TRADE OPENNESS AND EXCHANGE RATE MISALIGNMENTS

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Abstract

The paper examines the claim that the benefits of real exchange rate flexibility under real foreign shocks and nominal rigidities are smaller for more closed economies. Openness is defined as a country's steady state exports to GDP ratio, and the benefits of exchange rate flexibility as the welfare difference between fixed and flexible rate outcomes. The paper shows why the benefits of exchange rate flexibility are not systematically related to openness. The main reason is that rigid relative prices cause a contractionary shock to hit demand for all goods equally on impact.

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1 Introduction

The debate on the relative merits of fixed versus flexible exchange rates, a staple of 1960s/70s international economics, has again become very lively. Particularly following the Asian currency crises of 1997, where the usual suspect of fiscal deficits was not as evident as it tends to be in Latin America, observers felt that the main problems were 'soft peg' exchange rate regimes. Since then a sense has developed that the choice should be between the extremes of dollarization and some form of floating exchange rate.

The factors that make a floating exchange rate preferable are well-known. Most importantly, if an open economy is faced with exogenous real shocks such as terms of trade shocks or real interest rate shocks, and if there are price and/or wage rigidities, then flexible exchange rates are superior to fixed rates. This has now also been shown in modern dynamic general equilibrium models with nominal rigidities such as Cespedes, Chang and Velasco (2000), Gali and Monacelli (2002), Parrado and Velasco (2002), and Schmidt-Grohe and Uribe (2001). On the other hand, several authors have cautioned that such arguments ignore important other aspects of the economic realities facing emerging markets. For example, Calvo and Reinhart (2001, 2002) state that policy credibility and financial vulnerability are very important and may advise against floating exchange rates.

There is however another argument that is sometimes used to downplay the benefits of exchange rate flexibility. This is that external shocks are of little importance for economies that are relatively **closed to international trade**, and that therefore the exchange rate regime is relatively unimportant if its role is to ease the adjustment to such shocks. This conjecture was used by policymakers in Argentina under its 1990s currency board, and this was found to be persuasive. Argentina is very closed to trade, and it was therefore argued that it was not likely to suffer much from devaluations by its trading partners, specifically from the Brazilian devaluation of 1999. This was proved wrong by events, which highlights the need for a better theoretical understanding. The existing literature gives us very little guidance on this question. Part of the difficulty may be giving content in terms of a model to the notion of openness to international trade. In this paper we specify a model that allows us to naturally vary openness as a parameter affecting preferences and technologies. We find that the conjecture does not hold: Exchange rate flexibility has similar advantages for open and closed economies, and to the extent that benefit varies with openness the relationship tends to be non-monotonic.

The exchange rate helps in smoothing the adjustment to shocks when relative prices are rigid. Much of the existing discussion on this issue is couched in terms of expenditure switching effects of nominal exchange rate changes, through changes in the *relative price of home and foreign tradable goods*. It is true that the quantitative importance of such effects is small in a more closed economy. But we would like to redirect the emphasis away from this relative price. This is because for emerging markets expenditure switching is not likely to be as important, because these countries have competitive export and import sectors that must take world prices as given.[1] Instead we stress that nominal exchange rate changes also change the *relative price of tradable and nontradable goods*, and thereby the demand for nontradables output. Foreign real shocks require large adjustments in this relative price to maintain full employment in domestic production. We will show that this effect generally implies that the benefits of exchange rate flexibility are *larger* for a relatively closed economy.

[1] We stress that in our calibrated model imports are to a large extent intermediate inputs. Final goods, embodying a large local factor content, do feature nominal rigidities. All we rule out is rigidity in the price of cif imports themselves, and of exports of domestic products.

A simple example illustrates why at the most elementary level it is not clear why there should be any link between the degree of openness and the benefits of exchange rate flexibility (see Figure 1). Assume an exchange economy with a fixed endowment of traded goods and demand determined non-traded goods output as in Calvo and Vegh (1993). Non-traded goods prices are sticky, and consumption preferences are homothetic between the two goods. Now assume a terms of trade shock that reduces the value of the tradables endowment and therefore requires an immediate reduction in tradables consumption by a given percentage, say x%. We focus only on the first period and ignore the dynamics of price adjustment, but a more complete analysis would not alter the basic logic of the argument. With homothetic preferences and rigid relative prices, it is clear that nontradables and therefore overall consumption also have to fall by x%, with utility accordingly reduced from u_0 to u_1. If openness is defined as the expenditure share of traded goods in overall consumption, it is clear that the degree of openness makes no difference whatsoever to this argument. Even in a very closed economy with say a 1% expenditure share of traded consumption, if the latter has to contract by 10% and if relative prices are fixed, then non-traded and therefore total consumption also have to contract by 10%.

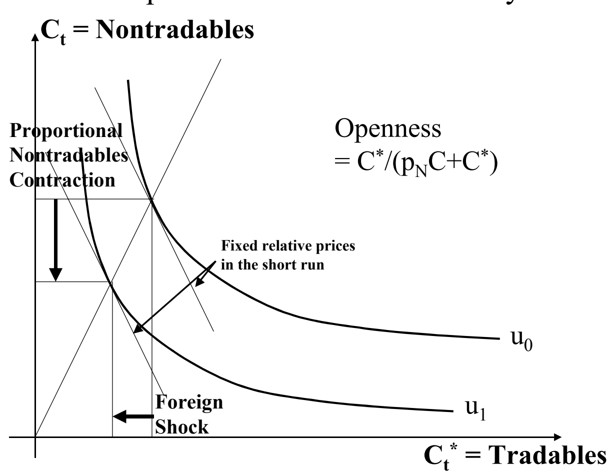

Figure 1

However, we believe that in order to make this argument more convincing it is essential to examine the issue in terms of a more realistic model. We therefore specify a very comprehensive structural model with household preferences over four different types of consumption and labor and with capital accumulation in four different sectors of production. The latter also feature complete intermediate input linkages between all four sectors and the rest of the world. To discipline ourselves the model's parameters are then calibrated using detailed Chilean national accounts data. This exercise can be performed for any economy with adequate data, and we therefore do not see our openness exercise as being a model of Chile.

The model is an important contribution in its own right, quite apart from its application to the openness issue in this paper. The detailed structure of the supply side and the multiple sources of nominal rigidities allow us to analyze a rich set of interactions that elude more aggregative models.

We proceed to adopt a very natural concept of trade openness that is based entirely on preferences and technologies. Specifically, increasing openness means increasing *foreign goods expenditure shares* in both domestic production and consumption. To give content to the notion of the benefit of exchange rate flexibility we evaluate the response of our model economy to real interest rate and terms of trade shocks under either a fixed or a flexible exchange rate regime and at different degrees of trade openness. The benefit of exchange rate flexibility is the *incremental welfare gain of flexible over fixed exchange rates*.[2] Our result is that the basic intuition of our simple example above carries over to the more complex model. Two additional results deserve emphasis. First, to the extent that the

[2] It should be stressed that we therefore do not argue with two accepted results of international economics. One is the Mundellian result that flexible exchange rates are always superior to fixed rates under real foreign shocks. We only ask "how superior" as we vary the degree of openness ? The other is that a proportional negative real foreign shock, such as a decline in the terms of trade, has a more detrimental effect on a more open economy. Here we note that there is nothing that the exchange rate regime can do about that, and we only ask "how much more detrimental" this effect is under fixed exchange rates as we vary the degree of openness.

benefit of flexibility varies, it tends to vary non-monotonically. Second, under conventional preference specifications the welfare benefit is very small for any degree of openness, despite significantly greater fluctuations in output and employment under exchange rate targeting.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 discusses calibration. Section 4 shows impulse responses and welfare results. Section 5 concludes.

2 The Model

Consider a small open economy that consists of households, firms and a government.

Households are identical and infinitely lived. They consume nontraded goods c^n, import goods c^m, export goods c^x and foreign goods c^f. Foreign goods are direct imports while import goods combine foreign intermediate inputs with a significant local factor content. We can think of the import sector as a domestic distribution sector. Households sell their heterogeneous labor services $l(j)$ at wages $W(j)$ through a competitive employment agency that sells final homogenous labor output $L = l^n + l^m + l^x + l^k$ to producers of nontraded goods, import goods, export goods and investment goods at the nominal wage W. Households therefore behave as monopolistic competitors in the labor market, and the nominal wage is allowed to be rigid. Households also supply capital $k^n/k^m/k^x/k^k$ directly to the same firms. The households' interactions with the rest of the economy are represented in Figure 2a (omitting only the employment agency).

All firms are competitive in all factor markets. They use capital and labor inputs, but they also use part of the output of firms in other sectors as intermediate inputs - comprehensive intermediate goods input linkages are a distinctive feature of this model. Producers of export goods and capital goods are assumed to be competitive in the goods market, and their final products are homogenous. Producers of nontraded goods and import goods are assumed to be monopolistically competitive in the goods market. In these two sectors competitive wholesalers combine individual goods varieties produced by monopolistic competitors into homogenous final products. The outputs of the nontraded goods, import goods and export goods sectors are sold either for final consumption or for use as intermediate inputs. The output of the investment goods sector is sold to households, who separately accumulate capital in the four domestic production sectors. The linkages between the different sectors that make up the supply side are represented in Figure 2b, which for ease of presentation omits all linkages with the household sector.

The government's fiscal policy is Ricardian, and it gives production subsidies to eliminate the mark-up distortions from monopolistic price- and wage-setting. We will compare the performance of our model economies under two kinds of monetary policy, exchange rate targeting and inflation targeting.

2.1 Households

Household preferences have the form

$$\mathcal{E}_t \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t \left\{ \frac{u_t^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}} + \frac{\Upsilon}{1-\chi} x_t^{1-\chi} \right\} \quad , \tag{1}$$

$$u_t = \left(C_t^{1-\kappa} (T - H_t)^{\kappa} \right) , \tag{2}$$

where $\mathcal{E}_t$ represents expectation conditional on information available at time t, which includes the realization of shocks for that period. Households' subjective discount rate is set equal to the steady state value of the real international interest rate r to rule out inessential dynamics. The parameter γ denotes the intertemporal elasticity of substitution. The consumption aggregator C_t is given by

$$C_t = A_c \left(c_t^n\right)^{\sigma_n} \left(c_t^m\right)^{\sigma_m} \left(c_t^x\right)^{\sigma_x} \left(c_t^f\right)^{\sigma_f} \quad , \; A_c = \sigma_n^{-\sigma_n} \sigma_m^{-\sigma_m} \sigma_x^{-\sigma_x} \sigma_f^{-\sigma_f} \; , \tag{3}$$

with $\sum_{i=n,m,x,f} \sigma_i = 1$.

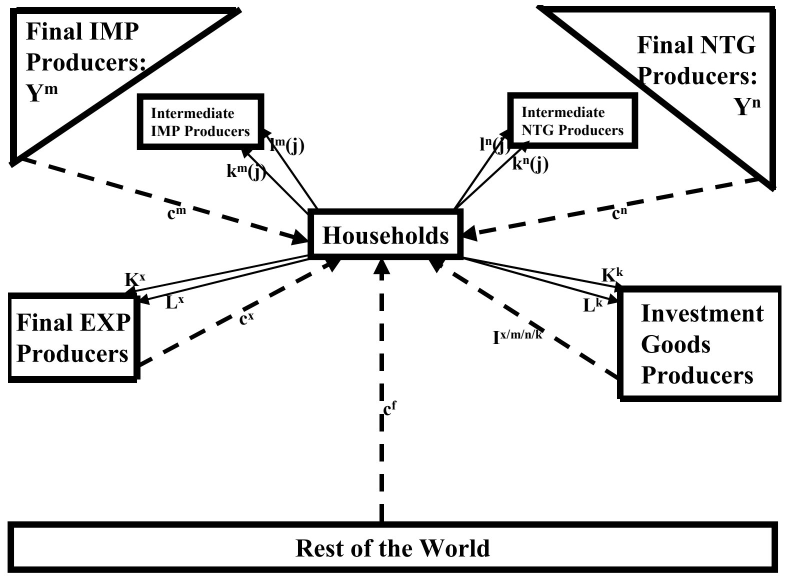

Figure 2a

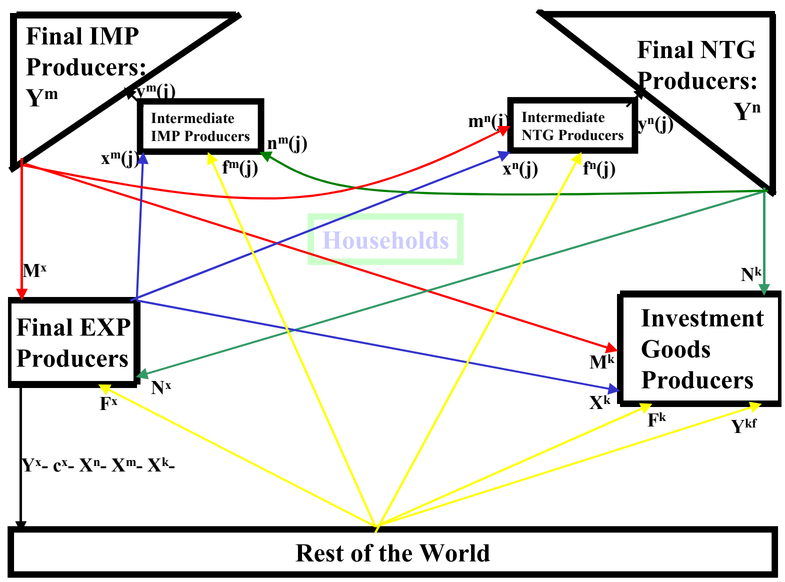

Figure 2b

Note that the consumption based price index for this economy is

$$P_t^c = (P_t^n)^{\sigma_n} (P_t^m)^{\sigma_m} (P_t^x)^{\sigma_x} (E_t(1+\tau))^{\sigma_f} \quad . \tag{4}$$

The total endowment of time is denoted by T, and H_t represents aggregate labor supply in hours, i.e. the integral over inputs of all individual labor varieties $l_t(j)$:

$$H_t = \int_0^1 l_t(j)dj \; . \tag{5}$$

Households also accumulate physical capital, which is assumed to be non-transferrable across sectors. They therefore separately accumulate four capital stocks k_t^n, k_t^m, k_t^x and k_t^k by investing I_t^n, I_t^m, I_t^x and I_t^x, subject to a common depreciation rate of Δ:

$$k_t^i = (1-\Delta)k_{t-1}^i + I_{t-1}^i \quad , \quad i = n, m, x, k. \tag{6}$$

The real returns on capital in terms of the respective outputs are r_t^n, r_t^m, r_t^x and r_t^k, and quadratic capital stock adjustment costs are $(u^i/2)((I_t^i/k_t^i) - \Delta)^2$, $i = n, m, x, k$.

Households can borrow and lend freely in international capital markets. Their holdings of non-contingent one-period bonds bought in period t and maturing in $t+1$, and paying off r_t units of international goods in $t+1$, are denoted by b_t. The real interest rate r_t is taken as exogenous by the individual household. Financial markets are incomplete, securities whose payoff is contingent on the realization of exogenous shocks, particularly terms of trade and real international interest rate shocks, are not available. Households also hold nominal money balances X_t, with real money balances equal to $x_t = X_t/P_t^c$. Households receive lump-sum transfers in terms of international goods g_t from the government, they pay an import tariff at the rate τ on direct imports c^f, and they receive lump-sum profit distributions $\tilde{\Pi}_t^m, \tilde{\Pi}_t^n$ from the producers of import goods and nontraded goods varieties. We write the household budget constraint in terms of the foreign goods numeraire, with relative prices of nontradables, imports, exports, investment goods and labor of $p_t^n = P_t^n/E_t$, $p_t^m = P_t^m/E_t$, $p_t^x = P_t^x/E_t$, $p_t^k = P_t^k/E_t$, $w_t = W_t/E_t$, $w_t(j) = W_t(j)/E_t$. The terms of trade p_t^x will be assumed to follow an exogenous stochastic process. The rate of depreciation of the exchange rate is $\varepsilon_t = (E_t - E_{t-1})/E_{t-1}$, and for sectorial inflation rates we have $\pi_t^n = (P_t^n - P_{t-1}^n)/P_{t-1}^n$, $\pi_t^m = (P_t^m - P_{t-1}^m)/P_{t-1}^m$, $\pi_t^w = (W_t - W_{t-1})/W_{t-1}$. The period budget constraint is then

$$\begin{aligned} b_t &= (1+r_{t-1})b_{t-1} - p_t^c x_t + \frac{p_{t-1}^c x_{t-1}}{1+\varepsilon_t} + g_t + \tilde{\Pi}_t^m + \tilde{\Pi}_t^n \qquad (7) \\ &\quad + \int_0^1 w_t(j) l_t(j) dj + p_t^n r_t^n k_t^n + p_t^m r_t^m k_t^m + p_t^x r_t^x k_t^x + p_t^{kd} r_t^k k_t^k \end{aligned}$$

$$-p_t^n c_t^n - p_t^m c_t^m - p_t^x c_t^x - c_t^f (1+\tau) - p_t^k \left(I_t^n + I_t^m + I_t^x + I_t^k \right)$$
$$-p_t^k \left[\frac{u^n}{2} \left(\frac{I_t^n}{k_t^n} - \Delta \right)^2 + \frac{u^m}{2} \left(\frac{I_t^m}{k_t^m} - \Delta \right)^2 + \frac{u^x}{2} \left(\frac{I_t^x}{k_t^x} - \Delta \right)^2 + \frac{u^k}{2} \left(\frac{I_t^k}{k_t^k} - \Delta \right)^2 \right].$$

The household maximizes (1) subject to (2), (3), (5), (6), (7) and the transversality condition

$$\lim_{l \to \infty} \mathcal{E}_t \frac{b_{t+l}}{\Pi_{s=0}^{l-1}(1+r_s)} \geq 0 \quad . \qquad (8)$$

The first-order conditions for b_t, c_t^i, $i = n, m, x, f$, I_t^i, k_{t+1}^i, $i = n, m, x, k$ are: [3]

$$\lambda_t = \frac{(1+r_t)}{(1+r)} \mathcal{E}_t \lambda_{t+1} \quad , \qquad (9)$$

$$u_t^{1-\frac{1}{\gamma}} (1-\kappa)\sigma_i = \lambda_t p_t^i c_t^i \quad , \quad i = n, m, x, f \quad , \qquad (10)$$

$$q_t^i - 1 = \frac{u^i}{K_t^i} \left(\frac{I_t^i}{K_t^i} - \Delta \right) \quad , \quad i = n, m, x, k \quad , \qquad (11)$$

$$\begin{aligned} \lambda_t p_t^k q_t^i &= \frac{1}{1+r} \mathcal{E}_t \lambda_{t+1} p_{t+1}^k \left(\frac{p_{t+1}^i r_{t+1}^i}{p_{t+1}^k} + q_{t+1}^i (1-\Delta) + \frac{u^i I_{t+1}^i}{(k_{t+1}^i)^2} \left(\frac{I_{t+1}^i}{k_{t+1}^i} - \Delta \right) \right) \qquad (12) \\ i &= n, m, x, k. \end{aligned}$$

In addition (8) holds with equality. Here λ_t is the multiplier of the budget constraint (7).

Households sell their heterogeneous labor services to a competitive employment agency that combines them using a CES technology to produce aggregate labor input L_t. It solves

[3] The first-order condition for x_t is redundant when monetary policy does not target a monetary aggregate. The central bank simply has to adjust the money supply to achieve its monetary policy target.

the following problem:

$$\underset{l_t(j),\; j\in[0,1]}{Min} \int_0^1 W_t(j)l_t(j)dj \;\; s.t.\; L_t = \left(\int_0^1 l_t(j)^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}} . \tag{13}$$

The solution is the following set of labor demands

$$l_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\phi} L_t \;, \tag{14}$$

where the aggregate nominal wage W_t is

$$W_t = \left(\int_0^1 W_t(j)^{1-\phi}dj\right)^{\frac{1}{1-\phi}} . \tag{15}$$

Households set their wages in a staggered fashion as in Calvo (1983). Specifically, the random opportunities to change their wage for variety j follow a geometric distribution, with a probability $1-\delta_w$ of being able to set a new wage for any variety. They choose that wage $W_{t,t}(j)$ taking account of labor demand (14), and thereafter update their wage at the steady state inflation rate $\bar{\pi}$, as was first suggested by Yun (1996). The government subsidizes their labor supply at the rate $\varrho_w = (\phi-1)^{-1}$ to eliminate the steady state markup distortion. The relevant part of their optimization problem can therefore be written as

$$\underset{W_{t,t}(j)}{Max}\mathcal{E}_t \sum_{l=0}^{\infty}\left(\frac{\delta_w}{1+r}\right)^l \left\{ \frac{\left(C_{t+l}^{1-\kappa}\left[1-\int_0^1\left(W_{t,t}(j)(1+\bar{\pi})^l\right)^{-\phi}W_{t+l}^{\phi}L_{t+l}dj\right]^{\kappa}\right)^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}} \right. .....$$

$$\left. ..... + \lambda_{t+l}\left[... \int_0^1 \frac{\left(W_{t,t}(j)(1+\bar{\pi})^l\right)^{1-\phi}W_{t+l}^{\phi}L_{t+l}(1+\varrho_w)dj}{E_{t+l}}\right]\right\} . \tag{16}$$

All firms solving this problem will choose identical values, and we can therefore drop the index j in what follows. The first-order condition is as follows:

$$\mathcal{E}_t \sum_{l=0}^{\infty}\left(\frac{\delta_w}{1+r}\right)^l \lambda_{t+l}l_{t+l}(j)\left\{\frac{W_{t,t}(1+\bar{\pi})^l}{E_{t+l}} - \frac{\kappa u_{t+l}^{1-\frac{1}{\gamma}}}{(1-H_{t+l})\lambda_{t+l}}\right\} = 0 \;. \tag{17}$$

We linearize the model's equations around the nonstochastic steady state, which is denoted by a bar above the respective variable. A circumflex above a variable x generally denotes $\hat{x}_t = \frac{x_t-\bar{x}}{\bar{x}}$, including gross interest and inflation rates. For net foreign assets and household investment good purchases we have $\hat{x}_t = x_t - \bar{x}$. Note first that by linearizing L_t and H_t one finds that $\hat{L}_t = \hat{H}_t$ (also, $\bar{L} = \bar{H}$). Let $\Gamma = \bar{L}/(T - \bar{L})$. Then the linearized household first-order conditions are:

$$\mathcal{E}_t \hat{\lambda}_{t+1} = \hat{\lambda}_t - \hat{r}_t \quad , \tag{18}$$

$$\frac{\gamma - 1}{\gamma} \hat{u}_t = \hat{\lambda}_t + \hat{p}_t^i + \hat{c}_t^i \quad , \quad i = n, m, x, f, \tag{19}$$

$$\hat{q}_t^i = \frac{u^i}{\left(\bar{k}^i\right)^2} \hat{I}_t^i - \frac{u^i \Delta}{\bar{k}^i} \hat{k}_t^i \quad , \quad i = n, m, x, k \quad , \tag{20}$$

$$\bar{k}^i \hat{k}_t^i = (1 - \Delta) \bar{k}^i \hat{k}_{t-1}^i + \hat{I}_{t-1}^i \quad , \quad i = n, m, x, k \quad , \tag{21}$$

$$\begin{aligned} \hat{\lambda}_t + \hat{p}_t^k + \hat{q}_t^i &= \mathcal{E}_t \left(\hat{\lambda}_{t+1} + \frac{1 - \Delta}{1 + r} \hat{p}_{t+1}^k + \frac{1}{1 + r} \hat{q}_{t+1}^i + \frac{r + \Delta}{1 + r} (\hat{w}_{t+1} + \hat{L}_{t+1}^i - \hat{K}_{t+1}^i) \right) \\ i &= n, m, x, k \quad , \end{aligned} \tag{22}$$

$$\hat{\pi}_{t+1}^w = (1 + r) \hat{\pi}_t^w - \Theta_w \left[\frac{\gamma - 1}{\gamma} \hat{u}_t + \Gamma \hat{L}_t - \hat{\lambda}_t - \hat{w}_t \right] \quad , \tag{23}$$

where $\Theta_w = \frac{1 - \delta_w}{\delta_w} (1 + r - \delta_w)$.

2.2 Firms

This paper differs from much of the literature in that, instead of value added production functions, it uses gross production functions that allow for intermediate inputs from all other sectors of the economy and the rest of the world. This captures the important role played by intermediate goods in the transmission of shocks. Output is Cobb-Douglas in the following factors, with $\sum_{j=k,l,n,m,x,f} \alpha_i^j = 1$:

$$y_t^i = \left(k_t^i\right)^{\alpha_i^k} \left(l_t^i\right)^{\alpha_i^l} \left(n_t^i\right)^{\alpha_i^n} \left(m_t^i\right)^{\alpha_i^m} \left(x_t^i\right)^{\alpha_i^x} \left(f_t^i\right)^{\alpha_i^f} \ , \ i = n, m, x, k. \tag{24}$$

We assume $\alpha_j^j = 0$ for $j = n, m, x$, i.e. we only consider the net output supplied by each sector to all other sectors and ignore inputs supplied by a sector to another firm in the same sector. For the competitive export goods and investment goods sectors (24) is the aggregate production function. For the nontraded goods and import goods sector the underlying production functions of producers of varieties have an identical form:

$$y_t^i(j) = \left(k_t^i(j)\right)^{\alpha_i^k} \left(l_t^i(j)\right)^{\alpha_i^l} \left(n_t^i(j)\right)^{\alpha_i^n} \left(m_t^i(j)\right)^{\alpha_i^m} \left(x_t^i(j)\right)^{\alpha_i^x} \left(f_t^i(j)\right)^{\alpha_i^f} \ , \ i = n, m. \quad (25)$$

These aggregate to (24) with $\int_0^1 \vartheta_t^i(j)dj = \vartheta_t^i, \ i = n, m, \ \vartheta = k, l, n, m, x, f$ because all factor markets are competitive so that relative prices of all pairs of individual inputs into variety j are equalized across all varieties. Finally, real marginal cost for each sector is

$$mc_t^i = \frac{MC_t^i}{P_t^i} = A_i \left(r_t^i\right)^{\alpha_i^k} \left(\frac{w_t}{p_t^i}\right)^{\alpha_i^l} \left(\frac{p_t^n}{p_t^i}\right)^{\alpha_i^n} \left(\frac{p_t^m}{p_t^i}\right)^{\alpha_i^m} \left(\frac{p_t^x}{p_t^i}\right)^{\alpha_i^x} \left(\frac{(1+\tau}{p_t^i}\right)^{\alpha_i^f} \ , \quad (26)$$

where we have again assumed that all direct imports are subject to a tariff τ, and where $A_i = \prod_{i=k,l,n,m,x,f} \alpha_i^{-\alpha_i}$. This can be linearized, using the relationship $\hat{p}_t^i + \hat{r}_t^i = \hat{w}_t + \hat{l}_t^i - \hat{k}_t^i$:

$$\widehat{mc}_t^i = \left(\alpha_i^k + \alpha_i^l\right) \hat{w}_t + \alpha_i^k (\hat{l}_t^i - \hat{k}_t^i) + \alpha_i^n \hat{p}_t^n + \alpha_i^m \hat{p}_t^m + \alpha_i^x \hat{p}_t^x - \hat{p}_t^i \ . \quad (27)$$

The solution of the profit maximization problem of export goods and investment goods producers is simply:

$$mc_t^i = 1 \ \forall t, \ i = x, k. \quad (28)$$

We therefore have $\widehat{mc}_t^x = \widehat{mc}_t^k = 0 \ \forall t$. Producers of nontraded goods and import goods varieties face price rigidities that, similar to households' wage setting problem, can be characterized by a Calvo (1983) random arrival rate of price setting opportunities, with probabilities of being able to set a new price of $(1 - \delta_n)$ and $(1 - \delta_m)$, respectively. They sell their varieties to a competitive wholesaler who solves the following problem:

$$\underset{y_t^i(j), j \in [0,1]}{Min} \int_0^1 P_t^i(j) y_t^i(j) dj \ s.t. \ y_t^i = \left(\int_0^1 y_t^i(j)^{\frac{\theta-1}{\theta}} dj\right)^{\frac{\theta}{\theta-1}} \ , i = n, m. \quad (29)$$

The solution is the following set of goods demands:

$$y_t^i(j) = y_t^i \left(\frac{P_t^i(j)}{P_t^i}\right)^{-\theta} \ , \quad (30)$$

where the aggregate sectorial price level is

$$P_t^i = \left(\int_0^1 P_t^i(j)^{1-\theta} dj\right)^{\frac{1}{1-\theta}} \ . \quad (31)$$

The problem of producers of individual varieties is therefore to maximize profits

$$\underset{P^i_{t,t}(j)}{Max}\ \mathcal{E}_t \sum_{l=0}^{\infty} \delta_i^l R^i_{t,l} y^i_{t+l}(j) \left(\frac{P^i_{t,t}(1+\bar{\pi})^l (1+\varrho_i)}{P_{t+l}} - mc_{t+l} \right)\ ,\ i=n,m, \tag{32}$$

subject to (30), and where $R^i_{t,l}$ is the l-period ahead real discount factor based on the own rates of interest of nontraded goods or import goods. This yields the familiar New Keynesian Phillips curves (with $\Theta_i = \frac{1-\delta_i}{\delta_i}(1+r-\delta_i)$):

$$\hat{\pi}^i_{t+1} = (1+r)\hat{\pi}^i_t - \Theta_i \widehat{mc}^i_t\ . \tag{33}$$

Due to the multiple intermediate goods linkages there are a number of additional linearized optimality conditions, principally the linearized production functions and input demands.

2.3 Government

Fiscal policy is assumed to be Ricardian, i.e. lump-sum transfers g_t are used to rebate the net revenue arising from monetary policy and the production subsidy. The sequence of budget constraints is:

$$h_t = (1+r_{t-1})h_{t-1} + x_t p^c_t - \frac{x_{t-1}p^c_{t-1}}{1+\varepsilon_t} - \varrho_n p^n_t y^n_t - \varrho_m p^m_t y^m_t - \varrho_w w_t L_t - g_t \quad , \tag{34}$$

where h_t are government foreign exchange reserves, and where we have used the fact that

$$\int_0^1 (P^i_t(j) y^i_t(j) dj)/E_t = p^i_t y^i_t \quad , \quad i=m,n,$$

and similarly for wages. We impose the following transversality condition:

$$\lim_{l\to\infty} \mathcal{E}_t \frac{h_{t+l}}{\Pi_{s=0}^{l-1}(1+r_s)} = 0 \quad . \tag{35}$$

Our main interest is in different monetary policy rules permitting different degrees of exchange rate flexibility. The first monetary policy to be considered is **exchange rate targeting**, $\varepsilon_t = \bar{\pi}\ \forall t$, or $\hat{\varepsilon}_t = 0\ \forall t$. It is understood as usual that this is a target for the path of the level of the exchange rate E_t, i.e. jumps in E_t are ruled out. This is necessary to obtain nominal and real determinacy in this model. To discuss the 'flexible exchange rates' option, we have to specify more precisely what is meant by that term. The most popular form of flexible exchange rates is currently **inflation targeting**, and in practice this is invariably a version of consumer price index (CPI) inflation targeting. To avoid the technical complications, due to indeterminacy considerations, of specifying an interest rate rule for a small open economy, one could therefore define inflation targeting directly as a target path for the CPI price index (4). Given that this is what is actually done in practice, a positive analysis should consider this case, i.e. targeting

$$\hat{\pi}_t^c = \Omega_n \hat{\pi}_t^n + \Omega_m \hat{\pi}_t^m + \Omega_x \hat{\pi}_t^x + \Omega_f \hat{\varepsilon}_t = 0 \ \ , \ \ \Omega_i = \sigma_i \ , \ i = n, m, x, f. \tag{36}$$

However, it is also well-known that in our environment such a rule if far from optimal, as monetary policy should aim to stabilize inflation in sectors that exhibit price rigidities while allowing the nominal exchange rate to realign their relative prices following a shock. An analysis of optimal monetary policy is beyond the scope of this paper, and would in any event be very difficult given the complexity of the model. But for the case of flexible wages and equal price rigidities in nontraded goods and import goods the following rule is known to be very close to optimal:

$$\Omega_n \hat{\pi}_t^n + \Omega_m \hat{\pi}_t^m = 0 \ \ , \ \ \Omega_n = \sigma_n / (\sigma_n + \sigma_m) \ \ , \ \ \Omega_m = \sigma_m / (\sigma_n + \sigma_m). \tag{37}$$

We will therefore specify the case of 'flexible exchange rates' according to this rule, to give inflation targeting as large an advantage as possible over exchange rate targeting. As in the case of exchange rate targeting, this is understood as a target for the path of the level of the subindex $P_t^{it} = (P_t^n)^{\Omega_n} (P_t^m)^{\Omega_m}$, i.e. jumps are ruled out.

We define a *government policy* under exchange rate targeting as a sequence $\{E_t\}_{t=0}^{\infty}$, a stochastic process $\{g_t\}_{t=0}^{\infty}$, and constant proportional subsidies $\varrho_i, \ i = n, m, w$ such that, given stochastic processes $\left\{x_t, [W_t(j), l_t(j)]_{j \in [0,1]}\right\}_{t=0}^{\infty}$ chosen by households, and given stochastic processes $\left\{[P_t^n(j), y_t^n(j), P_t^m(j), y_t^m(j)]_{j \in [0,1]}\right\}_{t=0}^{\infty}$ chosen by firms, the budget constraint (34) holds at all times. For the case of inflation targeting a government policy is similarly defined as a sequence $\{P_t^{it}\}_{t=0}^{\infty}$, a stochastic process $\{g_t\}_{t=0}^{\infty}$, and subsidies.

2.4 Exogenous Shocks

The model exhibits two sources of uncertainty in the form of a shock to the terms of trade p_t^x and a shock to the real international interest rate ρ_t. The terms of trade are assumed to follow the following AR1 process, with $\bar{p}^x = 1$:

$$\ln p_t^x = \eta \ln p_{t-1}^x + \varsigma_t^\tau \quad . \tag{38}$$

This is linearized as:

$$\hat{p}_t^x = \eta \hat{p}_{t-1}^x + \hat{\varsigma}_t^x \quad . \tag{39}$$

The real interest rate faced by residents of the country is

$$(1 + r_t) = (1 + \rho_t)(1 + \varpi_t) \quad . \tag{40}$$

The second component on the right-hand side ϖ_t is an interest rate premium that will be discussed in more detail below. The first component ρ_t is the time-varying real international interest rate which is assumed to follow the AR1 process

$$\ln(1 + \rho_t) = R + \nu \ln(1 + \rho_{t-1}) + \varsigma_t^\rho \quad . \tag{41}$$

We assume that $R = (1 - \nu)\ln(1 + r)$, i.e. $\bar{\rho} = r$. Equation (41) may be linearized as

$$\hat{\rho}_t = \nu \hat{\rho}_{t-1} + \hat{\varsigma}_t^\rho \quad . \tag{42}$$

2.5 Equilibrium and Balance of Payments

We define an *allocation* as the following list of stochastic processes:

$$\Big\{ b_t, h_t, x_t, c_t^n, c_t^m, c_t^x, c_t^f, L_t, H_t, l_t^n, l_t^m, l_t^x, l_t^k, I_t^n, I_t^m, I_t^x, I_t^k, k_t^n, k_t^m, k_t^x, k_t^k,$$
$$y_t^n, y_t^m, y_t^x, y_t^k, n_t^m, n_t^x, n_t^k, m_t^n, m_t^x, m_t^k, x_t^n, x_t^m, x_t^k, f_t^n, f_t^m, f_t^x, f_t^k,$$
$$[y_t^n(j), y_t^m(j), l_t^n(j), l_t^m(j), k_t^n(j), k_t^m(j), n_t^m(j), m_t^n(j), x_t^n(j), x_t^m(j), f_t^n(j), f_t^m(j), l_t(j)]_{j\in[0,1]} \Big\}_{t=0}^{\infty}$$

A *price system* under exchange rate targeting is the list of stochastic processes

$$\Big\{ P_t^n, P_t^m, P_t^k, q_t^n, q_t^m, q_t^x, q_t^k, W_t, [P_t^n(j), P_t^m(j), W_t(j)]_{j\in[0,1]} \Big\}_{t=0}^{\infty} \quad ,$$

and a *price system* under inflation targeting is the list of stochastic processes

$$\left\{E_t, P_t^n, P_t^m, P_t^k, q_t^n, q_t^m, q_t^x, q_t^k, W_t, [P_t^n(j), P_t^m(j), W_t(j)]_{j\in[0,1]}\right\}_{t=0}^{\infty} \quad .$$

Finally let $f_t = b_t + h_t$, the economy's overall level of net foreign assets. Then equilibrium is defined as follows:

An equilibrium given initial conditions f_{-1}, p_{-1}^x, ρ_{-1} and, in the case of exchange rate targeting, p_{-1}^m and p_{-1}^n, *is an allocation, a price system, a government policy and a list of exogenous stochastic processes $\{p_t^x, \rho_t\}_{t=0}^{\infty}$ such that*

*(a) given the price system, the government policy and the exogenous stochastic processes, the allocation solves the household's problem of maximizing (*1*) subject to (*2*), (*3*), (*7*), (*6*) and (*8*), with respect to all variables except wages,*

*(b) the stochastic processes $\left\{[y_t^n(j), y_t^m(j), l_t(j)]_{j\in[0,1]}\right\}_{t=0}^{\infty}$ solve the goods wholesalers' and the employment agency's problems (*29*) and (*13*), given the stochastic processes $\left\{P_t^n, P_t^m, W_t, Y_t^n, Y_t^m, L_t, [P_t^n(j), P_t^m(j), W_t(j)]_{j\in[0,1]}\right\}_{t=0}^{\infty}$,*

(c) given the government policy, the restrictions on price and wage setting, and the stochastic processes $\{P_t^n, P_t^m, W_t, \rho_t, p_t^x, Y_t^n, Y_t^m\}_{t=0}^{\infty}$ for exchange rate targeting and $\{E_t, P_t^n, P_t^m, W_t, \rho_t, p_t^x, Y_t^n, Y_t^m\}_{t=0}^{\infty}$ for inflation targeting, *the stochastic processes $\left\{\left[P_{t,t}^n(j), P_{t,t}^m(j), W_{t,t}(j)\right]_{j\in[0,1]}\right\}_{t=0}^{\infty}$ solve the optimization problems of intermediate nontraded goods and import goods producers (*32*) and of wage setters (*16*),*

*(d) given the price system, the allocation satisfies condition (*28*) for export goods and investment goods producers,*

(e) *the nontraded goods market clears at all times,*

$$y_t^n = c_t^n + n_t^m + n_t^x + n_t^k \qquad \forall t, \tag{43}$$

(f) the import goods market clears at all times,

$$y_t^m = c_t^m + m_t^n + m_t^x + m_t^k \qquad \forall t, \tag{44}$$

(g) the labor market clears at all times,

$$L_t = l_t^n + l_t^m + l_t^x + l_t^k \qquad \forall t \ , \tag{45}$$

(h) the investment goods market clears at all times,

$$\begin{aligned} y_t^k &= I_t^n + I_t^m + I_t^x + I_t^k \\ &+ \frac{u^n}{2}\left(\frac{I_t^n}{k_t^n} - \Delta\right)^2 + \frac{u^m}{2}\left(\frac{I_t^m}{k_t^m} - \Delta\right)^2 + \frac{u^x}{2}\left(\frac{I_t^x}{k_t^x} - \Delta\right)^2 + \frac{u^k}{2}\left(\frac{I_t^k}{k_t^k} - \Delta\right)^2 \quad . \end{aligned} \tag{46}$$

Equations (34), (7) and the definition of equilibrium imply that the following aggregate budget constraint, or current account equation, must hold:

$$f_t = (1 + r_{t-1})f_{t-1} + p_t^x(y_t^x - c_t^x - x_t^n - x_t^m - x_t^k) - c_t^f - f_t^n - f_t^m - f_t^x - f_t^k \ . \tag{47}$$

Market clearing and current account equations are linearized as usual.

2.6 The Real Interest Rate and Stationarity

It is common in small open economy models with incomplete financial markets to impose the assumption $r_t = r \ \forall t$ in the perfect foresight case, or $\bar{r} = r$ in stochastic models. These assumptions imply that one of the model's roots is located on the unit circle, which complicates computation. In a recent paper, Schmidt-Grohe and Uribe (2002) have summarized the state of the literature as regards the solution of this class of models. They point out that there are three common tricks used to induce stationarity, namely Uzawa-type preferences as used by Mendoza (1991), a debt-elastic interest rate as used by Schmidt-Grohe and Uribe (2002), and quadratic portfolio adjustment costs as used by Neumeyer and Perri (2001). For the purpose of this paper we will adopt the debt-elastic interest rate. In this method the elasticity of the real international interest rate with respect to the level of aggregate net foreign debt $-f_t$ is set to a positive but very small value. This induces stationarity by converting the unit root to a root with absolute value just inside the unit circle. While this gives rise to different dynamics to the nonstationary case at very long horizons, at business cycle frequencies the dynamics are virtually identical. Specifically, we assume that $(1 + \varpi_t) = (1 + \xi(e^{\bar{f} - f_t} - 1))$, where ξ is positive and very close to zero, and where $\bar{f}$ is the steady state value of net foreign assets. The real interest rate facing the economy therefore becomes

$$(1 + r_t) = (1 + \rho_t)(1 + \xi(e^{\bar{f} - f_t} - 1)) \quad . \tag{48}$$

We log-linearize this relationship as follows:

$$\hat{r}_t = \hat{\rho}_t - \xi \hat{f}_t \quad . \tag{49}$$

The Euler equation (18) therefore becomes

$$\mathcal{E}_t \hat{\lambda}_{t+1} = \hat{\lambda}_t - \hat{\rho}_t + \xi \hat{f}_t \quad . \tag{50}$$

This completes our description of the model dynamics. For exchange rate targeting the linearized dynamic system consists of 54 equations in 54 variables, while two further variables have to be added for inflation targeting. Before discussing the model solutions, the key remaining issue is the definition of trade openness.

2.7 Trade Openness

We parameterize the trade openness of an economy in the most natural way, as being a function of the deep structural parameters of the economy, specifically of the expenditure shares on foreign goods imports in consumption and in production. The statistic we use is the steady state exports to GDP ratio $\bar{O}$:

$$\bar{O} = \frac{\overline{exports}}{\overline{consumption} + \overline{investment} + \overline{exports} - \overline{imports}} \quad . \tag{51}$$

where $\overline{exports} = \bar{p}^x(\bar{y}^x - \bar{c}^x - \bar{x}^n - \bar{x}^m - \bar{x}^k)$, $\overline{consumption} = \bar{p}^n\bar{c}^n + \bar{p}^m\bar{c}^m + \bar{p}^x\bar{c}^x + \bar{c}^f$, $\overline{investment} = \bar{p}^k\bar{y}^k$, $\overline{imports} = \bar{c}^f + \bar{f}^n + \bar{f}^m + \bar{f}^x + \bar{f}^k$. This definition of trade openness requires a detailed discussion of the steady state for this economy. We start by calibrating all share parameters of our model economy from detailed Chilean national accounts data for 1996 (details see below). This fixes $\alpha_i^j,\ i,j = n,m,x,k,f$, and $\sigma_i,\ i = n,m,x,f$. When all production share parameters are fixed, the steady state versions of the four marginal cost expressions (26) allow us to compute the steady state relative prices $\bar{p}^n, \bar{p}^m, \bar{p}^k, \bar{w}$. This fixes the input proportions in all sectors, and fixing the σ_i also fixes the consumption proportions. Therefore all that remains to be determined is the scale of each sector's production, represented for example by the labor allocation between the four types of labor l^i, $i = n, m, x, k$, and the scale of consumption. These five values are determined by simultaneously solving the four steady state market clearing conditions for nontraded goods, import goods, investment goods and labor, and the current account. We compute $\bar{O}$ for this baseline case as 29.95%. This is extremely close to the Chilean exports to GDP ratio in the same year (30.12% without taxes). We then define a new variable $\bar{S}$, which is allowed to vary between 0.01 and 0.50, and where $\bar{S} = \bar{O}$ at the baseline values. To vary openness, we fix the expenditure shares of direct consumption imports σ_f and of intermediate goods imports α_i^f, $i = n, m, x, k$ as multiples of $\bar{S}$ while leaving all remaining share parameters fixed in proportion to each other. We then recompute $\bar{O}$ to confirm that this procedure does indeed produce values of openness in the desired range. We find that $\bar{O}$ differs from $\bar{S}$ by at most 1% for all values, i.e. using this procedure we vary the range of the exports to GDP ratio between 1% and 50%.

3 Calibration

The main parameter values are assigned in accordance with Table 1. The time unit is one quarter. S/S stands for steady state.

The value for the steady state real international interest rate is higher than values typically chosen for the US, but is nevertheless below the typical Brady bond yield for a Latin American emerging market. The steady state inflation rate only affects the presentation of results, it has no effects on the dynamics. The proportion of time spent working in steady state follows Cooley and Prescott (1995). The 55% debt to GDP ratio is only little above the current value of Chile. It was considerably lower in 1996, the year on which our share parameter values are based, but in that year Chile ran a more than 4% current account deficit and debt was growing. Our procedure for calibrating share parameters remains valid even though Chile clearly was not in steady state in 1996, as long as deviations from steady state affect only the scale of production and consumption but not expenditure shares, a reasonable assumption. The intertemporal elasticity of substitution is set to a low value of 0.5, which is justified by empirical evidence, e.g. Reinhart and Vegh (1995). The depreciation rate is standard, and we assign values for the capital stock adjustment cost parameters u^i consistent with the calibration of Mendoza (1991).

Parameter	Value	Description
$\bar{O}$	$\in (0.01, 0.50)$	S/S Exports to GDP Ratio
δ_n, δ_m	0.75	NTG, IMP Price Stickiness
δ_w	0.0001 or 0.75	Wage Stickiness
$\bar{p}^x$	1	S/S Terms of Trade
r	8% $p.a.$	S/S Real International Interest Rate
$\bar{\pi}$	10% $p.a.$	S/S Inflation
T	1000	Time endowment
L	$(1/3) * T$	S/S Time Spent Working
$dgdp$	0.55	S/S Debt to GDP Ratio
γ	0.5	Intertemporal EoS
Δ	0.025	Capital Depreciation Rate
u	0.028	Capital Adjustment Cost
ξ	0.0001	Debt Elasticity of Real Interest Rate
ν	0.9	AR1 coefficient of interest rate shock
η	0.999	AR1 coefficient of ToT shock

Table 1

The share parameters are based on 1996 Chilean national accounts data. The lengthy list is relegated to Appendix A. The data source is broken down into 74 different industries and corresponding product categories. We classify these industries as follows: First, the investment goods industries are classified according to the share of an industry's output used for final investment expenditure. Construction and three machinery industries are selected. For the remaining 70 industries the criterion for classifying an industry as import goods or export goods is whether a large fraction of the corresponding good's output (20% or more) is imported or exported. All remaining industries are classified as nontraded goods. After the classification we analyzed the 74 by 74 input-input matrix to determine intermediate goods expenditures according to source industries, and we analyze the breakdown of industry value added to determine the return to labor and capital. Together this allows us to determine expenditure shares. Consumption expenditure is also broken down by product category, and we used our classification to determine the shares of the four different consumption categories.

4 Model Evaluation

The following impulse responses compare the dynamic response of the economy to a foreign real shock under exchange rate targeting (solid line) and inflation targeting (dashed line). The first two panels of each set of impulse responses show the respective shocks. Model solutions are computed using the method of Binder and Pesaran (1995). We start with the real interest rate shock, specifically a realistic benchmark case of a 4% real interest rate increase (a 50% increase over the initial 8% real interest rate) at a large export to GDP ratio of 40%. This case is the 'open' economy. For comparison we then show an otherwise identical but much more closed economy, with an export to GDP ratio of only 5%. We concentrate on the case of flexible wages for the impulse responses, and only discuss the sticky wage case in the welfare section. But note that except for a larger drop in labor the results are very similar to the flexible wage case. A discussion of terms of trade shocks is also omitted to save space. They are however fundamentally similar to interest rate shocks, in that both shocks work through the marginal utility of foreign wealth.

To make the comparison between different degrees of openness more systematic, we end this section by comparing the welfare losses of the real interest rate shock across a whole range of export to GDP ratios. The welfare comparisons follow Lucas (1987), i.e. the welfare loss of a real shock is the percentage Φ by which steady state consumption must be reduced to make households indifferent between the reduced steady state streams of consumption and leisure and the consumption and leisure allocations obtained as a result of the foreign shock:[4]

$$\frac{1+r}{r}\left(\left[\bar{C}\left(1-\frac{\Phi}{100}\right)\right]^{1-\kappa}\left[T-\bar{L}\right]^{\kappa}\right)^{1-\frac{1}{\gamma}} \tag{52}$$
$$= \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^{t}\left(\left[C_t\right]^{1-\kappa}\left[1-L_t\right]^{\kappa}\right)^{1-\frac{1}{\gamma}} .$$

4.1 An 'Open' Economy, $\bar{O} = 40\%$

Figures 3a-3g present the results for the open economy. The drops in consumption and labor are much larger under exchange rate targeting than under inflation targeting. In fact the dynamic response of the economy under inflation targeting can be shown to be (unsurprisingly) quite close to the flexible price outcome. The only difference to that case arises because an exchange rate jump cannot change all relative price levels independently of each other.

The increase in the real interest rate reduces consumption demand on impact. Given that the country is assumed to be a net debtor, higher real interest rates have a negative wealth effect as well as an intertemporal substitution effect. This means that the marginal utility of a unit of foreign goods wealth λ_t rises sharply on impact and then begins to fall. All else equal, this requires a drop in nontradables and imports consumption by (10). But under inflation targeting this effect is partly offset by a quick drop in the relative prices p_t^n and p_t^m of those goods, thereby reducing the required drop in consumption. Under exchange rate targeting these relative prices are rigid. At their original levels there will therefore be a very large drop in consumption demand. This leads to a large drop in labor through a combination of a supply and a demand channel. On the supply side the drop in output demand reduces labor input demand because the capital stock is close to fixed in the short run, so that variable factors including labor need to fall. This reduction in labor demand feeds back to the demand side to reduce both consumption and labor even further. The reason is that increased

[4] As is common, we ignore the money component of utility by assuming that Υ is close to zero.

leisure at an unchanged level of aggregate consumption would decrease the marginal utility of consumption, not increase it as required by the higher marginal utility of nontradables and imports wealth $\lambda_t p_t^n$ and $\lambda_t p_t^m$. We can see this by rewriting the first order conditions in terms of aggregate consumption and leisure, using the relative price $p_t^c = P_t^c / E_t$:

$$\hat{\lambda}_t + \hat{p}_t^c = \left(\frac{1-\gamma}{\gamma} \kappa \Gamma \right) \hat{L}_t - \left(1 + \frac{1-\gamma}{\gamma} (1-\kappa) \right) \hat{C}_t \ . \tag{53}$$

Under inflation targeting the increase in λ_t is largely offset by a drop in the aggregate price index p_t^c, and therefore the required changes in aggregate consumption and leisure are moderate. Under exchange rate targeting however p_t^c is rigid. Therefore, when the drop in labor demand tends to drive down the marginal utility of aggregate consumption, C_t has to drop much further than implied by the increase in λ_t. Under inflation targeting there is not only a much smaller drop in consumption demand, but also a steeper increase in the cost of foreign goods intermediate inputs. Substitution away from these inputs is in fact strong enough for labor demand to increase. Investment behavior does not differ much between the two monetary regimes, as most of the response to the temporary fall in goods demand can be met from a drop in variable factor use.

The consequence of lower consumption and labor demand under exchange rate targeting is therefore a lower real wage and a lower real return to capital in the sectors that exhibit nominal rigidities, nontraded and import goods. These two effects dominate overall marginal cost of production, which therefore falls sharply on impact. This in turn lowers inflation and therefore begins to reduce the relative prices p_t^n and p_t^m, which under inflation targeting was accomplished much less painfully through a jump in the exchange rate. Once they have fallen sufficiently, consumption and therefore investment return to their steady state levels.

The export sector's initial behavior is dominated by the fact that it continues to sell its output at the world price, while its inputs of labor, imports and nontradables become much cheaper. This generates an output surge on impact, and this is larger under inflation targeting because domestic imports drop in price more rapidly. The export surge together with the drop in imports of international goods leads to a current account surplus that is similar between the two regimes. Under exchange rate targeting it is driven to a greater extent by a collapse in imports while under inflation targeting there is a larger increase in exports.

4.2 A Closed Economy, $\bar{O} = 5\%$

This case is presented in Figures 4a-4g. The qualitative response is identical to that of the open economy. This is precisely what the simple model in the Introduction asserts. The crucial factor is rigid relative prices. Given the temporarily very much higher benefit to saving, the fact that domestic goods remain 'expensive' means that households significantly reduce their consumption of these goods until their relative price has declined sufficiently. There is however one noticable difference to the open economy case. This is that the contraction in nontraded and import goods consumption is now significantly deeper relative to the inflation targeting case. Consequently the increase in unemployment is also larger. The reason is that foreign goods are now such a small factor of production that substitution out of these inputs cannot do much to reduce overall variable factor input. Consequently a larger burden of adjustment falls on labor. However, as we will now see, despite the larger consumption and labor fluctuations in a more closed economy the welfare difference between the two cases is not unambiguous.

4.3 Welfare

Figures 5a-c show welfare results when the degree of openness $\bar{O}$ is varied between 0.01 and 0.50. As explained in our above discussion, each new value for $\bar{O}$ is associated with a full recalibration of preferences and technologies. As expected, and independently of the monetary regime, the effect of a proportional real foreign shock increases as the importance of foreign goods in the economy increases, i.e. as the economy becomes more open. Also as expected, inflation targeting is always superior to exchange rate targeting. What is less obvious is the (small) size of the welfare benefit of flexibility, and the fact that it varies non-monotonically with openness. We start with the latter: The result of the simple model in the Introduction is essentially confirmed, in that welfare losses do not go to zero as the economy becomes more closed. This may seem surprising when one thinks of a completely closed economy as a limiting case - in such an economy the exchange rate clearly would not matter. But then neither would foreign real shocks. Terms of trade shocks imply the existence of an export and/or import sector. And real interest rate shocks imply participation in the world capital market. In that case an economy that is completely closed to trade is simply not the relevant limiting case, as the ability to sell (and buy) goods is a prerequisite for participation in the capital market. The fact that losses do not go to zero for an almost closed economy was seen very clearly in our discussion of Figure 4, where despite the much larger size of the nontraded goods sector, demand for nontraded goods had to initially fall almost in proportion to the fall in the much smaller foreign goods imports, due to the rigidity in relative prices. The non-monotonic behavior of the welfare benefit is harder to explain, given the complexity of the model. But this result needs to be qualified in two ways. First, we have worked with other calibrations and other shocks in which the welfare differences were sometimes either monotonically increasing or decreasing. The result is therefore not general, i.e. no unambiguous conclusions can be drawn so far about this relationship. Second, note that the absolute size of the difference is very small. A fixed exchange rate entails not only a much larger drop in consumption, *especially* for a very closed economy, but also a much larger increase in unemployment. But the way higher unemployment shows up in the welfare results is as a beneficial increase in leisure. With the chosen preferences the net effect is close to zero.[5] We conjecture on the basis of Figures 3 and 4 that preferences which penalize unemployment have the potential to make the welfare benefit of exchange rate flexibility decreasing in openness over the entire range.

[5] Using a second-order approximation for the computation of both impulse responses and welfare may increase these losses somewhat. We are working on this question. But it is unlikely that the difference will be very large.

5 Conclusion

It is well known that flexible exchange rates are superior to fixed exchange rates when an open economy is subject to foreign real shocks and there are nominal rigidities. This paper addresses a related but more subtle and highly policy relevant question: Does less trade openness make the benefits of exchange rate flexibility less significant. Our answer is that this is not generally true. Depending on preferences, technologies and calibrated parameter values the relationship between openness and the benefits of exchange rate flexibility can be non-monotonic, increasing or decreasing. The benefit certainly does not need to go to zero as the economy becomes more closed.

To analyze this question we present a very comprehensive dynamic general equilibrium model of a small open economy. The economy is specified in such a way that all key preference and technology parameters can be recalibrated as a function of the degree of trade openness of the economy, which is defined as the steady state exports to GDP ratio. This allows us to consider the effect of foreign real shocks on economies that exhibit different degrees of openness but that are otherwise identical.

The specification of preferences is most critical to our results, and we are exploring alternatives to the common form used here. We conjecture that for many reasonable preference specifications the benefits of exchange rate flexibility may well be decreasing in trade openness.

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Appendix A. Expenditure Share Parameters

Share Parameter	**Value**
$\sigma_f, \alpha_n^f, \alpha_m^f, \alpha_x^f, \alpha_k^f,$	Multiples of $\bar{O}$
Consumption	————
σ_n	$0.846 * (1 - \sigma_f)$
σ_m	$0.121 * (1 - \sigma_f)$
σ_x	$0.033 * (1 - \sigma_f)$
Nontraded Goods	————
α_n^k	$0.483 * (1 - \alpha_n^f)$
α_n^l	$0.385 * (1 - \alpha_n^f)$
α_n^m	$0.113 * (1 - \alpha_n^f)$
α_n^x	$0.019 * (1 - \alpha_n^f)$
Import Goods	————
α_m^k	$0.365 * (1 - \alpha_m^f)$
α_m^l	$0.250 * (1 - \alpha_m^f)$
α_m^n	$0.309 * (1 - \alpha_m^f)$
α_m^x	$0.076 * (1 - \alpha_m^f)$
Export Goods	————
α_x^k	$0.393 * (1 - \alpha_x^f)$
α_x^l	$0.196 * (1 - \alpha_x^f)$
α_x^n	$0.306 * (1 - \alpha_x^f)$
α_x^m	$0.106 * (1 - \alpha_x^f)$
Investment Goods	————
α_k^k	$0.257 * (1 - \alpha_k^f)$
α_k^l	$0.300 * (1 - \alpha_k^f)$
α_k^n	$0.144 * (1 - \alpha_k^f)$
α_k^m	$0.245 * (1 - \alpha_k^f)$
α_k^x	$0.054 * (1 - \alpha_k^f)$

Table 2

Figures

1. Open Economy, $\bar{O} = 40\%$

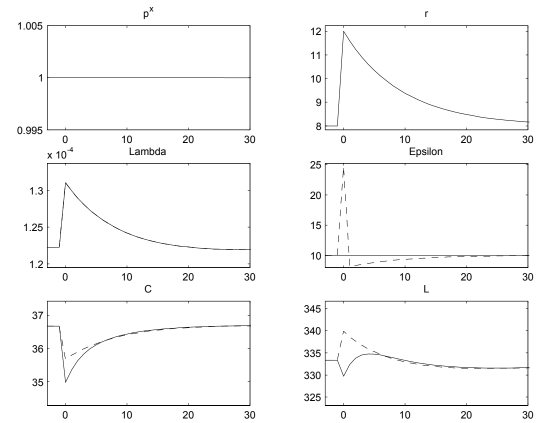

Figure 3a : Summary

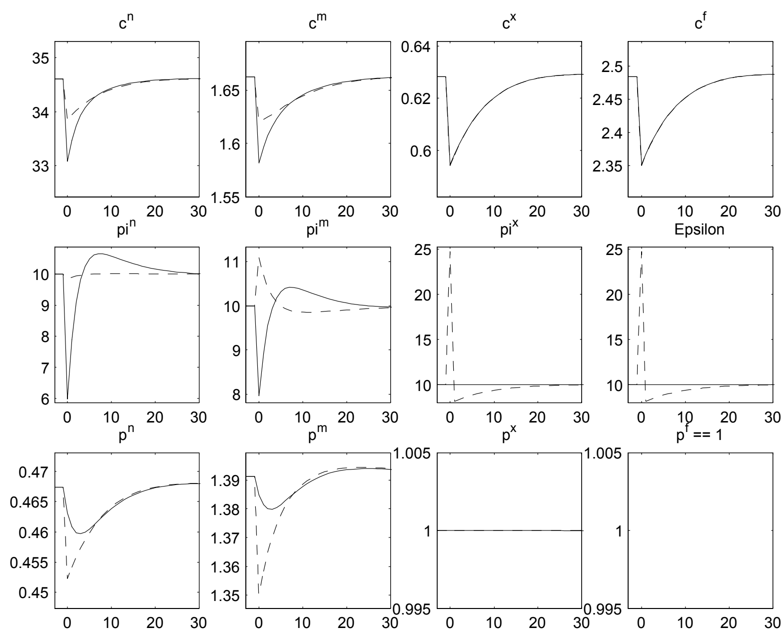

Figure 3b : Consumption

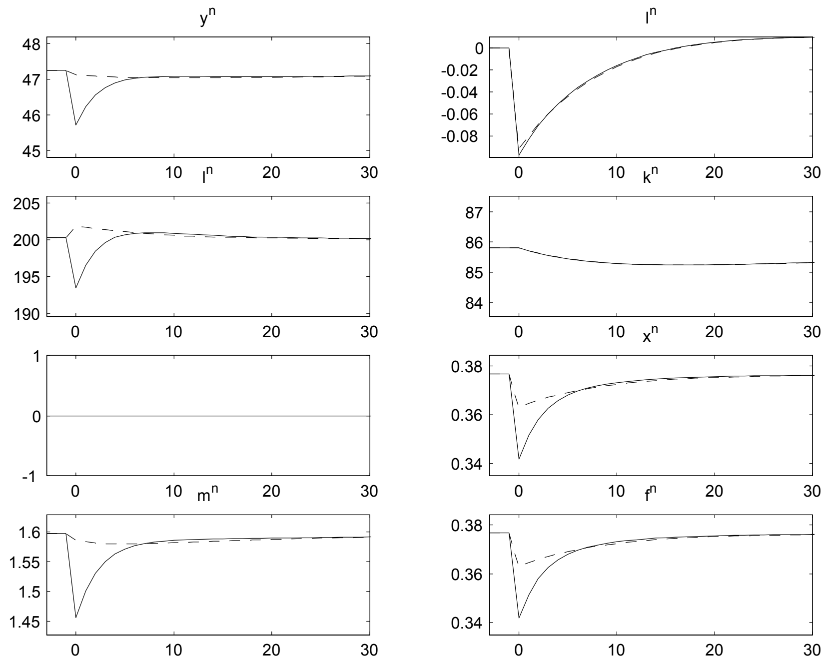

Figure 3c(i) : Nontradables Production

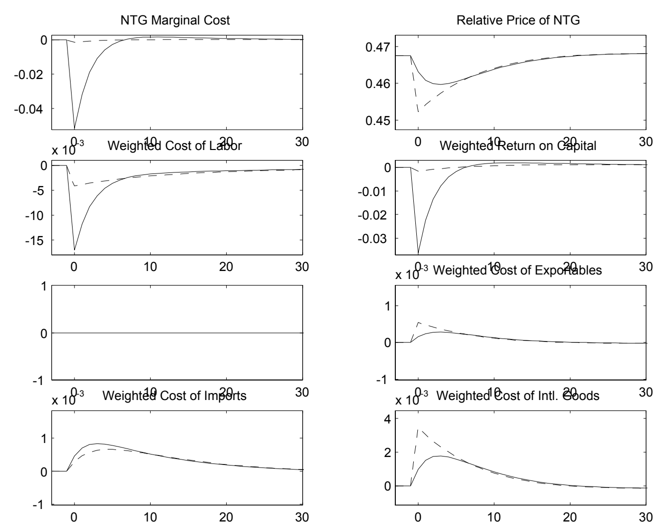

Figure 3c(ii) : Nontradables Marginal Cost

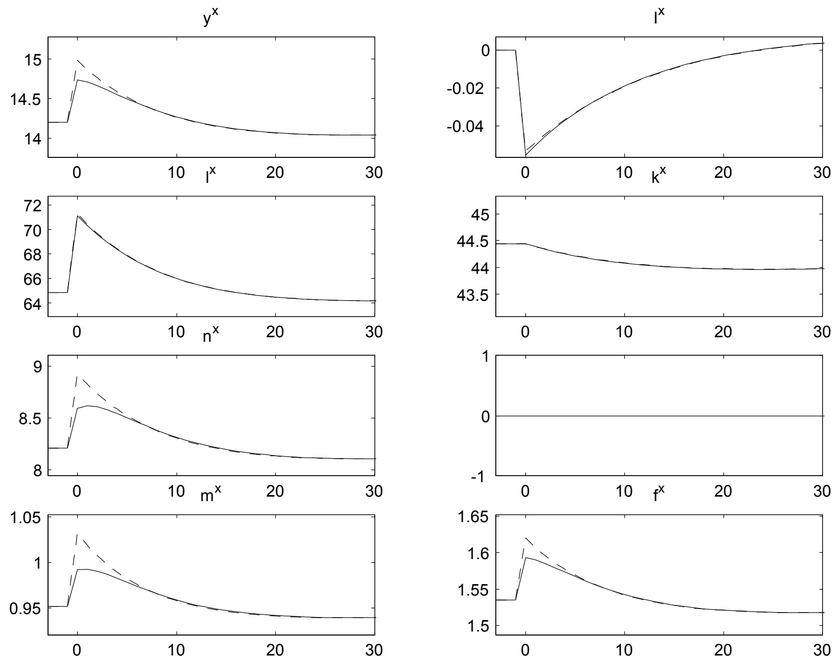

Figure 3d(i) : Exports Production

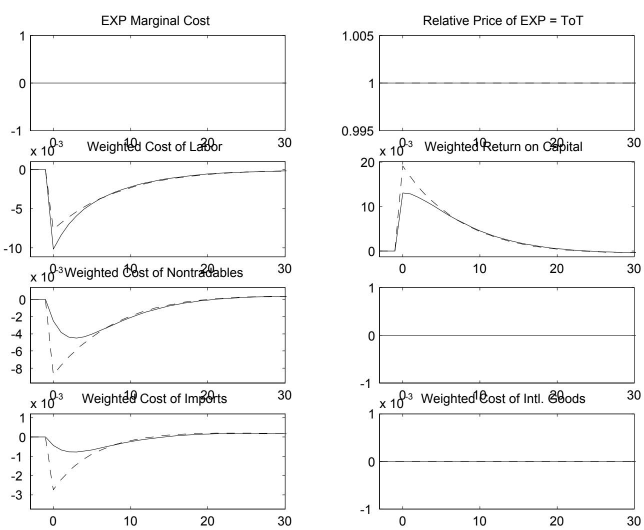

Figure 3d(ii): Exports Marginal Cost

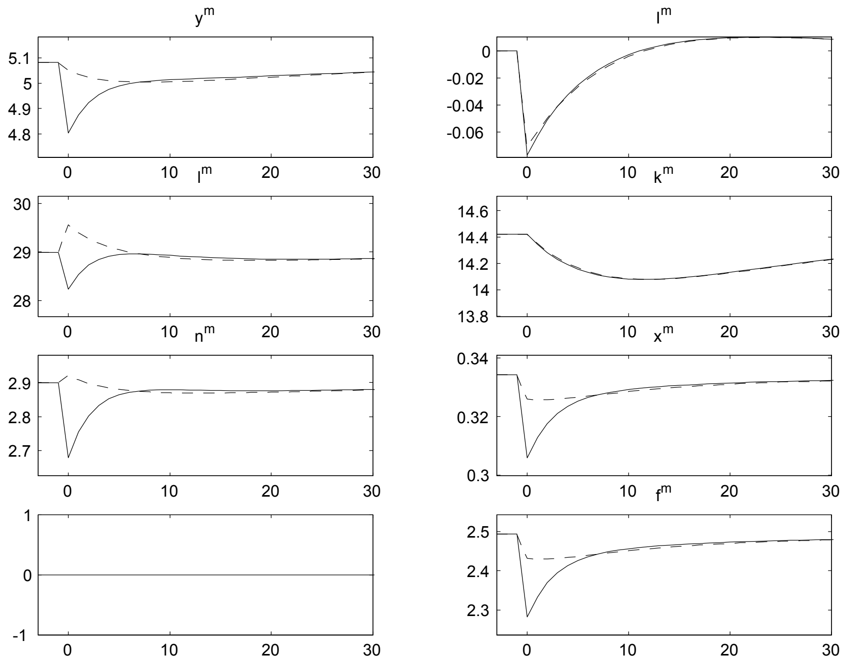

Figure 3e(i) : Imports Production

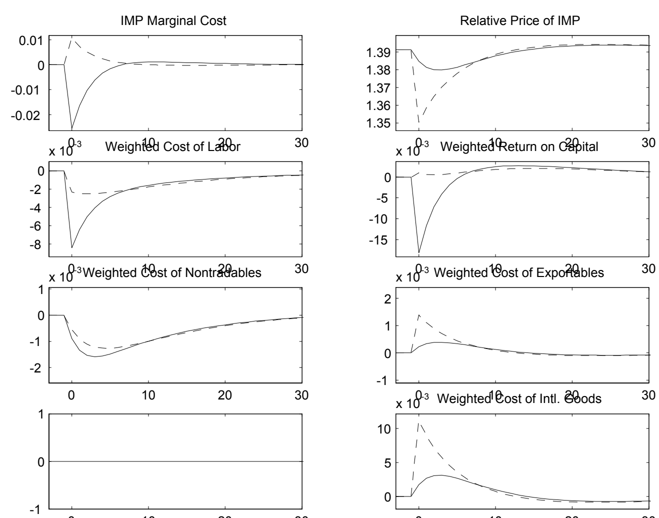

Figure 3e(ii): Imports Marginal Cost

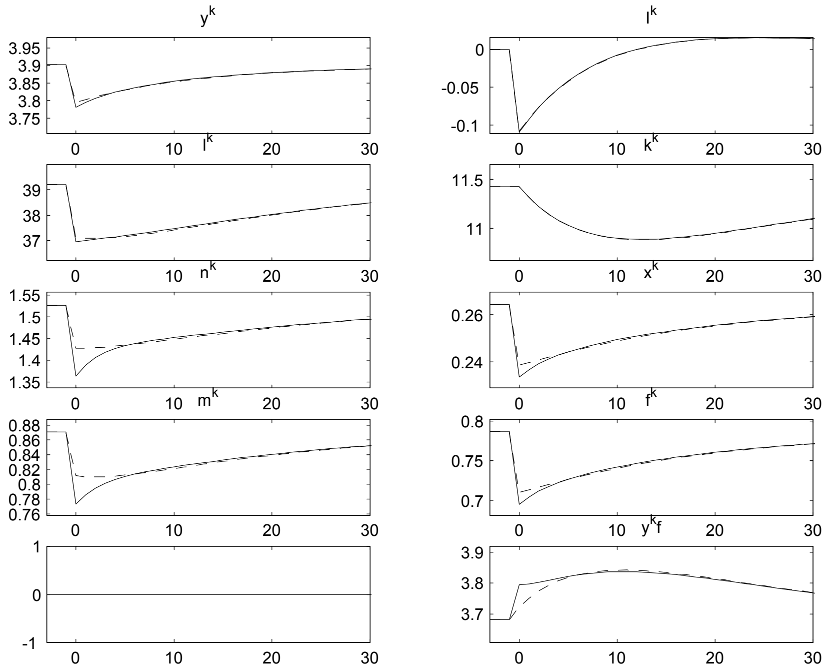

Figure 3f: Capital Goods Production

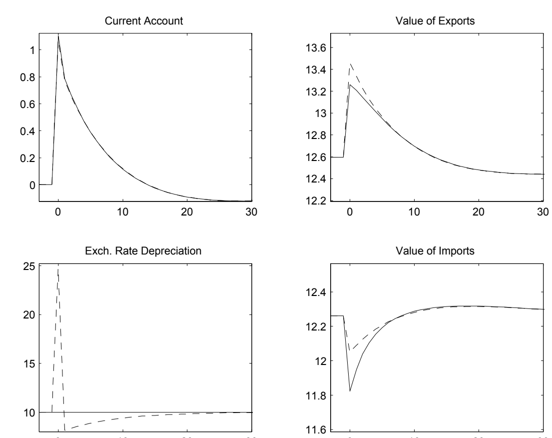

Figure 3g : Current Account

2. Closed Economy, $\bar{O} = 5\%$

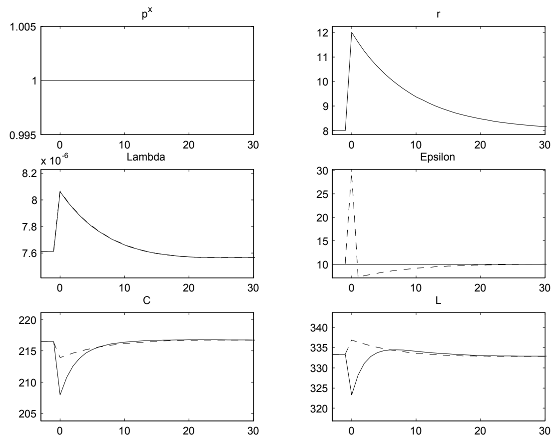

Figure 4a : Summary

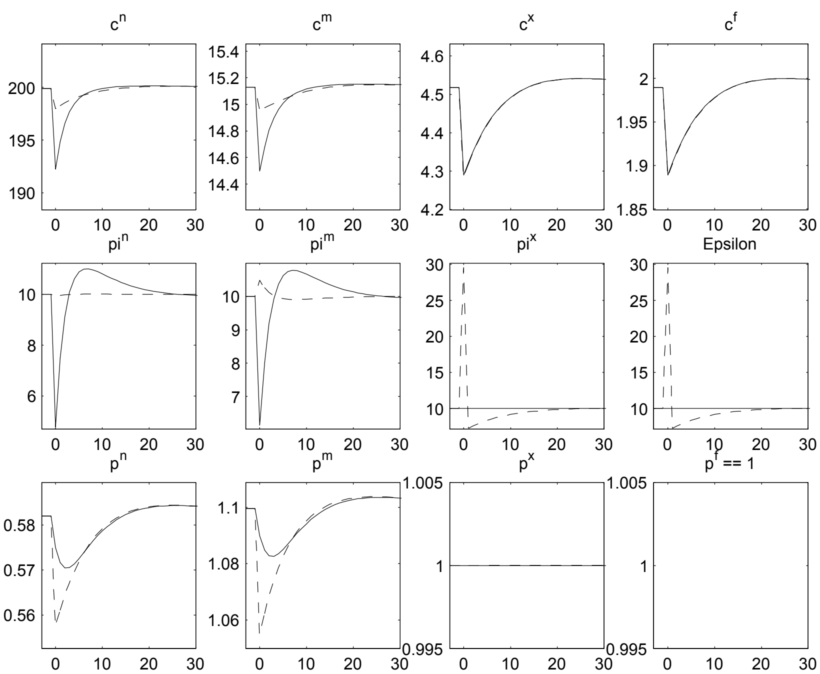

Figure 4b : Consumption

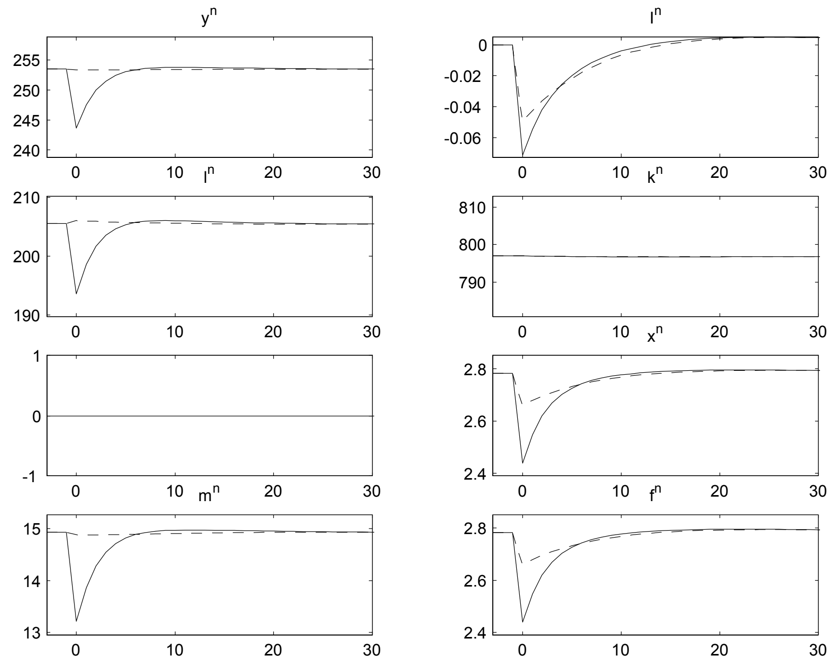

Figure 4c(i) : Nontradables Production

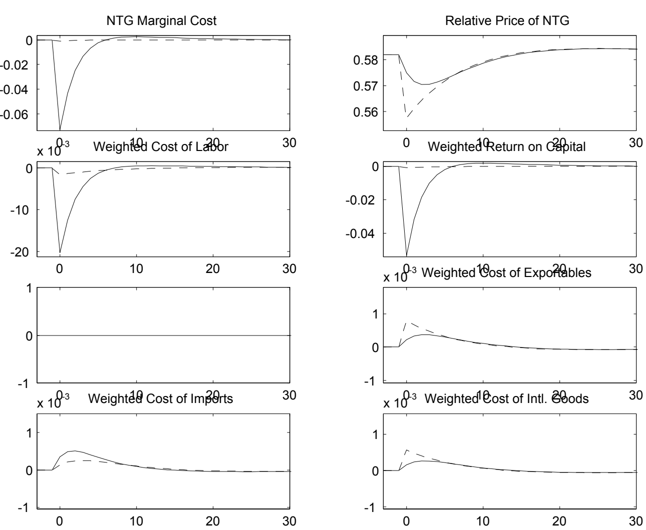

Figure 4c(ii) : Nontradables Marginal Cost

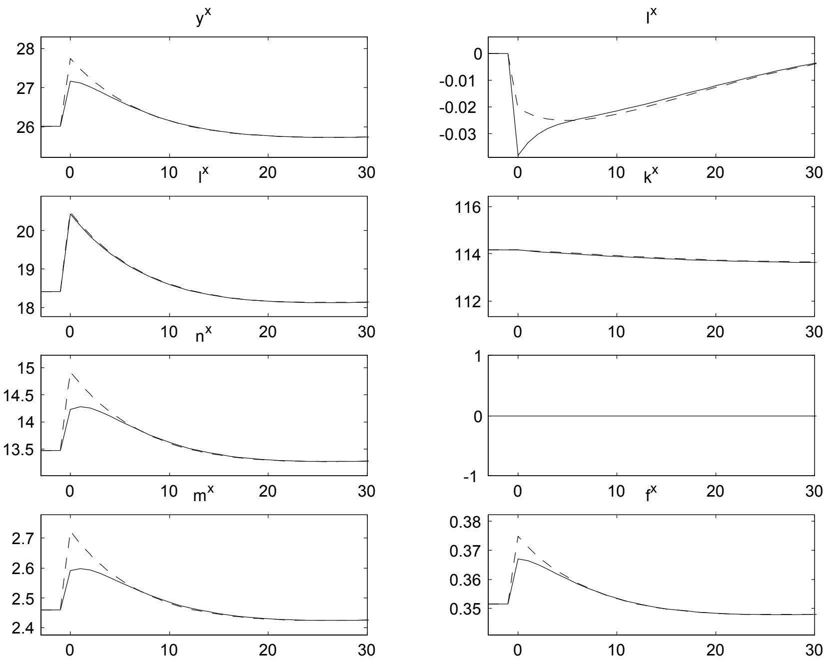

Figure 4d(i) : Exports Production

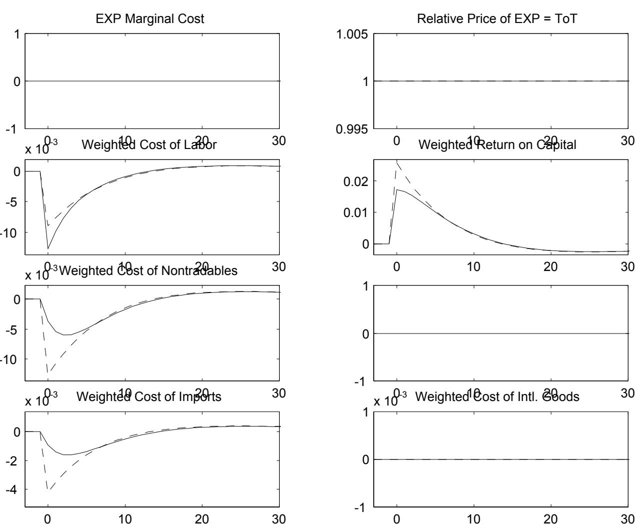

Figure 4d(ii): Exports Marginal Cost

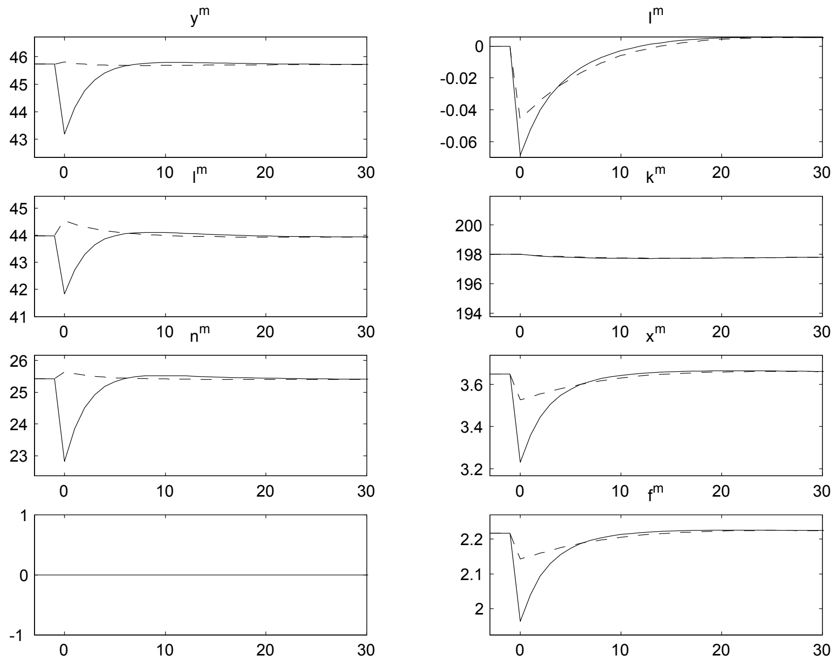

Figure 4e(i) : Imports Production

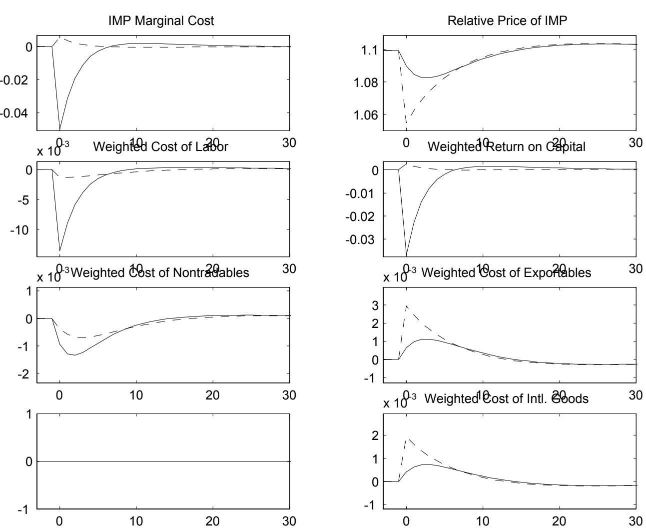

Figure 4e(ii): Imports Marginal Cost

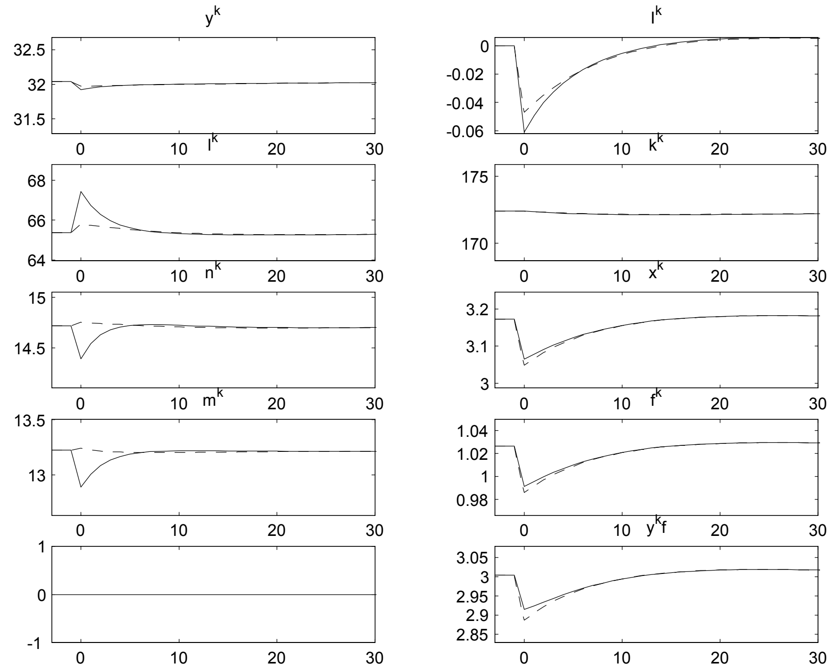

Figure 4f : Capital Goods Production

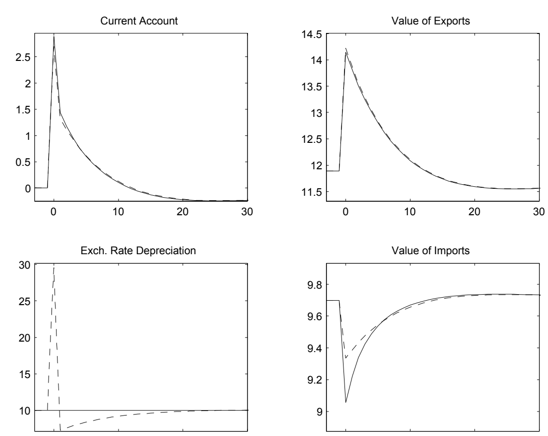

Figure 4g : Current Account

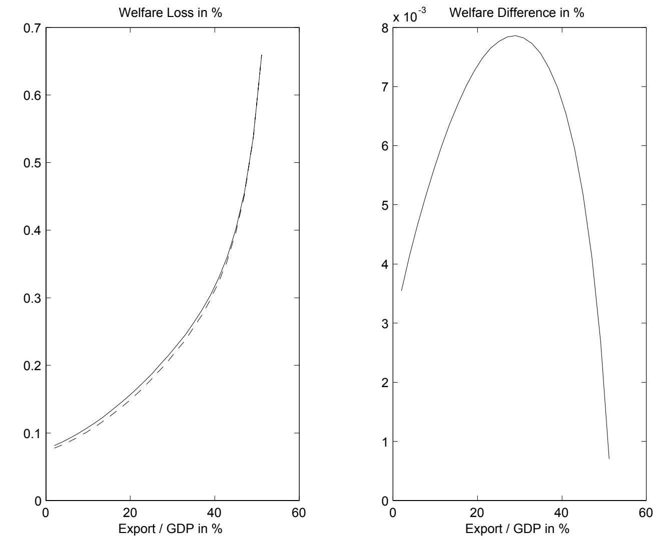

Figure 5a : Welfare, Flexible Wages

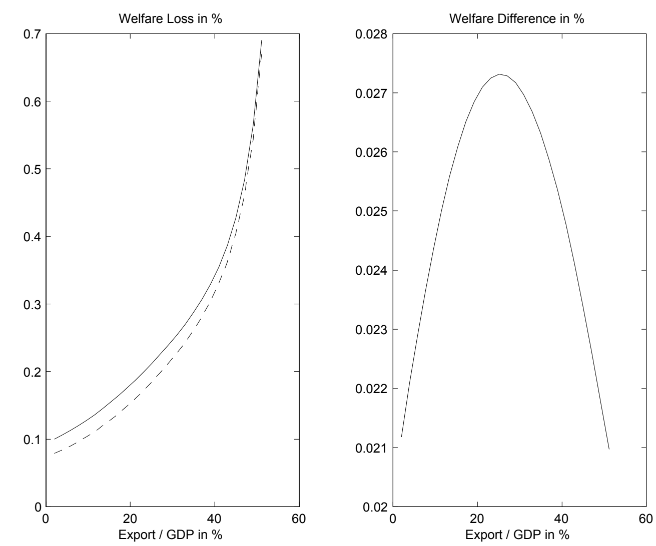

Figure 5b : Welfare, Rigid Wages