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EXCHANGE-RATE BASED INFLATION STABILIZATION: THE INITIAL REAL EFFECTS OF CREDIBLE PLANS

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ABSTRACT

This paper presents a dynamic general equilibrium model of a small, open, monetary economy in order to analyze the short-run effects of credible stabilization plans that fix the nominal exchange rate in a regime of free convertibility. In this model inflation acts as a tax on domestic market transactions. In particular, it generates a wedge between the rate of return on investment in domestic capital and the rate of return on investment in foreign assets. The model stresses the importance of adjustment costs (including gestation lags) in explaining the precise character of the initial dynamics. The main stylized facts of this type of programs namely an initial phase characterized by several months of real exchange rate appreciation, trade balance deterioration and expansion in aggregate demand and production, followed by a deflationary slowdown in real activity, are replicated without resorting to credibility problems, sticky prices, adaptive expectations, or gradual disinflation schemes. Finally, the model is calibrated using long-run relations from the Argentinean economy, and its quantitative predictions are compared to the initial effects of that country's Convertibility Plan of April 1991.

Exchange-Rate Based Inflation Stabilization: The Initial Real Effects of Credible Plans

Martín Uribe*

1 Introduction

This paper investigates the short-run dynamics of credible stabilization plans that permanently reduce the inflation rate by fixing the time path of the nominal exchange rate. Particular attention is given to the initial response of the real exchange rate, the trade balance and the components of aggregate demand.

During the late 70s and early 80s, several high-inflation countries adopted stabilization plans that fixed the time path of the nominal exchange rate. Well studied examples are the stabilization attempts in Argentina (1979-81 and 1985-86), Chile (1978-82) and Israel (1982-83 and 1985). All these stabilization attempts had similar initial real effects: the real exchange rate, defined as the price of traded goods in terms of nontraded goods, experienced a steady and long decline, the trade balance continuously deteriorated and aggregate demand boomed.[1]

A long literature has been devoted to the construction of models capable of explaining the initial effects of this type of stabilization plans. The theoretical explanations used in the late 70s

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[1]There is a large number of papers describing these episodes, here we suggest only a few of them. For the Argentinean case see Fernández (1985) and Sjaastad (1989). For the Chilean experience see Edwards (1985) and Corbo (1985) and for the Israeli, Bruno and Fischer (1986). Végh (1992) analyzes these and other episodes.

and early 80s were greatly influenced by the work of Rodríguez (1982) and Dornbusch (1982). In their models, adaptive expectations and sluggish adjustment in the market for home goods play a key role in generating the right initial effects.

Probably due to the fact that many of the stabilization attempts mentioned above were eventually abandoned, another important branch of this literature, pioneered by the work of Krugman (1979), Obstfeld (1984) and Calvo (1986) and further studied by Calvo (1987), Drazen and Helpman (1987) and Reinhart and Végh (1993a,b) among many others, analyzes rational expectations models in which the path of fiscal deficits expected at the moment the plan is implemented is too high to be consistent with the announced nominal exchange rate policy, so that a future departure from the exchange rate rule is expected by the public.[2] In these models inflation works as a tax on consumption. A temporary reduction of the inflation rate leads consumers to substitute current for future consumption generating an increase in current aggregate demand, a deficit in the current account and appreciation of the real exchange rate.

By contrast, this paper presents a model that is capable of replicating these initial real effects even if the stabilization plan is fully credible. That is, even if it is understood by the public that the announced path for the nominal exchange rate is sustainable. Such a model is of theoretical interest. One would like to know whether the real effects predicted by a model of a perfectly credible stabilization program are different from those predicted by a model of imperfect credibility. However, the model is of more than theoretical interest. The initial real effects described above were observed not only in stabilization episodes which lacked the necessary fiscal reforms to be sustainable over time (like the tablita plans of Uruguay and Argentina in the 70s), but also in stabilization episodes that were accompanied by important fiscal reforms at the outset of the plan (e.g., Israel in 1985, Mexico in 1987 and Argentina in 1991).

In our model inflation acts as a tax on domestic market transactions. In particular, it generates a wedge between the rate of return on investment in domestic capital and the rate of return on investment in foreign assets. This wedge causes the domestic capital stock to be decreasing in the rate of inflation. Hence, expectations of lower domestic inflation due to a reduction in the expected devaluation rate generate an expansion in aggregate demand and especially in private investment.

[2] Real effects of the type observed might also occur if some particular fiscal reform, rather than the abandonment of the exchange rate rule, is expected by the public. See Drazen and Helpman (1987, 1988).

As the supply of non-traded goods is relatively inelastic in the short-run, the relative price of the traded good in terms of the non-traded good (or the real exchange rate) falls and the trade balance deteriorates in a context of expansion in real activity. The model stresses the importance of adjustment costs in the accumulation of physical capital, including gestation lags, in explaining the precise character of the initial dynamics. In particular, the slow convergence of inflation.

Other authors have constructed models that capture some of the stylized facts of exchange rate based stabilization plans under the assumption of full credibility. Obstfeld (1985) and Roldós (1993) use continuous time models with money-in-the-utility-function (the former) and cash-in-advance constraints (the latter) to analyze the effects of credible stabilization plans that consist in a preannounced time path for the devaluation rate converging gradually from a high to a low level. This gradual convergence is crucial for their models to predict an initial phase of real exchange rate appreciation together with an expansion in aggregate demand.[3] The model developed in this paper displays real effects of the type observed in the data even if the devaluation rate is set at its long-run level right at the moment the plan is announced.

In a recent paper, Rebelo (1992) presents a real model with a similar production structure as the one discussed below (but for gestation lags), to analyze the recent Portuguese experience under a fixed exchange rate regime. In his paper, the initial expansion in aggregate demand is created by simply setting the initial level of the capital stocks low enough. In our model this initial conditions are endogenously determined. Our paper shows that inflation rates like the ones observed in Latin America in the last two decades can indeed generate distortions in domestic capital markets and wealth effects such that their elimination generates investment and consumption booms of the same magnitude as those actually observed.

After showing that our model can qualitatively replicate the observed behavior of key macroeconomic variables in the aftermath of inflation stabilization plans, we further test it by confronting its quantitative predictions with a particular stabilization episode, the Argentinean Convertibility plan of April 1991. In order to do so, the model is calibrated using long-run relations derived from that economy.

The remainder of the paper is organized as follows. Section 2 develops the model and defines a

[3]These models also predict a real exchange rate depreciation and a contraction in aggregate demand on impact, which are not observed in the data.

competitive equilibrium. Section 3 is devoted to the calibration of the model. Section 4 confronts the predictions of the model with actual data and section 5 concludes.

2 The Model

Consider a two-sector small open economy in which traded and nontraded goods are produced and consumed, and in which agents have access to a foreign-currency denominated bond that pays the exogenously given interest rate r. Assume also that at the beginning of each month the government announces the devaluation rate that will prevail within the period and commits itself to exchange domestic currency (pesos) for foreign currency (dollars) and vice versa at the corresponding exchange rate, defined as the price of one dollar in terms of pesos. In the next subsections we describe in detail the problem faced by each of the economic units of this economy.

2.1 Households

Each of the identical households of this economy is assumed to be formed by a shopper, a worker and an entrepreneur. The sequence of transactions and payments each period is as follows. At the beginning of each period the household has an initial wealth of x dollars and receives from the government a lump-sum transfer of τ dollars. At this point a financial market opens in which the household invests part of its wealth at the interest rate r and allocates the rest to buy traded and nontraded goods, g_H^T and g_H^N, (where T stands for traded, N for nontraded and H for household).

The shopper buys goods in a continuous fashion within the month and is subject to a domestic-cash-in-advance constraint. At this stage, however, we will simply assume that the cost incurred by the shopper for having to purchase goods in domestic currency in an inflationary environment is proportional to the volume of his monthly transactions. In particular, we will assume that in order to buy one dollar worth of goods, the shopper must spend $d^S(\varepsilon, q) > 1$ dollars, where $d^S(\cdot,\cdot)$ is increasing in both, the devaluation rate ε and the parameter q that measures the cost of reducing the exposure to inflation (the superscript S is for shopper). An explicit derivation of this function will be postponed until subsection 2.4. At the end of the month, the worker, who supplies inelastically H units of labor per period, and the entrepreneur, bring their income home.

The household's wealth at the beginning of $t+1$, is then given by

$$x_{t+1} = (1+r)\left[x_t + \tau_t - d^S(\varepsilon_t, q)(g_{Ht}^T + p_t g_{Ht}^N)\right] + \pi_t + w_t H \tag{1}$$

where p denotes the relative price of the nontraded good in terms of the traded good, π denotes profits and w the real wage. The dollar price of one unit of traded good is assume to be one and all dated variables in (1), except for ε, are measured in dollars. The household aggregates the traded and nontraded goods into a composite consumption good c through the following Cobb-Douglas aggregator

$$c_t = {g_{Ht}^T}^{\theta} {g_{Ht}^N}^{1-\theta} \tag{2}$$

The household seeks to maximize the following utility function defined over consumption sequences

$$\sum_{t=0}^{\infty} \gamma_t \frac{c_t^{1-\sigma}}{1-\sigma}$$

$$\text{with} \quad \gamma_{t+1} = \gamma_t(1+c_t)^{-\beta} \tag{3}$$

$$\text{and } \gamma_0 \text{ given}$$

where $\sigma > 1$ and $\beta > 0$. The assumption of an endogenous discount factor, which was first analyzed by Koopmans (1960), and more recently introduced in models of small open economies by Obstfeld (1981) and Mendoza (1991) among others, makes the deterministic steady state of the model independent of the initial level of wealth. This would not be the case with a constant discount factor, since the economy is assumed to face a constant rate of return on foreign assets.[4]

The household's problem then consists in choosing sequences $\{c_t, g_{Ht}^T, g_{Ht}^N, x_{t+1}, \gamma_{t+1}\}_{t=0}^{\infty}$, taking as given the sequences for transfers, real wage and profits, $\{\tau_t, w_t, \pi_t\}_{t=0}^{\infty}$, and the initial conditions x_0 and γ_0, so as to maximize (3) subject to (1), (2) and to a borrowing constraint that prevents it from engaging in Ponzi-type schemes. Since the utility function (3) is concave in the product topology (see Schmitt-Grohé (1993)), the solution to the household's problem consists in finding

[4] Alternative ways of obtaining a stationary steady state are to assume a positive probability of death as in Blanchard (1985), Helpman and Razin (1987) and Cardia (1991), or by assuming that the rate of return faced by the country as a whole is increasing in the nation's stock of debt, see Senhadji (1994).

sequences that satisfy (1), (2), (3) and the following first order conditions,

$$p_t = \frac{1-\theta}{\theta}\frac{g^T_{Ht}}{g^N_{Ht}} \tag{4}$$

$$\psi_{t+1} = (1+c_t)^{-\beta}(1+r)\psi_t \tag{5}$$

$$\lambda_t\theta(g^N_{Ht}/g^T_{Ht})^{(1-\theta)} = (1+r)d^S(\varepsilon_t, q)\psi_t \tag{6}$$

$$\mu_t = \frac{c_{t+1}^{1-\sigma}}{1-\sigma} + (1+c_{t+1})^{-\beta}\mu_{t+1} \tag{7}$$

$$\lambda_t = c_t^{-\sigma} + \mu_t\beta(1+c_t)^{-(1+\beta)} \tag{8}$$

where ψ, λ and μ are Lagrange multipliers associated with (1), (2) and with the expression describing the law of motion of the subjective discount factor in (3), respectively. The interpretation of the above first order conditions is straight forward. Equation (4) says that the marginal rate of substitution between traded and nontraded goods in producing consumption goods has to be equal to the relative price of the two inputs. The multiplier ψ represents the value, in terms of period-t utility, of one dollar available at the beginning of $t+1$. So (5) is a typical asset-pricing equation. The multiplier λ denotes the price, also in terms period-t utility, of one unit of the consumption good in t. Equation (6) then says that the consumer has to be indifferent between purchasing an extra unit of traded good for consumption today and buying $d^S(\varepsilon, q)$ units of a bond that earns the interest rate r in dollars between t and $t+1$. Equation (7) says that μ represents (the negative of) the level of utility of the household from period $t+1$ on. Finally, equation (8) says that the value of one unit of consumption in terms of current utility, λ, is given by the sum of the period marginal utility (the first term on the right hand side) and the product of the future utility, μ, times the effect of increasing current consumption on the discount factor.

2.2 Firms Producing Traded and Non-Traded Goods

These firms hire labor and capital and buy raw materials in perfectly competitive markets to produce traded and non-traded goods. Assume for the moment, that inflation acts as a tax on sales of goods. In particular, assume that for each dollar sold, the firm receives only $0 < d^F(\varepsilon, q, n) < 1$ dollars after paying for raw materials and for the inflation tax, where $d^F(\cdot,\cdot,\cdot)$ is decreasing in the devaluation rate ε, the parameter q, which, as in the case of the consumer, measures the cost of reducing the exposure to inflation, and in the parameter n that measures the importance of raw materials in gross output. Again, an explicit specification of this function will be postponed until subsection 2.4. Let k^T and H^T denote the demand for capital and labor services by firms producing traded goods. Define k^N and H^N in a similar way. We will assume that these two sectors have Cobb-Douglas production technologies. The problem of these firms consists in choosing input quantities so as to maximize profits, that is

$$
\begin{aligned}
&\max_{k^T H^T} \left\{ d^F(\varepsilon_t, q, n) \left[k_t^{T\alpha_T} H_t^{T1-\alpha_T} \right] - r_t^T k_t^T - w_t H_t^T \right\} \\
&\max_{k^N H^N} \left\{ p_t \, d^F(\varepsilon_t, q, n) \left[k_t^{N\alpha_N} H_t^{N1-\alpha_N} \right] - r_t^N k_t^N - w_t H_t^N \right\}
\end{aligned} \tag{9}
$$

where r^T and r^N are the rental prices of capital productive in the traded and nontraded sectors, and are expressed in dollars. The rental prices and the wage rate are paid at the end of each period. The first order conditions associated with these problems are

$$d^F(\varepsilon_t, q, n)\alpha_T (H_t^T / k_t^T)^{1-\alpha_T} = r_t^T \tag{10}$$

$$d^F(\varepsilon_t, q, n)(1 - \alpha_T)(k_t^T / H_t^T)^{\alpha_T} = w_t \tag{11}$$

$$p_t \, d^F(\varepsilon_t, q, n)\alpha_N (H_t^N / k_t^N)^{1-\alpha_N} = r_t^N \tag{12}$$

$$p_t \, d^F(\varepsilon_t, q, n)(1 - \alpha_N)(k_t^N / H_t^N)^{\alpha_N} = w_t \tag{13}$$

Note that we are implicitly assuming that labor is perfectly mobile across sectors but that capital is sector specific. These assumptions are spelt out in the next subsection.

Note that the factor $d^F(\varepsilon, q, n)$ is acting as a wedge between the rate of return on domestic investment and the rate or return on foreign assets. A stabilization program that permanently reduces the devaluation rate, ε, is then equivalent to a positive and permanent technology shock affecting only the domestic economy.

2.3 Firms Producing Capital

It is clear from the previous section that within the framework being developed so far, a permanent exchange-rate based stabilization program will be associated with an initial boom in domestic investment.[5] Although an initial boom in aggregate demand is necessary in order for the model to have any chance at replicating the stylized facts associated with this type of programs, it is clearly not sufficient. The actual booms look like the first half of an inverted U rather than like the first half of a U. The inverted-U shape in the initial dynamics of aggregate demand is also necessary in order to generate slow convergence in inflation and sustained real exchange rate appreciation. In this model this is accomplished by introducing adjustment cost, including gestation lags, in the accumulation of physical capital.

Adjustment costs have been extensively used in modeling the dynamics of small open economies, to avoid excess volatility in aggregate investment in response to technology shocks or to shocks to the real rate of return on foreign investment (see Mendoza (1991), Cardia (1991) and Schmitt-Grohé (1993)). In the context of a two-sector model like the one presented here, adjustment costs are also useful in avoiding excess volatility of sectorial investment in response to changes in relative prices. This is particularly important for the type of stabilization programs this paper is concerned with, for they are accompanied by substantial changes in the real exchange rate (the relative price of traded goods in terms of home goods).

The stocks of physical capital productive in each of the two sectors, k^T and k^N, are assumed to be produced by firms who sell their services at competitively determined rental prices r^T and r^N, paid at the end of each month. In order to build capital, these firms buy traded and nontraded goods, g_K^T and g_K^N (the subscript refers to the production of capital). As in the case of the household, these purchases are subject to an inflation tax. In particular, the effective price paid at the beginning of the period for each dollar worth of inputs is $d^S(\epsilon, q) > 1$. These inputs are then converted into investment good through the same Cobb-Douglas aggregator function as the one used by consumers.

The presence of gestation lags is modeled in the same way as is done in the traditional RBC literature (see for instance Kydland and Prescott (1982) and Backus, Kehoe and Kydland (1992)). Specifically, we will assume that in order to build s units of capital available J periods from t, the

[5] And also in aggregate consumption, as will be made clear in section 2.4.

household has to invest s/J units of the composite good for J consecutive periods starting in t.

We will further assume that firms have access to the international bond market. It then follows, from the consumer's optimal portfolio choice (equation (5)), that the price of one dollar held at the beginning of period t in terms of dollars at the beginning of period zero is given by $(1+r)^{-t}$. The problem of the producer of capital goods consists in maximizing the present discounted value of profits, that is[6]

$$\max \sum_{t=0}^{\infty}(1+r)^{-t}\left[(r_t^T k_t^T + r_t^N k_t^N)(1+r)^{-1} - d^S(\varepsilon_t, q)(g_{Kt}^T + p_t g_{Kt}^N)\right]$$

subject to

$$k_{t+J}^T = (1-\delta)k_{t+J-1}^T + s_t^T - \phi/2\frac{(k_{t+J}^T - k_{t+J-1}^T)^2}{k_{t+J-1}^T} \tag{14}$$

$$k_{t+J}^N = (1-\delta)k_{t+J-1}^N + s_t^N - \phi/2\frac{(k_{t+J}^N - k_{t+J-1}^N)^2}{k_{t+J-1}^N} \tag{15}$$

$$i_t^T = J^{-1}\sum_{i=0}^{J-1} s_{t-i}^T \tag{16}$$

$$i_t^N = J^{-1}\sum_{i=0}^{J-1} s_{t-i}^N \tag{17}$$

$$i_t^T + i_t^N = g_{Kt}^{T\ \theta} g_{Kt}^{N\ 1-\theta} \tag{18}$$

$$\text{given} \quad k_0^T,\ k_0^N,\ s_{-i}^T,\ s_{-i}^N \quad i = 0, 1, \ldots, J-1$$

where s_{t-i}^T and s_{t-i}^N denote the number of investment projects initiated in period $t-i$ that will be productive in period $t-i+J$ in the traded and non-traded sectors respectively, i^T and i^N denote the amount invested in the traded and nontraded sectors and are measured in terms of the composite good, and ϕ is an adjustment cost parameter. The first order conditions associated with this maximization problem are

$$p_t = \frac{1-\theta}{\theta}\frac{g_{Kt}^T}{g_{Kt}^N} \tag{19}$$

$$\nu_t = (1+r)^{-1}\frac{\nu_{t+1}\left[(1-\delta) + \phi/2[(k_{t+J+1}^T/k_{t+J}^T)^2 - 1]\right] + (1+r)^{-J} r_{t+J}^T}{1 + \phi(k_{t+J}^T/k_{t+J-1}^T - 1)} \tag{20}$$

[6]Rentals are collected at the end of each period, that is why they have to be multiplied by $(1+r)^{-1}$.

$$\nu_t = (1+r)^{-1}\frac{\nu_{t+1}\left[(1-\delta)+\phi/2[(k^N_{t+J+1}/k^N_{t+J})^2-1]\right]+(1+r)^{-J}r^N_{t+J}}{1+\phi(k^N_{t+J}/k^N_{t+J-1}-1)} \tag{21}$$

$$\nu_t = J^{-1}\sum_{i=1}^{J-1}(1+r)^{-i}d^S(\varepsilon_{t+i},q)\theta^{-1}(g^T_{Kt+i}/g^N_{Kt+i})^{1-\theta} \tag{22}$$

Equation (19) says that the producers of capital will use traded and nontraded inputs in a proportion such that the marginal rate of substitution in producing the composite good equals their relative price p. Equations (20) and (21) are asset pricing formulas stating that the dollar price of one unit of capital productive in period $t+J$, ν_t, equals the present value of the dividend it will generate in that period, r^T_{t+J}, plus the present value of the undepreciated part $(1-\delta)$, everything corrected for adjustment costs. Finally, equation (22) says that the dollar price of one unit of capital available in $t+J$ has to equal the present discounted value of the resources spent in producing it.

2.4 The Functions $d^S(\varepsilon,q)$ and $d^F(\varepsilon,q)$

One of the purposes of this paper is to use the model economy presented above to simulate the effects of an exchange-rate based stabilization plan and compare them with actual data. In order to do so, it is necessary to spell out an explicit theory for the cost functions $d^S(\varepsilon,q)$ and $d^F(\varepsilon,q,n)$. In a latter section, we will calibrate the parameters q and n in such a way that at the long-run inflation rate prevailing in the actual economy, the model and actual economies display the same money velocity and the same ratio of gross output to GDP.

Let us start with the function $d^S(\varepsilon,q)$. At the beginning of each month, the household chooses the amount of each type of good, g^T_H and g^N_H, to be consumed. These goods have to be purchased in a continuous fashion over the moth, and are subject to a domestic-cash-in- advance constraint. The shopper, however, can reduce his exposure to inflation by holding dollars, and exchange this dollars for pesos, at any time during the month, at the proportional shoe-leather or brokerage cost of q dollars per dollar of monthly transactions. We will refer to the number of times the household incurs in this cost as trips to the bank and will denote it by N^S. We will assume that changes in the relative price of the non-traded good, p, occur only at the beginning of each period.

If the devaluation rate prevailing during a given month is ε and the shopper decides to make

N trips to the bank, then the dollar value of each withdrawal is

$$(g^T + pg^N) \cdot \int_0^{\frac{i}{1+N}} e^{\epsilon i} di$$

and the dollar cost of each trip to the bank is

$$q \cdot (g^T + pg^N)$$

The total cost of buying goods is then given by N times the sum of these two expenses (we assume that getting pesos at the beginning of the month does not require a trip to the bank)[7]

$$\left[Nq + (N+1) \int_0^{\frac{i}{1+N}} e^{\epsilon i} di \right] (g^T + pg^N)$$

The optimal number of trips to the bank, N^S, is defined as the natural number that minimizes this expression with respect to N. It is easy to show that N^S exists. The function $d^S(\varepsilon, q)$ is then obtained by evaluating the factor multiplying $g^T + pg^N$ in the above equation at N^S. This same motivation can be given for the use of this function in the problem of the producer of capital.

We now turn to an explicit interpretation of the function $d^F(\varepsilon, q, n)$, which reflects the distortion created by inflation in the production of goods. We shall first state the cash-management problem faced by a firm that sells for domestic currency, a constant stream of y units of good at a price of p dollars per unit. This problem is symmetric to the one faced by consumers. Suppose that the firm can convert its peso-inflows in dollars at any point in time at the shoe-leather cost of $q \cdot yp$. If the devaluation rate is ε, and N the number of trips to the bank, then the real value of the firm's revenues measured at the end of the month is given by

$$\left[(N+1) \int_0^{\frac{1}{N+1}} e^{\epsilon[i - \frac{1}{N+1}]} di - Nq \right] py$$

Define the optimal number of trips to the bank, N^F, as the natural number that maximizes this expression with respect to N and the function $d^f(\varepsilon, q)$ as the expression multiplying yp, evaluated

[7]More precisely, one should take the present discounted value of these N transactions using the real rate r, as was done in an earlier draft of this paper (July (1994)). Since we are interested in cases for which ϵ is big compared to r (for example in the calibration exercise performed below ϵ =10% per month while r =10% per annum), the simplification adopted has no quantitative consequences.

at N^F.

We can now derive the demand for money in the presence of intermediate transactions. The motivation for introducing intermediate goods is the observed fact that firms hold much more money than do households. This fact is important in the present model, in which one of the sources of real effects of inflation stems from the distortions it creates in domestic capital markets. Consider first the following production structure. Suppose that in each sector (traded and nontraded) there are $n-1$ subsectors that produce intermediate materials m_i $(i = 1, 2, \ldots, n-1)$. Suppose also that the production of final goods requires capital, labor and materials from subsector $n-1$, that subsector $n-1$ produces materials using capital, labor and materials from subsector $n-2$ and so on, until subsector 1, which uses only capital and labor as inputs. Specifically, the structure we have in mind is as follows (for the moment we will drop the superscripts T and N because the problems are completely identical in both the traded and nontraded sectors. Time subscripts are also omitted)

$$
\begin{aligned}
m_1 &= k_1^{\alpha} H_1^{1-\alpha} \\
m_i &= \min\left\{k_i^{\alpha} H_i^{1-\alpha}, m_{i-1}\right\} \quad i = 2, \ldots, n-1 \\
y &= min\left\{k_n^{\alpha} H_n^{1-\alpha}, m_{n-1}\right\}
\end{aligned}
$$

where y denotes final output. We will refer to the subsector producing the final good as the n^{th} sector.

All transactions of intermediate materials and final goods are made in a continuous fashion during the month and are subject to domestic-cash- in-advance constraints. All firms are assumed to have access to the foreign exchange market at the proportional cost q and are unable to use the proceeds from their sales to pay for materials. Thus, they pay the effective price $d^S(\varepsilon, q)$ per dollar of materials purchased and get only $d^f(\varepsilon, q)$ per dollar sold. Wages and rentals are assumed to be paid at the end of each period. Let p_i $(1 \le i \le n)$ denote the relative price of one unit of the good produced in subsector i in terms of the final good produced in the sector (so $p_n \equiv 1$). The problem of a firm in subsector i, then, consists in choosing k_i and H_i so as to maximize its profits, which, measured at the end of the month are given by[8]

$$\left[p_i d^f(\varepsilon,q) - (1+r)p_{i-1} d^S(\varepsilon,q)\right] k_i^{\alpha} H_i^{1-\alpha} - rk - wH \qquad (23)$$

where $p_0 \equiv 0$. Comparing this expression with (9), it follows that $d^F(\varepsilon,q,n)$ is given by

$$d^F(\varepsilon,q,n) \equiv d^f(\varepsilon,q) - (1+r)p_{n-1} d^S(\varepsilon,q)$$

So we need to solve for p_{n-1}. The first order conditions associated with the maximization of (23) are

$$\left[p_i d^f(\varepsilon,q) - (1+r)p_{i-1} d^S(\varepsilon,q)\right] \alpha(H_i/k_i)^{1-\alpha} = r$$

$$\left[p_i d^f(\varepsilon,q) - (1+r)p_{i-1} d^S(\varepsilon,q)\right] (1-\alpha)(k_i/H_i)^{\alpha} = w$$

These conditions together with the Leontief technologies assumed for the production of value added, imply that all subsectors ($i = 1,\ldots,n$) will employ the same amount of capital and labor. Thus, the vector of relative prices $[p_1, p_2, \ldots, p_n]$ solves the following $n-1$ linear equations (recall $p_0 \equiv 0$ and $p_n \equiv 1$)

$$p_i d^f(\varepsilon,q) - (1+r)p_{i-1} d^S(\varepsilon,q) = p_{i-1} d^f(\varepsilon,q) - (1+r)p_{i-2} d^S(\varepsilon,q) \quad 2 \le i \le n$$

Summing up, we have that given values for ε, q and n, one can compute the number of trips to the bank N^S and N^f and the cost functions $d^S(\varepsilon,q)$, $d^f(\varepsilon,q)$ and $d^F(\varepsilon,q)$.

There are two other quantities one would like to be able to compute given values for ε, q and n. One is the gross-output-over-GDP ratio, (GOR), which is empirically observable and will be used to calibrate the parameter n, and the other is the total shoe-leather cost (SLC) incurred by consumers and firms in their effort to reduce their exposure to inflation. This cost is going to be one of the sources of expansion in aggregate demand in response to stabilization programs of the

[8]Note that $d^S(\varepsilon,q)$ measures the effective cost of each dollar bought of materials at the beginning of the month, that is why it appears multiplied by $(1+r)$.

type we are going to analyze. The first quantity is given by

$$GOR = 1 + \sum_{i=1}^{n-1} p_i \tag{24}$$

The total shoe-leather cost, measured in dollars at the beginning of each month, is given by the sum of cost of all trips to the bank made during that month by firms and households

$$SLC = q\left\{N^S\left[(g^T + pg^N) + (y^T + py^N)\sum_{i=1}^{n-1} p_i\right] + N^F(y^T + py^N)\sum_{i=2}^{n} p_i\right\} \tag{25}$$

where $g^T \equiv g_H^T + g_K^T$ and $g^N \equiv g_H^N + g_K^N$.

2.5 Competitive Equilibrium

We will define a competitive, perfect foresight equilibrium for this economy as sequences $\{c_t, \gamma_t, x_{t+1}, H_t^T, H_t^N, k_{t+J}^T, k_{t+J}^N, s_t^T, s_t^N, g_{Ht}^T, g_{Ht}^N, g_{Kt}^T, g_{Kt}^N, \pi_t, \tau_t, d^S(\varepsilon_t, q), d^F(\varepsilon_t, q, n)\}_{t=0}^{\infty}$, prices $\{p_t, w_t, r_t^T, r_t^N\}_{t=0}^{\infty}$ and initial conditions γ_0, x_0, k_0^T, k_0^N, s_{-i}^T, s_{-i}^N, $(i = 1, 2, \ldots, J-1)$ such that:

(i) Given sequences for prices, transfers, profits and the devaluation rate, $\{p_t, w_t, \tau_t, \pi_t, \varepsilon_t\}_{t=0}^{\infty}$ and initial conditions x_0, and γ_0, the sequences $\{c_t, \gamma_t, x_{t+1}, g_{Ht}^T, g_{Ht}^N\}_{t=0}^{\infty}$, solve the households problem, that is, they satisfy (1), (2), (4)-(8) and a borrowing constraint that prevents the household from engaging in Ponzi-type schemes.

(ii) Given prices for final goods and inputs and the devaluation rate p_t, w_t, r_t^T, r_t^T, and ε_t, the demands for inputs H_t^T, H_t^N, k_t^T, and k_t^N, maximize the profits of the producer of final goods, (9), that is, they satisfy (10)-(13).

(iii) Given sequences for prices and devaluation rate p_t, w_t, r_t^T, r_t^T, and ε_t, and initial conditions k_0^T, k_0^N, s_{-i}^T, s_{-i}^N, $(i = 1, 2, \ldots, J-1)$, the sequences k_{t+J}^T, k_{t+J}^N, s_t^T, s_t^N, solve the problem of the capital producer, that is, they satisfy (14)-(22).

(iv) In each period $t \geq 0$ profits are given by

$$\pi_t = (r_t^T k_t^T + r_t^N k_t^N) - (1 + r)d^S(\varepsilon, q)(g_t^T + p_t g_t^N)$$

(v) The labor market and the market for nontraded goods clear:

$$n(H_t^T + H_t^N) = H \tag{26}$$

$$g_{Ht}^N + ng_{Kt}^N = k_t^{N\alpha_N} H_t^{N1-\alpha_N} \tag{27}$$

(vi) The evolution of lump-sum taxes and of the devaluation rate are such that the government does not engage in Ponzi type schemes.

(vii) The evolution of aggregate per-household foreign asset holdings, call it b_t, is given by

$$b_{t+1} = (1+r)b_t + y_t^T - (g_{Ht}^T + ng_{Kt}^T) - SLC_t \tag{28}$$

where $y^T \equiv k^{T\alpha_T} H^{T^{1-\alpha_T}}$ denotes final output in the traded good sector and SLC is the shoe-leather cost associated with inflation and was explicitly defined in the previous section (equation (25)).

3 Calibration

Following King et al. (1988), Kydland and Prescott (1982) and many other authors in the equilibrium business cycle literature, we will use long-run empirical relations and model restrictions to identify the underling parameters of the model. Table 2 presents a summary of the results of this section. The time unit is a month. We will use data from the Argentine economy for the two decades preceding the Convertibility plan (1970-90). The average inflation rate over this period was 10.2% per month. In what follows, variables without a time subscript refer to steady state values.

3.1 The parameter of the aggregator function, θ

Equations (4) and (19) can be written as

$$\frac{1-\theta}{\theta} = \frac{g^T}{pg^N}$$

The steady state ratio of the trade balance over GDP, in turn, can be written as

$$tb \equiv \frac{y^T - g^T}{y^T + py^N}$$

Let θ^T denote the steady-state ratio of traded output over GDP, that is

$$\theta^T \equiv \frac{y^T}{y^T + py^N}$$

For the Argentine economy tb averaged 2.7%,[9] and θ^T 42% over the calibration period.[10] The above three relations can be solved for θ in terms of the long-run relations tb and θ^T. The value obtained was 0.4.

3.2 The proportional transaction cost q and the parameter n

The strategy followed to calibrate q is to set it at a level such that at the average inflation rate prevailing in Argentina during the calibration period, the model predicts the same money velocity as the actual average M1 velocity.

We will first get an expression for the average real balances held by those who shop for goods. That is, the household, who buys $g_H^T + pg_H^N$, the producer of capital, who buys $n(g_K^T + pg_K^N)$ and the producers of final and intermediate goods who buy materials for $(y^T + py^N)\sum_{i=1}^{n-1} p_i$, where p_i is the relative price of materials produced in subsector i in terms of the final good of that sector. These real balances, expressed as a fraction of total purchases at a point h between two consecutive trips to the bank, are given by

$$m^S(h, \varepsilon, q) = \int_h^{\frac{1}{1+N^S}} e^{\varepsilon(j-h)}\, dj = \frac{e^{\varepsilon(\frac{1}{1+N^S} - h)} - 1}{\varepsilon}$$

[9] See FIEL, various issues.

[10] The sectors considered traded were Agriculture, Manufacturing Industry and Mining. Data on sectorial output was obtained from FIEL, on sectorial employment from "La Cuestión Ocupacional Argentina: Una Evaluaci n de la Situaci n Actual y de Perspectivas Hacia Fines del Siglo XX" Instituto de Investigaciones Econ micas de la C.G.E., January 1989 and on the economy- wide labor share from "Estad sticas de la Evoluci n Económica de Argentina: 1913-1984" Estudios No. 39 (1986).

and average real balances are then given by

$$m^S(\varepsilon,q) = (1+N^S)\int_0^{\frac{1}{1+N^S}} m^S(h,\varepsilon,q)\,dh = \frac{(1+N^S)(e^{\frac{\varepsilon}{1+N^S}}-1)-\varepsilon}{\varepsilon^2}$$

A similar calculation can be carried out to obtain the average real balances held by firms and originated in their sales of final or intermediate goods, that is $(y^T + py^N)(1+\sum_{i=1}^{n-1} p_i)$. Expressed as a fraction of sales, these real balances are given by

$$m^f(\varepsilon,q) = \frac{(1+N^F)(e^{-\frac{\varepsilon}{1+N^F}}-1)+\varepsilon}{\varepsilon^2}$$

The average money velocity, v, is then given by

$$v = [(1-tb+\sum_{i=1}^{n-1} p_i)\,m^S(\varepsilon,q) + (1+\sum_{i=1}^{n-1} p_i)\,m^f(\varepsilon,q)]$$

The geometric average of money velocity, as measured by the ratio of annual GDP to real M1, was 15.4.[11] The relative prices p_i depend on the devaluation rate ε, on the international real interest rate r, and on the number of subsectors producing intermediate materials, $n-1$. The interest rate r was set at 6.5% per year, which is the number reported by King et. al. (1988) for the average equity return in the US for the period 1958-81. Given a value for n, one can choose q so as to make the value of money velocity predicted by the model equal to the actual figure. A value for n was chosen so as to make the ratio of gross output over GDP predicted by the model, GOR (see equation (24)) equal to the actual one, 2.96. This figure was obtained from an input-output table.[12] The values for q and n obtained in this way were .27% of monthly income and 6 respectively.

Table 1 shows the percentage difference between $d^F(0,q,n)$ and $d^F(\varepsilon,q,n)$ for different values of ε when q and n are set at their calibrated values of .27% and 6. This measure represents the size of the inflation tax rate on domestic value added, or the wedge introduced by inflation between the rate of return on domestic investment and the rate of return on foreign assets. Table 1 also

[11] FIEL, various issues. M1 was deflated by the Consumer Price Index. Dornbusch and De Pablo (1987, page 147, table C.14) also report data on money velocity for Argentina. Their series stops in 1986. The geometric average of their data for the period 70-86 is 13.5. When we restrict our calculation to this same period, we get an average of 13.2. The larger figure obtained when we include the period 87-90, is due to the very depressed real balances associated with the hyperinflations of 1989 and 1990.

[12] See United Nations, Industrial Development Organization (1985). This number was computed as the ratio of entries (32,31) over (29,31) both on page 23 of the cited source.

shows the total shoe-leather cost born by the economy (equation (25)) as a percentage of GDP. At the average monthly inflation rate of 10.25% prevailing in Argentina in the period 1970-1990, the inflation tax rate on value added was around 11% and the dead-weight cost of inflation 5.6% of GDP.

3.3 The parameters of the production functions: α_T and α_N

Write (11) and (13) in the following way,

$$\alpha_T = 1 - \frac{wH^T n}{y^T}\left[d^F(\varepsilon, q, n)\right]^{-1}$$

$$\alpha_N = 1 - \frac{wH^N n}{py^N}\left[d^F(\varepsilon, q, n)\right]^{-1}$$

where $\frac{wH^T n}{y^T}$ and $\frac{wH^N n}{py^N}$ are the labor shares in the traded and nontraded sectors, which for Argentina were estimated at 0.48 and 0.63 respectively.These figures together with the expression for $d^F(\varepsilon, q, n)$ derived in 2.4 and the values for n and q obtained in 3.2, imply $\alpha_T = .45$ and $\alpha_N = .28$.

3.4 The adjustment cost parameter ϕ and the number of gestation lags, J

The adjustment cost parameter ϕ was set at 25. This value ensures positive sectorial gross investment during the initial phase of the stabilization experiments analyzed below. The number of gestation lags was arbitrarily set at 2 years (J =24). We performed sensitivity analysis on these two parameters to assess their importance in explaining the precise character of the transitional dynamics.

3.5 The depreciation rate δ

The share of investment in GDP, s_i, which averaged 17% during the calibration period, can be used to identify the depreciation rate. By definition s_i can be written as

$$s_i \equiv \left[\frac{i^T n}{y^T}\theta^T + \frac{i^N n}{py^N}(1-\theta^T)\right]\left[\theta(g^N/gT)^{1-\theta}\right]^{-1}$$

where $[\theta(g^N/gT)^{1-\theta}]^{-1}$ is the relative price of the composite good in terms of traded goods. From (14)-(17), it follows that in the steady state, $i^T = \delta k^T$ and $i^N = \delta k^N$. From (10) and (12), in turn, it follows that $k^T/y^T = \alpha_T d^F(\varepsilon, q, n)/r^T$ and $k^N/(py^N) = \alpha_N d^F(\varepsilon, q, n)/r^N$ and from (20) and (21) that $r^T = r^N$. Finally, we can use these relations together with (20) and (22) to write s_i in the following form involving only δ as an unknown

$$s_i = \frac{\delta\, r\, J\, n\, d^F(\varepsilon, q, n)}{d^S(\varepsilon, q)[(1+r)^J - 1](r+\delta)} [\alpha_T \theta^T + \alpha_N (1 - \theta^T)]$$

The implied value for δ is 9.52% per year.

3.6 The parameters of the utility function β and σ

Finally, given the parameters obtained in (3.1)-(3.5), one can solve for the steady state of most of the endogenous variables of the model, among them consumption. Given this value one can use (5) to identify the parameter β. In steady state this equation becomes

$$1 = (1+c)^{-\beta}(1+r)$$

The implied value was β =0.01.

Using a model of a small open, endowment economy, Reinhart and Végh (1993a,b) estimate an intertemporal elasticity of substitution of around 0.2 for the Argentinean economy. We picked this number for $1/\sigma$.

4 The short-run dynamics of credible stabilization plans

In this section we first describe very briefly the main elements and effects of the Argentinean Convertibility Plan of April 1991. Then we simulate the response of the model presented above to a stabilization program of the same type and compare the actual and simulated results.

4.1 An example: The Argentinean Convertibility plan of April 1991

In April 1991 the Argentinean government ended a long period of high inflation by launching a stabilization plan that pegged the local currency to the US dollar.[13] The program had, as a crucial

[13]The Convertibility Act, passed by the parliament, obliged the Central Bank to exchange one peso for one dollar.

ingredient, an important fiscal reform that took place right from the outset. The fiscal deficit of the federal government (before income from privatization) was reduced from an average of 8.4% of *GDP* in the period 1985-90 to 1.5% in the period 1991-92 (see figure 1).

The initial effects of the plan on the inflation front were impressive. The inflation rate of the first twelve months of the plan was 30.2% if measured by the consumer price index and only 5.2% if measured by the wholesale price index. The inflation rate corresponding to the twelve months preceding the announcement had been 288.5%.

The initial effects were also important on the real side. Consider first the effects on relative prices. The ratio of the nominal exchange rate over the consumer price index, which can be thought of as a crude measure of the relative price of traded goods in terms of non-traded goods, went down steadily since April of 1991 and in the first year and a half of the plan decreased by 24.4%, see figure 2(a). Figure 2(b) shows the same measure of the real exchange rate but corrected by foreign CPI inflation. In this case it is also evident that the real exchange rate appreciated continuously since the implementation of the plan. For a basket of currencies (including dollar, German mark, yen, cruzeiro, lira and pound) this appreciation was 17.5% during the first 18 months of the plan. As a third measure of changes in relative prices, consider the ratio of the consumer price index over the wholesale price index: the CPI increased by 38.2% in the first six quarters of the plan while the WPI rose by only 7.4%, see figure 2(c). Since the CPI covers many more services than does the WPI, the behavior of the ratio of these two indices also supports the idea that the relative price of traded goods went down as a result of the stabilization program.

The monthly merchandise trade balance, in turn, declined sharply since the Convertibility Plan was launched, see Figure 3(a). In November of 1991 it became negative for the first time in ten years and stayed so until January 1993, with the exception of June 1992 when it was slightly positive. Figure 3(b) shows annual data for private capital inflows in billions of dollars. The negative figures in the period previous to 1991 contrast with the sharp positive figures of around 3 billion dollars in 1991 and 8 billion in 1992.

At the same time economic activity expanded during the initial phase. *GDP* grew by 8.9% in 1991 and by 8.6% in 1992 (see figure 4). This expansion was by no means even across sectors. The agricultural and mining sectors, which might be considered typical traded sectors, grew by only 1.4% in 1991, while the sector composed by wholesale and retail trade, restaurants, hotels, transportation, communications, storage, financial institutions, insurance and real estate (a typical nontraded sector) grew by 10.4% in the same period. On the other hand, all components of domestic private absorption expanded during the first two years of the plan (see again figure 4). Total consumption increased by 12.6% in 1991 and by 10.8% in 1992. Gross investment, in turn, grew by 25.1% in 1991 and by 30.9% in 1992. This increase, though, was not enough to reach the investment levels of the early 80s. Finally, the trade balance in merchandise and services displayed a similar declining pattern as the only-merchandise trade balance. It also became negative for the first time since the tablita plan of Martínez de Hoz in the early 80s.

4.2 The simulated response of the model

In this subsection we show the simulated response of the model to a stabilization plan that reduces the devaluation rate permanently from 24% to 0% per month. The pre-stabilization inflation rate of 24% per month corresponds to the average inflation over the four years preceding the Convertibility Plan. The simulation is carried out in the following way: we assume that at the instant the plan is announced the economy is at a steady state corresponding to a monthly inflation rate of 24%, and trace the dynamic path of the variables of interest to a zero-inflation steady state. In order to do so, we log-linearized the model around the new, slow- inflation steady state and fed as initial conditions for the state variables (capital stocks and foreign asset holdings) those corresponding to the high-inflation steady state. The log-linearization technique follows King et. al. (1988).

In this model the real effects of inflation stem from two sources. First, inflation acts as a tax on investment in domestic capital (or as a tax on domestic value added) because local firms use domestic currency as working capital to buy materials, and receive only domestic cash for their sales of goods. Second, inflation generates wealth effects since it induces firms and consumers to spend resources in trying to evade it. Table 1 shows that at the pre-stabilization inflation rate of 24% per month, the tax on domestic value added was 18%. Equivalently, the pre-stabilization rate of return on domestic investment was almost a fifth higher than the rate of return on foreign assets. The total shoe-leather cost of inflation, which is equivalent to a lump-sum tax, was around 11% of GDP. The elimination of these two distortions are the driving forces behind the initial dynamics of the inflation stabilization experiment.

Figure 5 shows the initial response of the trade balance, the real exchange rate (as measured by the relative price of tradables in terms of non-tradables), consumption, total and sectorial investment and capital inflows. The main features of this figure are that all variables behave as observed in the data, that is, the trade balance deteriorates continuously for several periods, the real exchange rate falls and a boom occurs in consumption, investment and capital inflows. Moreover, the model predicts an initial period characterized by sustained inflation, i.e., it captures the slow-convergence feature which seems to be one of the most important stylized fact of exchange-rate based stabilization programs. This effect is mainly due to the presence of gestation lags and adjustment costs in the production of capital. These two elements cause aggregate demand to be increasing over time and since in the short-run the supply of non-tradables is relatively inelastic, the result is an increasing path for the relative (and nominal) price of home goods.

In order to visualize the importance of gestation lags and adjustment costs in inducing the right path of the real exchange rate, we next show the initial dynamics for different values of the adjustment cost parameter and of the number of gestation lags. Panel (a) of figure 6 shows the dynamics of the real exchange rate when the number of gestation lags is reduced from the baseline value of 24 months to only 2 months. In this case the initial dynamics are characterized by an increase in the real exchange rate on impact, followed by a steady decline, or equivalently, by an initial increase in nominal prices followed by many periods of deflation, which is clearly at odds with the observed behavior of prices during the initial phase of exchange-rate based inflation stabilization programs.[14] In panel (b) of the same figure, we show what might go wrong if the adjustment cost parameter, ϕ, is made too small. The increased profitability in the non-traded sector at the beginning of the plan, induces agents to increase investment in this sector and to reduce it in the traded sector. If adjustment costs are made too small, gross sectorial investment could turn negative.

Table 3 provides a quantitative comparison of the predictions of the baseline model with the performance of the Convertibility Plan during its first two years of existence. The model does relatively well in replicating the magnitude of the real exchange rate appreciation (16% predicted versus 22% actual), of the investment boom (32% predicted versus 29% actual) and of the consumption boom (14% predicted versus 20% actual). On the other hand, it predicts a much bigger

[14] In a model without gestation lags, Rebelo (1992) explores the possibility of generating slow convergence of inflation by introducing productivity shocks in the tradable sector and shocks in the government demand for nontradables, with mixed results.

deterioration in the trade balance than the actually observed (16% of GDP predicted versus 7% actual). A detailed description of the way in which these initial effects were measured is provided at the bottom of table 3.

Finally, table 4 displays sensitivity analysis for the adjustment cost parameter, the pre-stabilization inflation rate, and the proportional cost of each trip to the bank. Of these parameters, the only one that was assigned an arbitrary number to was the adjustment cost parameter ϕ. The only variable that is significantly sensitive to changes in ϕ is, not surprisingly, aggregate investment.

5 Summary and Conclusions

This paper presents a model of a small open economy capable of explaining the stylized facts of exchange-rate based stabilization programs without resorting to credibility problems, adaptive expectations, sticky prices or gradual disinflation of the nominal exchange rate. The model is calibrated to match long-run data relations of the Argentinean economy, and its quantitative behavior is compared to the initial effects of that country's Convertibility Plan of April 1991. Its predictions for the initial real exchange rate appreciation, trade balance deterioration and expansion in consumption and investment are of the same order of magnitude as those actually observed.

It is worth mentioning that the model also predicts that the initial phase of expansion in economic activity caused by a credible stabilization plan is followed by a deceleration, a real exchange rate appreciation (which under a fixed exchange rate regime means deflation) and a slowdown in capital inflows. This deflationary period takes place because the increased investment in the non-traded sector becomes productive after some periods of gestation, expanding the supply of home goods. Similarly, the slowdown in capital inflows is due to the fact that the return on domestic investment decreases with the expansion of the stock of domestic physical capital. The policy implications of my hypothesis under which endogenous capital inflows increase and then decrease are very different from those of other hypothesis that attribute both the initial real exchange appreciation and the subsequent deflation to exogenous capital inflows which are temporary in nature (see Calvo, Leiderman and Reinhart (1993) on this interpretation).

Finally, the results of this paper should be interpreted as an explanation of the effects of reducing high inflation by pegging the nominal exchange rate when this peg is not only sustainable, but also believed to be so by the public. The requirement of an initial high level of inflation is crucial. Because of the channels through which inflation creates distortions and wealth effects in this model, it is more applicable to cases of stabilization of extreme inflation like those of Argentina, Mexico and Israel in the mid 1980s and early 1990s, than to cases of stabilization of mild inflation like those of Spain, France, Italy or Portugal in the same period (see Rebelo (1994) on this).

References

Backus, David, Kehoe, Patrick, and Kydland, Finn E., "International Real Business Cycles," *Journal of Political Economy,* August 1992, 100 pp. 745-775.

Blanchard Olivier, "Debt, Deficits and Finite Horizons," *Journal of Political Economy,* 1985, 223-47.

Bruno, Michael and Stanley Fischer, "The Inflationary Process: Shocks and Accommodation," in Y. Ben-Porath, Ed., *The Israeli Economy: Maturing Through Crises,* Cambridge Mass.: Harvard University Press 1986: pp. 347-374.

Calvo, Guillermo A., "Temporary Stabilization: Predetermined Exchange Rates," *Journal of Political Economy,* 1986, 94 pp. 1319-29.

Calvo, Guillermo A., "Balance-of-Payments Crises in a Cash-in-Advance Economy," *Journal of Money, Credit and Banking,* February 1987, 19 pp. 19-32.

Calvo, G. A., L. Leiderman and C. M. Reinhart, "Capital Inflows and Real Exchange Rate Appreciation in Latin America: The Role of External Factors," *IMF Staff Papers,* March 1993, 40 pp. 108-151.

Cardia, Emanuela, "The Dynamics of a Small Open Economy in Response to Monetary, Fiscal and Productivity Shocks," *Journal of Monetary Economics,* December 1991, 28 pp. 411-34.

Corbo, V., "Reforms and Macroeconomic Adjustment in Chile During 1974-84," *World Development,* 1985, 13:8.

Dornbusch, Rudiger, "Stabilization Policy in Developing Countries: What Lessons Have We Learnt?," *World Development,* September 1982, special issue 10 pp. 701-8.

Dornbusch, Rudiger and Pablo, Juan Carlos de, "Debt and Macroeconomic Instability in Argentina," in Sachs, Jeffrey D. (Ed.), *Developing Country Debt and Economic Performance. Volume 2,,* Chicago and London, The University of Chicago Press, 1987, pages x, 565.

Drazen, Allan and Elhanan Helpman,, "Stabilization with Exchange Rate Management," *Quarterly Journal of Economics,* 1987, 11 pp. 835-55.

Drazen, Allan and Elhanan Helpman,, "Stabilization with Exchange Rate Management Under

Uncertainty," in Elhanan Helpman, Assaf Razin and Efraim Sadka (Eds.), *Economic Effects of the Government Budget,*, Cambridge, The MIT Press 1988: 835-55.

Edwards, Sebastian,, "Stabilization with Liberalization: An Evaluation of Ten Years of Chile's Experience with Free Market Policies: 1973-1983," *Economic Development and Cultural Change,* 1985, 33 pp. 223-54.

FIEL (Fundacion de Investigaciones Econ micas Latinoamericanas), "Indicadores de Coyuntura," , Buenos Aires, Argentina, (several issues).

Fernández, Roque B., "The Expectation Management Approach to Stabilization in Argentina, 1976-82," *World Development,* August 1985, 13 pp. 871-92.

Helpman, Elhanan, and Assaf Razin, "The Role of Saving and Investment in Exchange Rate Determination Under Alternative Monetary Mechanisms," *Journal of Political Economy,* 1984, 13 pp. 307-325.

Helpman, Elhanan, and Assaf Razin, "Exchange Rate Management: Intertemporal Tradeoffs," *American Economic Review,* 1987, 77 pp. 107-123.

Kiguel, Miguel A., "Inflation in Argentina: Stop and Go Since the Austral Plan," *World Development,* 1991, 19 pp. 969-986.

King, R. G., C. L. Plosser and S. T. Rebelo, "Production, Growth and Business Cycles I: The Basic Neoclassical Model," *Journal of Monetary Economics,* May 1988, 21 pp. 191-232.

Koopmans, Tjalling C., "Stationary Ordinal Utility and Impatience," *Econometrica,* 1960, 28 pp. 287-309.

Krugman, Paul R., "A Model of Balance-of-Payments Crisis," *Journal of Money, Credit and Banking,* 1979, 11 pp. 311-25.

Kydland, Finn E., and Prescott Edward C, "Time to Build and Aggregate Fluctuations," *Econometrica,* November 1982, 50 pp. 1345-70.

Mendoza, Enrique G., "Real Business Cycles in a Small Open Economy," *American Economic Review,* September 1991, 81 pp. 797:818.

Novedades Económicas, Córdoba Argentina, various issues.

Obstfeld, Maurice, "Macroeconomic Policy, Exchange Rate Dynamics And Optimal Asset accumulation," *Journal of Political Economy,* 1981, 89 pp. 1142-1161.

Obstfeld, Maurice, "Balance-of-Payments Crises and Devaluation," *Journal of Money, Credit and Banking,* 1984, 16 pp. 208-17.

Obstfeld, Maurice, "The Capital Inflows Problem Revisited: A Stylized Model of Southern Cone Disinflation," *Review of Economic Studies,* 1985, 52 pp. 605-625.

Reinhart Carmen M. and Végh Carlos A., "Intertemporal Consumption Substitution and Inflation Stabilization: An Empirical Investigation," mimeo IMF, January 1993(a).

Reinhart Carmen M. and Végh Carlos A., "Nominal Interest Rates, Consumption Booms and Lack of Credibility: A Quantitative Examination," mimeo, IMF, 1993(b).

Rodríguez, Carlos A., "The Argentine Stabilization Plan of December 20th," *World Development,* September 1982, special issue, 10 pp. 801-11.

Rebelo, Sergio, "Inflation In Fixed Exchange Rate Regimes: The Recent Portuguese Experience," Institute for International Economic Studies, Sweden, seminar paper # 517, (July 1992), *Forthcoming in Torres F. and F. Giavazzi, "Adjustment and Growth in the European Monetary Union"*, Cambridge University Press, 1993.

Rebelo, Sergio, "What Happens When Countries Peg Their Exchange Rates? (The Real Side of Monetary Reforms)," mimeo, May 1994.

Roldós, Jorge E., "On Credible Disinflation," Manuscript, IMF, April 1993.

Senhadji, Abdelhak S., "Sources of Debt Accumulation in a Small Open Economy," mimeo Washington University School of Business, June 1994.

Sjaastad, Larry A., "Argentine Economic Policy, 1976-81," in G. di Tella and R. Dornbusch, Eds., *The Political Economy of Argentina, 1946-83,* Pittsburgh: University of Pittsburgh Press 1989, pp. 254-275.

United Nations, Industrial Development Organization, "Input-Output Tables for Developing Countries, Volume II," New York, United Nations, 1985.

Végh, Carlos A., "Stopping High Inflation: An Analytical Overview," *IMF Staff Papers,* September 1992, 39:3 pp. 626-695.

Table 1: The distortions and wealth effects of long-run Inflation

devaluation ε (% per moth)	distortion $\left[\frac{d^F(0,q,n)}{d^F(\varepsilon,q,n)} - 1\right]$ x 100	wealth effect Shoe-leather cost (% of GDP)
1	2.33	1.91
5	7.08	3.76
10	10.87	5.57
15	13.69	7.35
20	16.03	9.11
25	18.09	10.84
30	19.94	11.65
35	21.58	12.46
40	23.12	13.26
45	24.52	14.06
50	25.85	14.84

q=.27% of monthly transactions is the cost of one trip to the bank.
n=6 is the number of sectors producing value added.

Table 2: Calibration

Parameter	Description	Value
	(A) Long-run data relations	
ε	Inflation rate (% per month)	10.2
v	Annual Money velocity ($M1/(CPI \cdot GDP)$)	15.4
r	Real return of foreign assets (% per annum)	6.5
tb	Trade balance over GDP ratio (%)	2.6
s_i	Investment share in GDP (%)	17.0
θ^T	Traded-good output share in GDP (%)	41.8
$\frac{wH^T}{y^T}$	Labor share in the traded good sector (%)	48.0
$\frac{wH^N}{py^N}$	Labor share in the home good sector (%)	63.0
GOR	Gross output over GDP ratio	3
	(B) Calibrated Parameters	
$-\beta$	Elasticity of the discount factor with respect to (1+c)	-.01
$-\sigma$	Consumption elasticity of the period marginal utility	-5
θ	Traded-good elasticity of the aggregator function	0.4
α_T	Capital elasticity of traded output	0.45
α_N	Capital elasticity of non-traded output	0.28
δ	Depreciation rate (% per year)	9.52
q	Cost of one trip to the bank (% of monthly income)	0.27
n	Number of sub-sectors producing value added	6
	(C) Non-calibrated Parameters	
J	Number of gestation lags (months)	24
ϕ	Adjustment cost parameter	25

Table 3: Comparison of the model's predictions with actual data

	Real Exchange Rate (RER)	Trade Balance (TB)	Investment (I)	Consumption (C)
Data	-22.80	-7.10	29.10	20.40
Model	-16.15	-16.69	32.94	14.72

DATA
RER denotes the percentage increase in the real exchange rate between the march 1991 and march 1993.
TB denotes the trade balance of 1992 minus the average trade balance over the 4 years previous to the Convertibility Plan, 1987-90, as a percentage of the average GDP over that period.
I denotes the percentage difference between investment in 1992 and the average investment in the period 1987-90;
C denotes the change in aggregate consumption measured in the same way as I.
Source: TB, C and I, Central Bank of Argentina; RER, Novedades Economicas (basket of currencies).
Note: In the case of RER, march 1991 rather than the average over 1987-91 was chosen as a basis because the outliers occurred during the hyperinflations of mid 1988 and late 1989 completely dominate the average;

MODEL
RER denotes the percentage change in the real exchange rate, the price of tradables in terms of nontradables, between the second year of the stabilization plan its value previous to the plan.
TB denotes the change of the trade balance between the second year of the Plan and the high-inflation steady state as a percentage of output at the high-inflation steady state.
C and I denote consumption and investment in terms of the composite good and their initial response was calculated in the same way as with RER.

Table 4: Sensitivity Analysis

	Real Exchange Rate (RER)	Trade Balance (TB)	Investment (I)	Consumption (C)
Data	-22.80	-7.10	29.10	20.40
ϕ	Varying the adjustment cost parameter			
1	-14.40	-14.22	14.15	14.96
5	-16.28	-16.88	34.19	14.69
10	-16.57	-17.16	36.53	14.67
25	-16.15	-16.69	32.94	14.72
50	-15.39	-15.92	26.97	14.80
100	-14.48	-15.06	20.20	14.87
175	-13.78	-14.41	15.11	14.91
250	-13.37	-14.04	12.25	14.93
500	-12.72	-13.45	7.74	14.95
ε	Varying the devaluation rate (% per month)			
5	-6.25	-6.01	11.49	5.28
15	-11.89	-11.82	24.57	10.20
25	-16.15	-16.69	32.94	14.72
35	-18.80	-19.65	42.80	16.85
45	-21.13	-22.39	51.69	18.89
q	Varying the cost of each trip to the bank (% of monthly income)			
0.05	-8.88	-7.91	14.12	7.10
0.10	-11.84	-11.13	19.28	10.12
0.27	-16.01	-16.47	32.87	14.48
0.50	-18.32	-20.42	42.48	17.97
1.00	-21.21	-27.47	44.15	26.20

See description of actual and simulated data at the bottom of table 3

Figure 1

Argentina: fiscal deficit of the federal government

(before income from privatization)

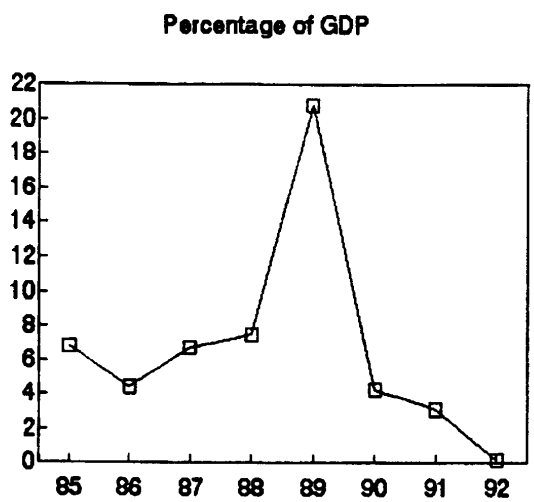


Figure 2

Three simple measures of real exchange rate appreciation

since the convertibility.

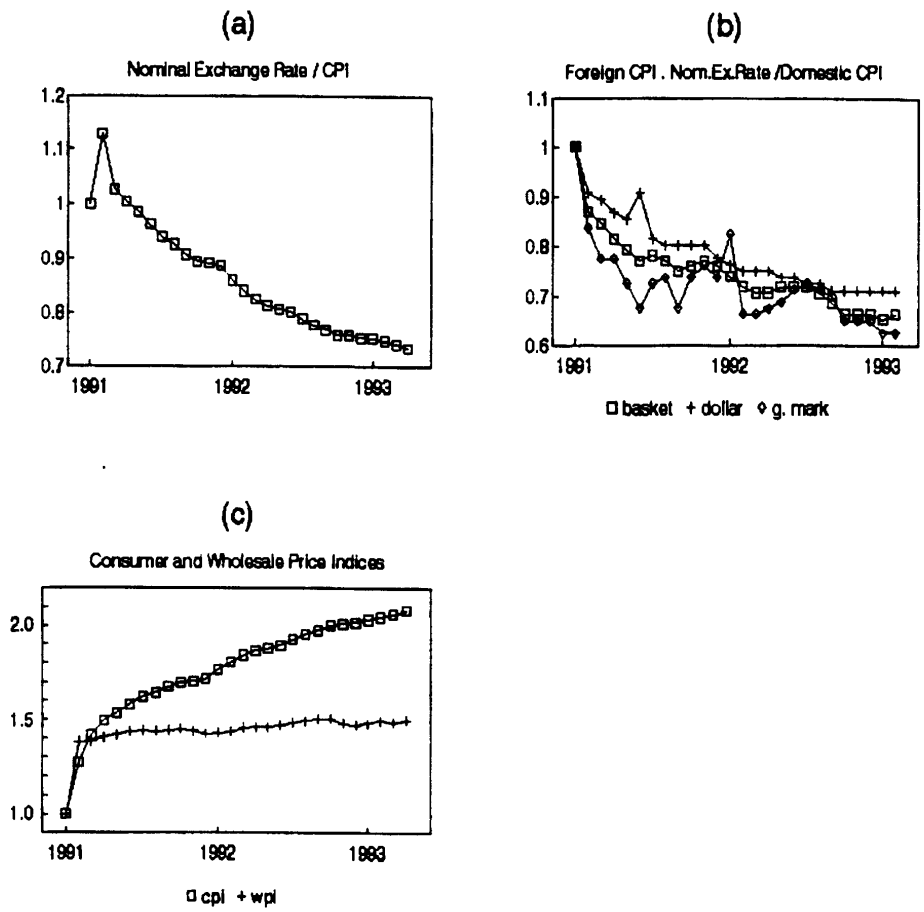


Figure 3
Argentina: trade balance in goods and private capital inflows

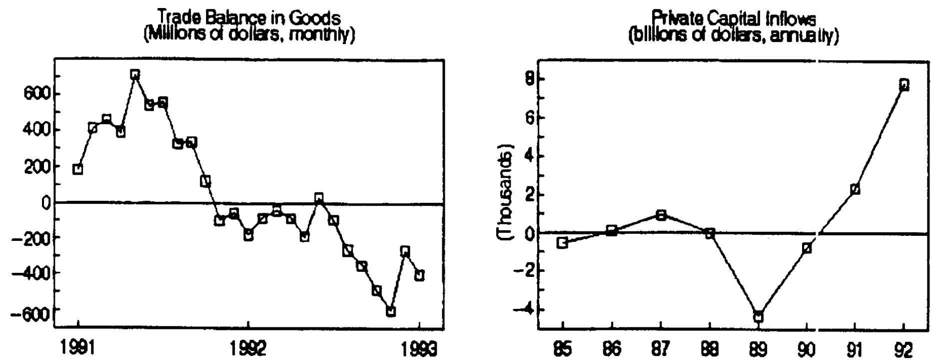
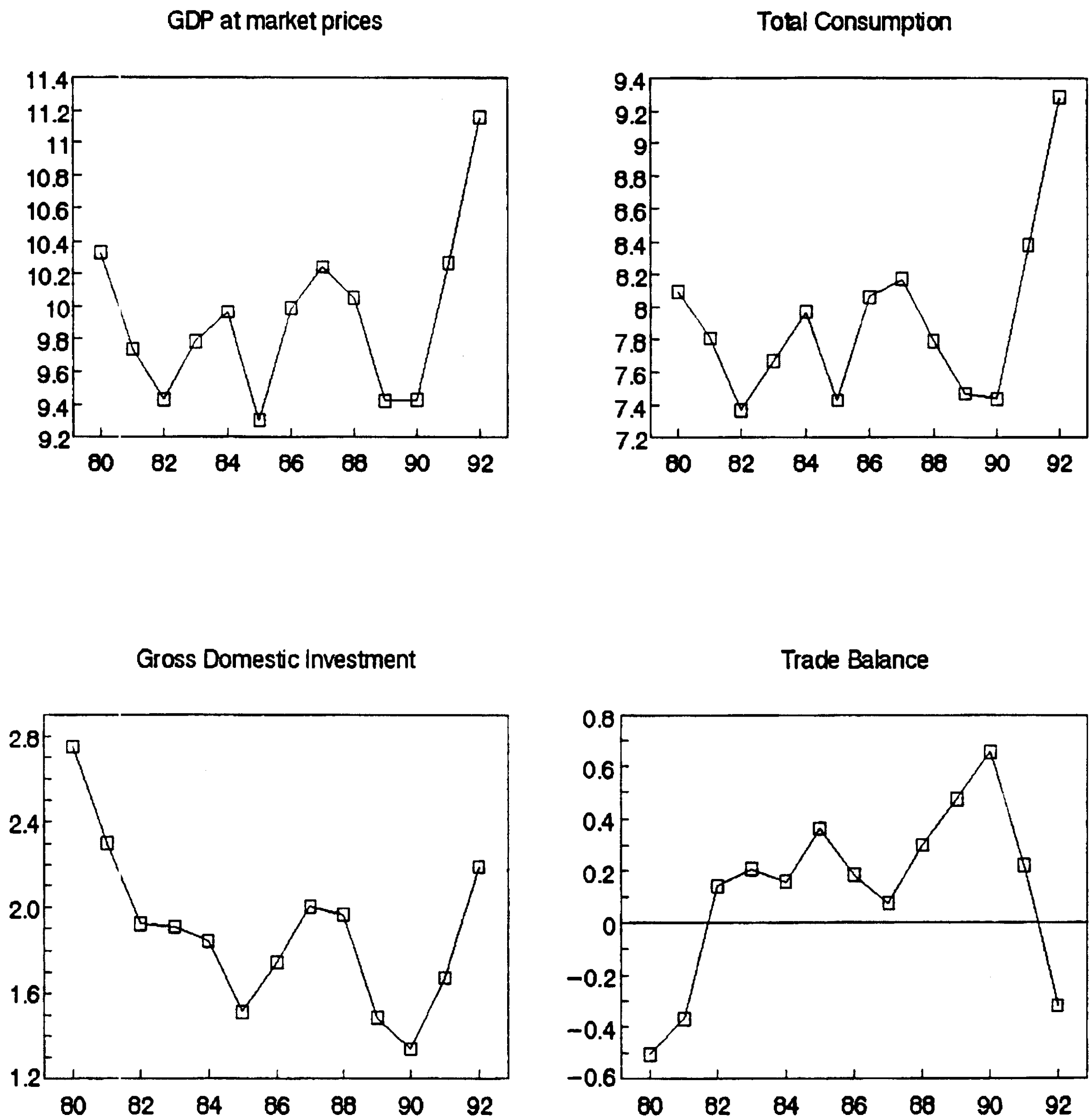


Figure 4

Initial effects of the convertibility plan on aggregate supply and demand

(annual data in millions of Pesos of 1986)



Source: Central Bank of Argentina

Figure 5

The initial dynamics as predicted by the model

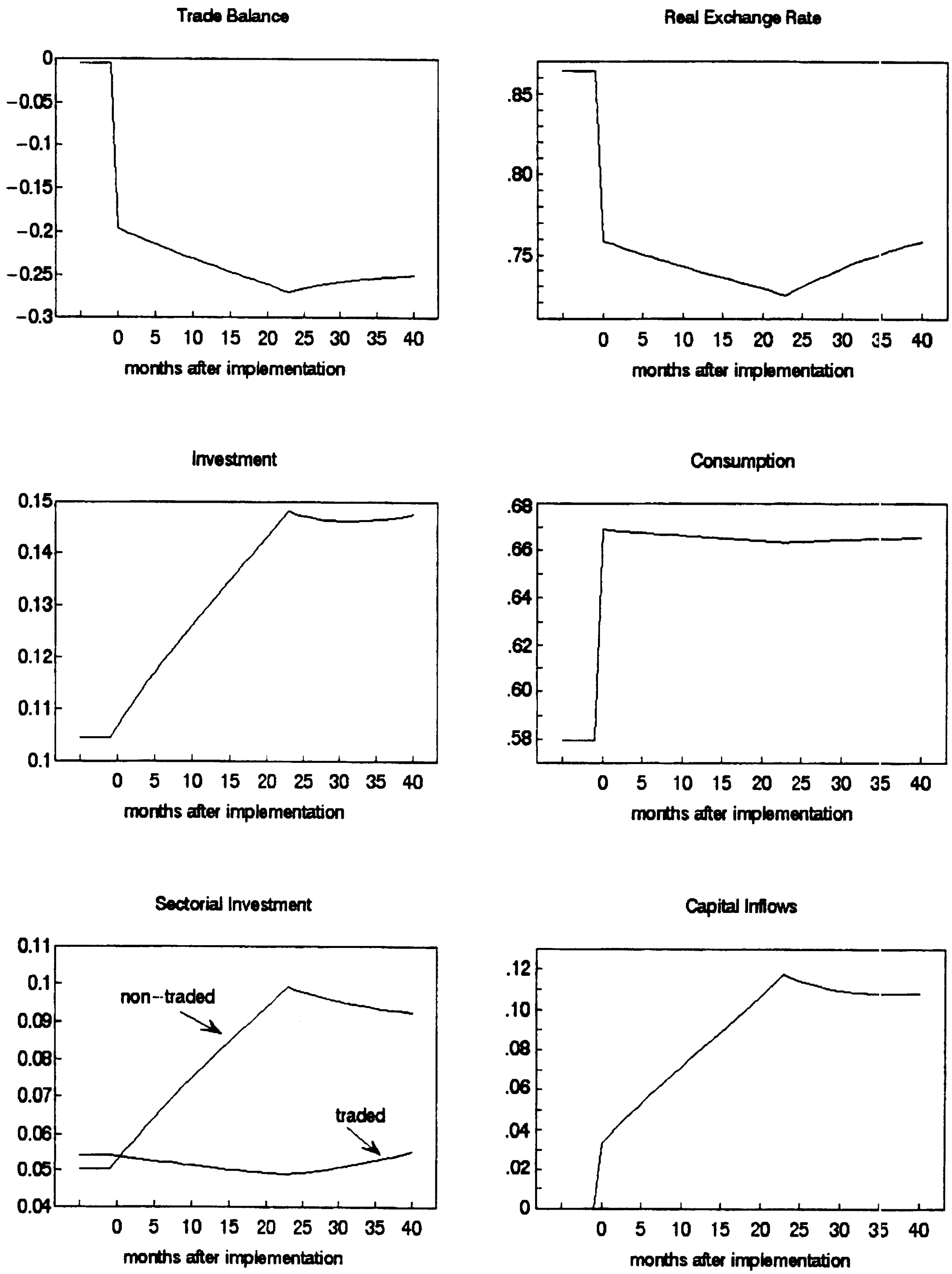
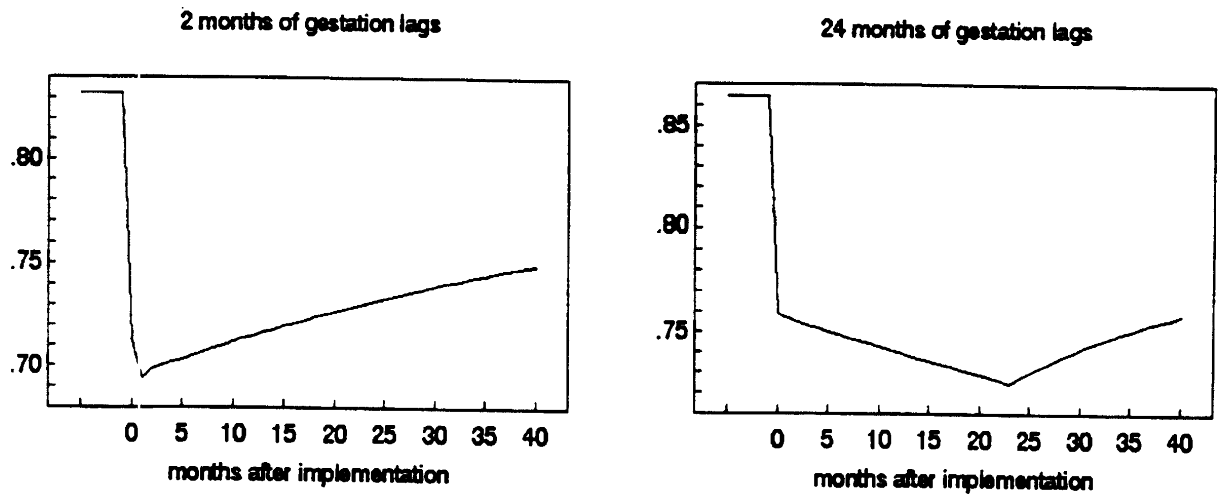


Figure 6

The role of gestation lags and adjustment costs

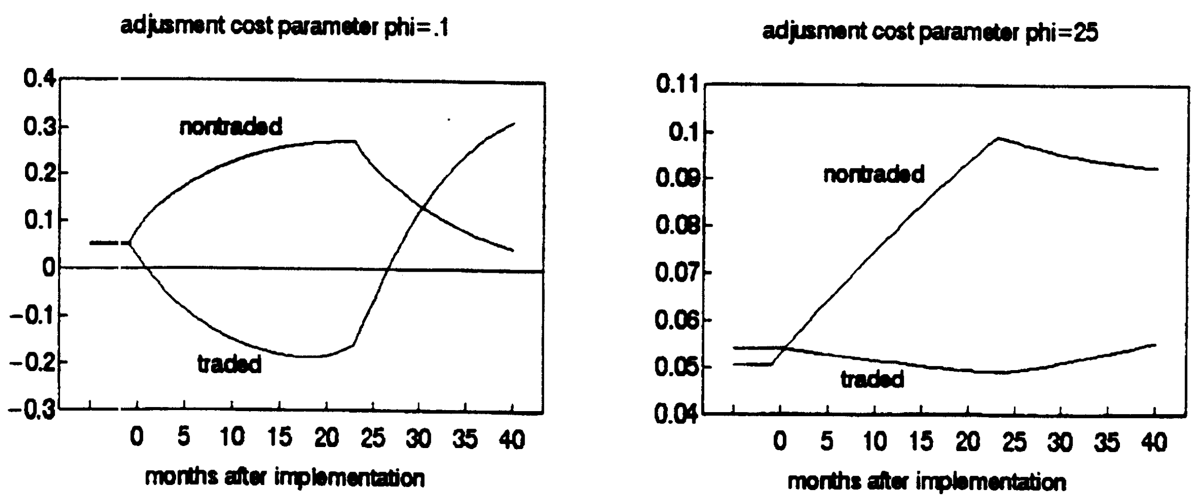
Panel (a)

The number of gestation lags and the response of the real exchange rate



Panel (b)

Adjustment costs and the response of sectorial investment



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