes up. In the first year, with the increase in the demand for Argentinean bills (and the small decline in the demand for American bills), foreign reserves increase, but later they go down as well. The Argentinean central bank sells the dollars in exchange for pesos, but now there are fewer pesos in circulation than the required amount to keep the interest rate at the desired level, so the central bank *buys the bills the government is issuing with the pesos required to keep the interest rate constant*. That is how the increased PSBR is 'financed.' However implausible this might seem (and it does seem unrealistic to us), there is one good, relevant, and important feature: the outflow of foreign reserves, even in a fixed exchange rate regime, *need not go together with a reduction in the domestic money supply*. As long as Argentina has (enough) foreign reserves, this process can go on for ever. Mundell–Fleming does not apply. A country can have (and sustain) a domestic interest rate that is different from the international one. The key is that there is imperfect substitution between the assets (Lavoie 2000): investors do not see them as equal or competing with others. Capital controls might not theoretically be necessary to accomplish this, and there are none in our model, but they help, and realistically they are indispensable, in my view.

In a flexible exchange rate regime, in 1961 we have an appreciated exchange rate, just like in the fixed exchange rate closure we had an initial increase in reserves. But in that period the effects are different: this causes a capital gain to the government, lowering (in one period) its borrowing requirements, together with the fall in the demand for bills denominated in dollars. In a sense, it actually achieves what it tried to achieve. But in this simulation this development only lasts for one period, as the mentioned increase in reserves in this simulation. Also, it should be taken into account that our investment function does not include a direct impact from the rate of interest.

The attentive reader may ask what happens with the expectations about the movement of the exchange rate. Well, there are two cases. In the fixed exchange rate closure, given that we chose to set an exchange rate level equal to what fundamentalist traders think it should be, expectations play no role. (They will in another simulation.) In the flexible exchange rate regime, the values obtained for the baseline are below the 'fundamental' exchange rate. As the actual exchange rate depreciates in the simulation, it gets closer to the fundamental value, and expectations about its future movement become more optimistic (that is, the expectation of depreciation is reduced, though in an attenuated way because of the Chartist traders).

The impact on output of an increase in the Argentinean interest rate, given our model, is slightly positive, less than 2 percent higher in the last period compared to the baseline (in the fixed exchange rate closure, it is 1 percent higher) because interest receipts increase disposable income and with it consumption. In the flexible exchange rate, we should also

add the impact of a positive trade balance. We did not include interest rates in the investment function; that remains for future work.

Finally, what happens when such an increase in the Argentinean interest rate goes hand in hand with an increase in the American interest rate? Sparing the reader more complicated graphics, we can confidently say, given the parameters of our model, that both PSBR (American and Argentinean) go up. The Argentinean government even has to pay more for its bills denominated in dollars. The behavior we observed previously is attenuated: depreciation is more nuanced, and Argentina even has a gain in its foreign reserves. Due to the cost effect of interest payments on loans (which also rise, in tune with the base rate), the real wage is somewhat decreased along the way. This counteracts the effect of interest receipts for a long time, especially in the fixed exchange rate closure.

What are the effects when we shock the portfolio decisions of households, that is, the proportions in which they allocate their wealth among different assets? For example, what happens when American households fear about the evolution of the Argentinean economy and increase their holdings of domestic bills at the expense of the others? And what if on top of this they have doubts about its solvency in dollars, and the coefficient \hat{e} rises? In the fixed exchange rate regime, private financial flows to Argentina fall, and so do foreign reserves. However, as we mentioned before, the ‘rules of the game’ of a gold standard do not apply: nobody plays by the rules. Domestic credit is increased by the central bank, as long as it has foreign reserves to defend the exchange rate. We will show later what happens when it does *not* defend the exchange rate. So far, the situation is not good. But what happens in a flexible exchange rate?

Several things are noticeable here. First, yes, the exchange rate depreciates. Does the story end there? No. Depreciation has certain effects on Argentina, and it is interesting to track them down. In this simulation, depreciation increases prices in Argentina and decreases them in the US, via two effects: increasing (decreasing) the cost of imports (and in the Argentinean case, the burden of interest payments on foreign loans); and increasing (decreasing) the mark-up. Profits in Argentina increase; in the US they vanish. Still, having decided in real terms how much to invest, price increases force Argentinean firms to borrow more, and American firms to borrow less, which means that Argentinean banks demand fewer bills, and American banks demand more. Real consumption also stays the same, but nominal consumption increases (even though the real wage falls). Looking at Equations (39) and (41), one would assume that *both* expected and actual nominal wealth fall in tandem (remember, expectations about disposable income are backward-looking in this model, and so they do not change initially). But that does not happen. Expected nominal wealth does fall, and with it the Argentinean demand for bills and deposits. But depreciation also causes a capital gain on their holdings of foreign bills (and the opposite goes for US households), which increases their *actual* disposable income. In the first period, therefore, they increase their cash holdings, the central bank buying the bills that foreigners, locals, and banks do not want. This is how the interest rate is kept at its target. In the USA, on the other hand, the central bank sells the bills the agents demand. The money supply is determined by the preference of the agents, not by the central bank.⁶ However, one should point out that, in the real world, capital gains due to exchange rate movements are typically enjoyed by a very small fraction of the population in developing countries, although they do have some impact on the real estate sector.

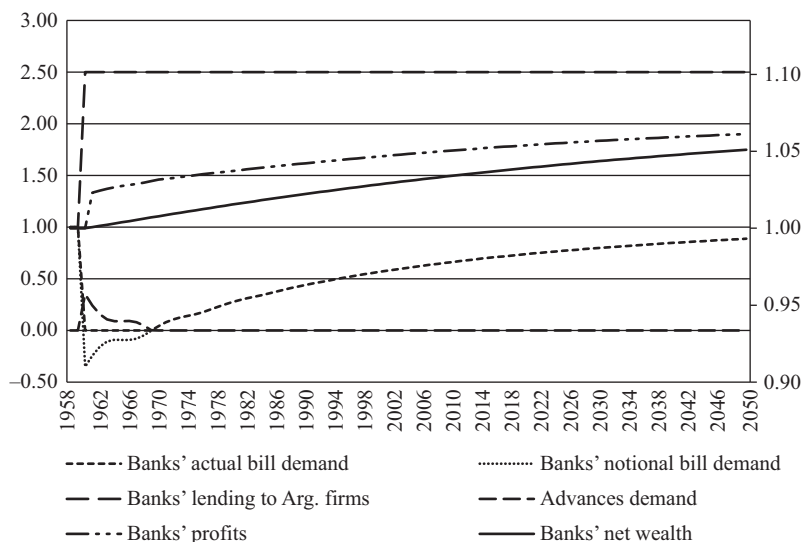
The capital account surplus is reduced as well as the current account deficit. PSBR in Argentina rely more on domestic financing than on foreign sources. The Argentinean real

6 Lavoie (2001). For a study of the gold standard period prior to the First World War, see Bloomfield (1959).

wage takes a big hit initially, which impacts on real consumption, but as the exchange rate stabilizes, it returns to normality, albeit at a higher price level. What happens with the expectations about the exchange rate? Keeping in mind that a positive $dxra^e$ implies that the Argentinean exchange rate is expected to depreciate, that variable *diminishes*. Initially, Chartist traders increase substantially their expectations of a depreciation, but the opposite happens with the fundamentalists: now the exchange rate is at a higher level, close to (or above) the value they judge to be appropriate. A similar story happens when there is a capital flight from Argentina households.

But it is also interesting to see what happens when *firms* change their funding decisions. Suppose Argentinean firms start to borrow more in the US. In the simulation with the flexible exchange rate regime, we increased that proportion from 20 percent to 30 percent of their total borrowing requirements, while in the fixed exchange rate closure we raised it to 50 percent. Let us start with the latter. The current account of Argentina deteriorates, but demand does not fall and prices do not change. Remember, the exchange rate does not move. But what happens to the banking sector and private debt is quite revealing. Figure 4 shows selected variables of the balance sheet of American banks. The lines corresponding to banks' profits and banks' net wealth should be read on the secondary axis (RHS), and the others on the LHS axis.

The increase in borrowing from Argentinean firms forces US banks to sell all their holdings of bills. They would sell even more bills than what they initially held (the pointed line representing *notional* demand of bills becomes negative)! But since they cannot do that, they are forced to ask for advances from the central bank to fund their lending (the line that, starting from zero, goes up initially, and then returns to zero around 1970; notional and actual demand of bills are the same after ten periods). The central bank is willing to provide advances, but because there is no increase on the liability side of its balance sheet, it is forced to sell the bills it holds. Who buys them? The



Notes: Behavior of selected variables in the balance sheet of American banks.

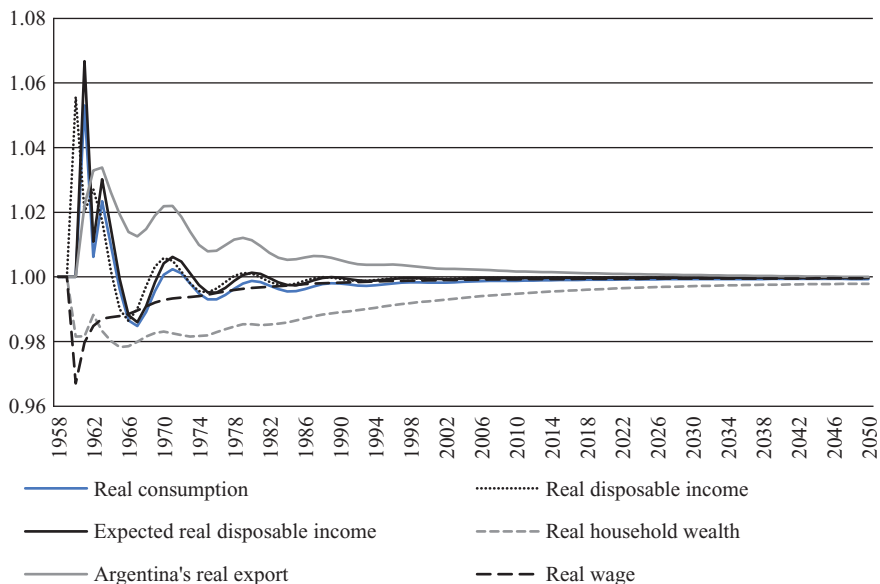
Figure 4 Higher private foreign borrowing

Argentinean central bank, of course. It must do so. Foreign reserves increase substantially (as foreign borrowing increases, dollars start to flood the country), and their rhythm is only reduced when banks start to invest their increased profits in bills, reducing the supply to the rest of the world. That is why US banks' profits and net wealth increase: lending goes up. The opposite happens in Argentina. Bank lending goes down, pulling down profits and net wealth. Banks invest what they do not lend in bills, which are sold by the central bank to sterilize its purchases of foreign reserves. I could say there is some analogy between this situation and the run-up to the Asian crisis, as told by Kregel (1998): an explosion of foreign borrowing in a context of stable ER and increased reserves, triggered by financial liberalization in those countries and increased reserves. When something went wrong, those reserves were not enough, because private debt had also escalated.

In the flexible exchange rate, the situation is as you should expect by now. The exchange rate appreciates, there is an inflow of capital, and the current account deteriorates, but not as much as in the fixed exchange rate closure. American banks are also forced to borrow from their central bank in order to keep with their lending.

We now examine another possibility, the case where Argentina is still on a fixed exchange rate and decides to proceed to a one-time devaluation of its currency. When this happens, households face two different effects: on one side, their real wage is diminished; on the other side, they enjoy a once-in-a-lifetime capital gain on their holdings of foreign bills. However, it should be kept in mind that, in the real world, the people who suffer mostly from the fall in real wages are more numerous than those who enjoy a capital gain. Which effect prevails? Figure 5 provides an answer.

The figure shows that real disposable income spikes first, later pushing up consumption. Remember that expected disposable income is backward-looking. But real wealth fell due to the impact of a higher price level on the other assets. In the medium run, disposable income



Notes: Impact in Argentina after a 10% devaluation in a fixed ER regime.

Figure 5 Devaluation in 'Argentina'

realigns itself with the real wage, albeit in a somewhat cyclical fashion due to the correction mechanism in expectations, as described in Equation (37). Real exports increase, foreign reserves increase, the demand for bills by American households and the Fed decline.

But what if a devaluation is expected but does not occur? Assume that $xra^{\#}$ increases by 10 percent: fundamentalist traders now believe that the Argentinean exchange rate is worth 10 percent less. The demand for bills denominated in pesos falls, and the demand for bills denominated in dollars, issued *both* by the American and the Argentinean government, increases. This is not corrected over time, since neither the exchange rate nor the value judged by the trader change. The impact of the higher demand for American bills is indeed responsible for the fall in foreign reserves. And what happens in the flexible exchange rate regime? It does translate into a small depreciation of the peso, which slightly *reduces* the PSBR of the American government. Argentineans demand more American bills, but their demand represents less in dollar terms (in a marginal magnitude, admittedly), and so interest payments in dollars fall. Argentinean real exports increase a bit, and so firms profit.

3.3 Distribution issues

In our model, does a higher wage demand (say, a higher ω_1) bring about higher growth? No. Does a higher mark-up (say, a higher π_0) cause higher growth? No. Both together? No. This model is very sensitive to the effect of price competitiveness factors on the balance of trade, and the results reflect that. One remarkable feature, however, is that even though the level of GDP is lower than the baseline in both cases, the rate of growth of capital stock is actually the same, in agreement with Allain (2013) and Serrano (1995).

In the case of an increase in ω_1 in the fixed exchange rate regime, there is actually a very slight increase of real consumption in the year 1962, but the fall in real exports is substantial, dragging down first real GDP and afterwards real investment. The effect of the latter is much more pronounced than in the flexible exchange rate. Two well-established facts are that investment tracks GDP, and that it follows it with wild fluctuations. That is the essence of the accelerator principle. Why does real consumption fall so hard, even if the real wage increases as it does? Because of the depressing effect of a falling real GDP on employment, one has to add the effects of real wages on productivity: a higher real wage stimulates productivity, as stated in Equation (20). The real wage bill (real wage times the employment level, which is a good proxy for the real wage rate) actually falls, even though the wage *share* rises because productivity increases only as a proportion q_a of the improvement in the real wage. But as was said before, in the long run the accumulation rate returns to the rate of growth of government expenditure, a typical feature of SFC models, so that what we observe is actually a fall in the *level* of GDP. We also performed experiments moving the flat segment of the Phillips curve for the 'USA.' We did not find major noticeable changes in the variables.

4 CONCLUSIONS

This paper presents an extension to chapter 12 of Godley/Lavoie (2007) while also incorporating elements present in Lavoie/Daigle (2011), regarding expectations of exchange rate changes. The methodology adopted is a Stock-Flow Consistent approach that ensures that there are no 'black holes' in the accounting of the model: everything comes from somewhere and goes somewhere else. In that line of literature, we added a simple investment function, drawing on the accelerator principle; the possibility of having foreign debt (both public and

private) in a foreign currency; the possibility of having banks borrowing advances from their central bank; a Phillips curve with a flat segment; a productivity growth function; and error correction mechanisms regarding income expectations and portfolio allocation.

Despite the simplistic nature of some of our assumptions, we have been able to extract some conclusions in light of the results of the simulations we performed. In particular:

- The behavior of the exchange rate depends on the financial positions of the different sectors (including the government), the portfolio allocation, and the exchange rate expectations of traders, and it is not strictly related to the behavior of the current account of the balance of payments. The exchange rate (in a flexible exchange rate regime) or the reserves equilibrate the demand and supply of funding that a country and its agents require and/or demand, according to the currency in which this funding is offered/required. In different simulations, a current account surplus for one country coexisted either with a depreciating exchange rate or an appreciating one. If any causality can be observed, one could say that the movement of the exchange rate influences the trade balance much more than the other way around. However, this does not mean that the exchange rate plays an equilibrating role on the balance of trade or the current account.
- Our results reject the ‘twin deficit’ view long held by the IMF, which blames fiscal deficits for balance of payments problems, by which it usually means a structurally negative current account. This view is also behind the economic policies imposed by the ‘Troika’ on the government of the European periphery. Twin deficits do not always happen, and even if they do, it does not imply there is necessarily a fiscal mess; it might well be the other way around (Ocampo et al. 2009, ch. 6).
- An important result is that, with sufficient foreign reserves, the ‘rules of the game’ of a fixed exchange rate or a gold standard regime *do not apply*. There need not be a direct relation between the balance of payments (which basically shows the extent of foreign lending/borrowing) and domestic credit.
- Our results show that different exchange rate regimes might have both positive and negative consequences under different circumstances. We therefore find ourselves in agreement with Palley (2003) in the sense that an active management of both exchange policy and capital mobility can avoid the dangers associated with the passivity of the government in the face of the disruptive consequence each extreme case might have. The set of rules *can* (and *should*) be designed to achieve different targets in terms of employment, output, inflation, and balance of payments performance: it is not an easy task, but it can be done, even in an open economy context.

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APPENDIX

Table A1 Initial values of variables and parameters

| | | | | | | | |
|--------------|------------|-------------------|-------------|--------------|-------------|------------------|-------------|
| $s_u =$ | 2288.51608 | $z_{3u} =$ | 0 | $L_{ud}^u =$ | 5000.00 | $\lambda_{23} =$ | -0.01 |
| $s_a =$ | 2288.51608 | $z_{1a} =$ | 1 | $L_{ad}^u =$ | 5000.00 | $\lambda_{24} =$ | -0.02 |
| $S_u =$ | 4577.03216 | $z_{2a} =$ | 0 | $L_{ad}^u =$ | 1000.00 | $\lambda_{32} =$ | -0.01 |
| $S_a =$ | 4577.03216 | $z_{3a} =$ | 0 | $F_{fu}^u =$ | 145.631068 | $\lambda_{33} =$ | 0.1 |
| $y_u =$ | 1830.81286 | $EMP_u =$ | 0.03 | $F_{fa}^u =$ | 145.631068 | $\lambda_{34} =$ | -0.05 |
| $y_a =$ | 1830.81286 | $EMP_a =$ | 0.03 | $Y_{ru} =$ | 3125 | $\lambda_{40} =$ | 0.125 |
| $Y_u =$ | 3661.62573 | $w_u =$ | 0.5 | $Y_{ra} =$ | 3125 | $\lambda_{41} =$ | -0.02 |
| $Y_a =$ | 3661.62573 | $w_a =$ | 0.5 | $T_u =$ | 625 | $\lambda_{42} =$ | -0.02 |
| $p_{yu} =$ | 2 | $N_u =$ | 2855.800483 | $T_a =$ | 625 | $\lambda_{43} =$ | -0.05 |
| $p_{ya} =$ | 2 | $N_a =$ | 2855.800483 | $\theta_u =$ | 0.2 | $\lambda_{44} =$ | 0.1 |
| $p_{mu} =$ | 2 | $pr_u =$ | 0.641085704 | $\theta_a =$ | 0.2 | $M_{ad}^n =$ | 1998.381877 |
| $p_{ma} =$ | 2 | $pr_a =$ | 0.641085704 | $YD_u =$ | 2500 | $B_{had}^a =$ | 4995.954693 |
| $IM_u =$ | 915.406432 | $g_{pru} =$ | 0.03 | $YD_a =$ | 2500 | $B_{ad}^u =$ | 2248.179612 |
| $IM_a =$ | 915.406432 | $g_{pra} =$ | 0.03 | $yd_u =$ | 1250 | $H_{ad}^n =$ | 757.48 |
| $X_u =$ | 915.406432 | $q_u =$ | 0.3 | $yd_a =$ | 1250 | $\lambda_{50} =$ | 0.2 |
| $X_a =$ | 915.406432 | $q_a =$ | 0.3 | $yd_u^e =$ | 1245.954693 | $\lambda_{51} =$ | 0.1 |
| $C_u =$ | 2208.73786 | $im_u =$ | 457.7032158 | $yd_a^e =$ | 1245.954693 | $\lambda_{52} =$ | -0.05 |
| $C_a =$ | 2208.73786 | $im_a =$ | 457.7032158 | $\beta_u =$ | 0.2 | $\lambda_{53} =$ | -0.03 |
| $I_u =$ | 776.699029 | $\varepsilon_o =$ | 0.25 | $\beta_a =$ | 0.2 | $\lambda_{60} =$ | 0.5 |
| $I_a =$ | 776.699029 | $\varepsilon_1 =$ | 0.7 | $YD_u^e =$ | 2491.909385 | $\lambda_{61} =$ | -0.05 |
| $G_u =$ | 676.188833 | $\varepsilon_2 =$ | 1 | $YD_a^e =$ | 2491.909385 | $\lambda_{62} =$ | 0.1 |
| $G_a =$ | 676.188833 | $\mu_o =$ | 0.25 | $V_{bu} =$ | 10000.00 | $\lambda_{63} =$ | -0.03 |
| $p_{su} =$ | 2 | $\mu_1 =$ | 0.7 | $V_{ba} =$ | 10000.00 | $\lambda_{70} =$ | 0.225 |
| $p_{sa} =$ | 2 | $\mu_2 =$ | 1 | $v_{bu} =$ | 5000 | $\lambda_{71} =$ | -0.03 |
| $\pi_u =$ | 0.159927 | $x_u =$ | 457.7032158 | $v_{ba} =$ | 5000 | $\lambda_{72} =$ | -0.03 |
| $\pi_a =$ | 0.159927 | $x_a =$ | 457.7032158 | $V_{fu}^u =$ | 9991.909385 | $\lambda_{73} =$ | 0.07 |
| $\pi_{0u} =$ | 0.159927 | $K_u =$ | 10000.00 | $V_{fa}^u =$ | 9991.909385 | $H_{ad}^u =$ | 757.48 |
| $\pi_{0a} =$ | 0.159927 | $K_a =$ | 10000.00 | $c_u =$ | 1104.368932 | $H_{ad}^a =$ | 757.48 |

(continues overleaf)

Table A1 Initial values of variables and parameters (Continued)

| | | | | | | | |
|------------------|---------|-----------------|-------------|------------------|-------------|-------------------|-------------|
| $\pi_{1u} =$ | 0.2 | $k_u =$ | 5000 | $c_a =$ | 1104.368932 | $z_{4u} =$ | 1 |
| $\pi_{1u} =$ | 0.2 | $k_a =$ | 5000 | $\alpha_{1u} =$ | 0.75 | $z_{4a} =$ | 1 |
| $W_u =$ | 1 | $i_u =$ | 388.3495146 | $\alpha_{2u} =$ | 0.035 | $M_{ud} =$ | 1998.381877 |
| $W_a =$ | 1 | $i_a =$ | 388.3495146 | $\alpha_{1a} =$ | 0.75 | $M_{ad} =$ | 1998.381877 |
| $\omega_{0u} =$ | 0.2 | $DA_u =$ | 485.4368932 | $\alpha_{2a} =$ | 0.035 | $z_{5u} =$ | 0 |
| $\omega_{0u} =$ | 0.2 | $DA_a =$ | 485.4368932 | $M_{ud}^n =$ | 1998.381877 | $z_{5a} =$ | 0 |
| $w_u^T =$ | 0.5 | $\delta_u =$ | 0.05 | $B_{hud}^u =$ | 4995.954693 | $dxtu^f =$ | 0 |
| $w_a^T =$ | 0.5 | $\delta_a =$ | 0.05 | $B_{hud}^{Sa} =$ | 999.1909385 | $dxta^f =$ | 0 |
| $\omega_{1u} =$ | 0.5 | $gk_u =$ | 0.03 | $B_{hud}^{Su} =$ | 1248.988673 | $\chi^f =$ | 0.75 |
| $\omega_{1u} =$ | 0.5 | $gk_a =$ | 0.03 | $H_{ud}^n =$ | 757.48 | $\lambda^c =$ | 0.25 |
| $\omega_{2u} =$ | 0.2 | $\gamma_{0u} =$ | 0.02 | $\lambda_{10} =$ | 0.2 | $dxta^{cf} =$ | 0 |
| $\omega_{2u} =$ | 0.2 | $\gamma_{0a} =$ | 0.02 | $\lambda_{11} =$ | 0.1 | $\zeta =$ | 0.2 |
| $bandb_u =$ | 0.003 | $\gamma_{1u} =$ | 0.3 | $\lambda_{12} =$ | -0.05 | $dxta^{cc} =$ | 0 |
| $bandt_u =$ | 0.003 | $\gamma_{1a} =$ | 0.3 | $\lambda_{13} =$ | -0.01 | $\zeta =$ | 0.2 |
| $bandb_a =$ | 0.003 | $z_u =$ | 0.3619304 | $\lambda_{14} =$ | -0.02 | $\rho =$ | 0.34110224 |
| $bandt_a =$ | 0.003 | $z_a =$ | 0.3619304 | $\lambda_{20} =$ | 0.5 | $\phi =$ | -0.00002 |
| $z_{1u} =$ | 1 | $V_{fu} =$ | 5000.00 | $\lambda_{21} =$ | -0.05 | $M_{us} =$ | 1998.381877 |
| $z_{2u} =$ | 0 | $V_{fa} =$ | 5000.00 | $\lambda_{22} =$ | 0.1 | $M_{as} =$ | 1998.381877 |
| $L_{uu}^u =$ | 5000.00 | $L_{ad}^u =$ | 4000 | $\lambda_{30} =$ | 0.1 | $L_{as}^u =$ | 4000 |
| $L_{uu}^a =$ | 1000.00 | $v =$ | 0.8 | $\lambda_{31} =$ | -0.01 | $B_{bud}^{uu} =$ | 1000 |
| $B_{bad}^{ua} =$ | 1000.00 | $r_{1a} =$ | 0.036 | $B_s^a =$ | 9001.62 | $B_{bad}^u =$ | 757.48 |
| $B_{bud}^{ua} =$ | 1000 | $t_u =$ | 0.2 | $B_s^{Sa} =$ | 7752.63 | $B_{bad}^{uas} =$ | 757.48 |
| $B_{bad}^{ua} =$ | 1000.00 | $t_a =$ | 0.2 | $B_{bus}^{uu} =$ | 4995.954693 | $B_{bad}^{uas} =$ | 757.48 |
| $z_{6u} =$ | 1 | $r_{mu} =$ | 0.03 | $B_{bus}^{ua} =$ | 4995.954693 | $B_{bad}^{uas} =$ | 904.57 |
| $z_{6a} =$ | 1 | $r_{ma} =$ | 0.03 | $B_{bus}^{ua} =$ | 2248.179612 | $B_{bad}^{uas} =$ | 904.57 |
| $A_{ud} =$ | 0 | $ra_u =$ | 0.033 | $B_{bus}^{Sa} =$ | 999.1909385 | $xra =$ | 1 |
| $A_{ad} =$ | 0 | $ra_a =$ | 0.033 | $B_{bus}^{Su} =$ | 1248.988673 | $xru =$ | 1 |

| | | | | | | | |
|------------|------------|--------------|-------------|----------------|--------|-------------|-------------|
| $z_{7u} =$ | 0 | $v_u =$ | 0.1 | $B_{bus}^u =$ | 1000 | $xra =$ | 1 |
| $z_{7a} =$ | 0 | $v_a =$ | 0.1 | $B_{bas}^a =$ | 1000 | $F_{cbu} =$ | 22.06261893 |
| $F_{bu} =$ | 172.153357 | $g_u =$ | 338.0944165 | $H_{us} =$ | 757.48 | $F_{cba} =$ | 49.19967755 |
| $F_{ba} =$ | 119.203032 | $g_a =$ | 338.0944165 | $H_{as} =$ | 757.48 | $CA_u =$ | 0 |
| $V_{bu} =$ | 4759.10 | $\sigma_u =$ | 0.03 | $A_{us} =$ | 0 | $CA_a =$ | 0 |
| $V_{ba} =$ | 2244.13 | $\sigma_a =$ | 0.03 | $A_{ad} =$ | 0 | $KA_u =$ | 0 |
| $rl_u =$ | 0.036 | $B_s^a =$ | 9906.19 | $B_{cbud}^u =$ | 757.48 | $KA_a =$ | 0 |