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Exchange-Rate-Based Inflation Stabilization: The Initial Real Effects

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ABSTRACT

The goal of this paper is to analyze the short-run effects of credible stabilization plans that fix the nominal exchange rate in a regime of free convertibility. The model presented succeeds in replicating 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, without resorting to neither credibility problems nor to gradual desinflation schemes (or tablitas). In the dynamic general equilibrium model proposed, inflation acts as a tax on domestic market transactions. In particular, it generates a wedge between the rate of return of investment in domestic capital and the rate of return of investment in foreign assets. The model stresses the importance of adjustment costs (including time-to-build) in explaining the precise character of the initial dynamics. Finally, the model is calibrated using long-run relations from the Argentinean economy, and its predictions are compared to the initial effects of that country's Convertibility Plan of April 1991.

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1. INTRODUCTION

The goal of this paper is to investigate 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 will be given to the initial response of the real exchange rate, the trade balance and the level of economic activity.

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 economic activity increased[1].

A long literature has been devoted to construct theoretical models capable of explaining the initial effects of this type of stabilization plans. The theoretical explanations used in the late 70s 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 most of stabilization attempts mentioned above were eventually abandoned, another important branch of this literature, pioneered by the work of Krugman (1979), Obstfeld (1984) and Calvo (1985) and further studied by Calvo (1986), Drazen and Helpman (1987) and Reinhart and Végh (1993 a,b) among many others, uses rational expectations models in which the fiscal deficit at the moment the plan is implemented is too high to be consistent with the announced time path of the nominal exchange rate, so that a future departure from the exchange rate rule is expected by the public. In this models inflation works as a tax on consumption. A temporary reduction of the inflation rate leads consumers to substitute current for future

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[1]There is a large number of papers describing these episodes, here I suggest only a few of them. For the Argentinean case see Sjaastad (1989) and Fernández (1985); for the Chilean experience see Edwards (1985) and Corbo (1985) and for the Israeli Bruno and Fischer (1986). The effects on private investment are analyzed in Solimano (1990).

consumption generating an increase in current aggregate demand 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 over time. The main motivation for building such a model is that the initial real effects mentioned above were also observed in stabilization episodes for which the hypothesis of lack of credibility did not seem plausible due to the presence of important fiscal reforms at the outset of the plan. In this paper I argue that an example of such an episode is the Argentinean Convertibility Plan of April 1991.

In this model inflation acts as a tax on domestic market transactions. In particular, it generates a wedge between the rate of return of investment in domestic capital and the rate of return of investment in foreign assets. This 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. This creates the conditions for the real exchange rate to appreciate and the trade balance to deteriorate 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.

Other authors have constructed models that capture some of the stylized facts 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 (the later) and analyze the effects of credible stabilization plans consisting in announcing a 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 expansion in aggregate demand[2]. The model developed in this paper displays real effects of the type observed in the data even if

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

the devaluation rate is set at its long-run level right at the moment the plan is announced (which is also a feature of the Argentinean Convertibility plan of 1991)[3].

Finally, the model will be calibrated using long-run relations derived from economic time series for the Argentinean economy for the twenty years preceding the plan of April 1991. The calibrated model will be then used to generate predictions for the initial response of key macroeconomic variables to a stabilization plan of the type described above.

The rest of the paper is organized as follows. Section 2 presents the model and defines a competitive equilibrium. In section 3 the model is calibrated and the method chosen to approximate the rational expectations dynamics is described. Section 4 presents the predictions of the model to a stabilization plan consisting in reducing the devaluation rate forever and compares them to the initial response of the Argentinean economy to the Convertibility Plan of April 1991. Section 5 closes the paper with some conclusions.

2. A Baumolian Model of a Dollarized Small Open Economy.

2.1. The Household

Each of the identical households of this economy is assumed to be formed by a shopper, a worker and two entrepreneurs; one produces capital goods and the other intermediate traded and non-traded goods. The sequence of transactions and payments each period is as follows. At the beginning of each month the household has some cash carried over from last period, m, and receives in cash a lump-sum transfer (or tax) from the government, of τ dollars. It also has foreign currency from the return on its savings in a risk-free bond denominated in the foreign currency, b^H, which pays the exogenously given interest rate r^*, and rights on physical capital. At this point it has to decide how many units of the foreign bond to buy and how much domestic cash ('pesos'), dc, and foreign cash ('dollars'), fc, to hold. This portfolio operation costs q^H dollars (which can be thought of as a fee paid to a foreign

[3]After the first draft of this paper was completed, my attention was brought to a paper by Rebelo (1992) in which a model with a similar production structure to the one presented here is used to analyze the recent Portuguese experience under a fixed exchange rate regime.

broker). So we have the following constraint (all quantities are expressed in dollars):

$$(1) \qquad b^H_{t+1} + dc_t + fc_t + q^H_t \le (1+r^*)b^H_t + m_t + \tau_t$$

The household uses the cash to finance a continuous stream of purchases (performed by the shopper) of traded and nontraded goods, g^T and g^N, during the month. This purchases have to be paid for in domestic currency. The household, however, can exchange pesos for dollars at any time within the month at the brokerage cost of q^H. Let p be the price of the nontraded good in terms of the traded good, then if the household decides to make N^H equally spaced financial transaction, the dollar cost of its purchases between two consecutive transactions is given by,

$$\int_0^{1/N^H} e^{\varepsilon h} \, (g^T_t+p_t g^N_t) \, dh = \varepsilon^{-1}(e^{\varepsilon/N^H} - 1)(g^T_t+p_t g^N_t)$$

Where ε is the nominal devaluation rate during period t. Note that I am assuming that no changes in relative prices can occur *within* the month. The household chooses N^H so as to minimize the total cost of its purchases,

$$(2) \qquad N^H = \underset{N}{\operatorname{argmin}} \left\{ Nq^H_t + N\varepsilon^{-1}(e^{\varepsilon/N} - 1)(g^T_t+p_t g^N_t) \right\}$$

It is easy to see that the expression in brackets is continuous and strictly convex for N>0 and goes to infinity as N approaches either zero or infinity, so the problem is well defined. It is also well defined if we restrict N to be an integer greater than zero.

The household aggregates the intermediate goods g^T and g^N into a final good g using a linearly homogeneous "aggregator function" $A:\mathbb{R}^2_+ \to \mathbb{R}_+$, so that $g=A(g^T,g^N)$. Part of g is kept by the household for consumption, c, and the rest is taken by the capital-good producer who uses it as investment, i^T and i^N, which in turn augment the capital stocks productive in the tradable, k^T, and nontradable sector, k^N.

The capital-good producer rents capital to the intermediate-good producer who pays, in domestic cash and at the end of the period, competitively determined rental prices r^T and r^N for the capital stock productive in the tradable and nontradable sectors respectively (r^T and r^N are expressed in dollars).

The producer of intermediate goods hires labor (H^T for the production of the traded good and H^N for the production of the non-traded good) for which he pays the nominal wage W in domestic cash at the end of the month, and demands physical capital services k^{Td} and k^{Nd} to produce a continuous stream of traded and nontraded goods, y^T and y^N, which are sold at money prices e and P^N respectively, where e is the nominal exchange rate (I will assume that the price of the traded good in terms of the foreign currency is exogenously given and equal to one); then the relative price of the nontraded good is $p=P^N/e$.

Domestic producers accept only domestic currency for their sales, but can exchange pesos for dollars at any time during the month at the cost q^F per transaction. So the firm solves a problem similar to the household's in managing its cash balances. If the firm decides to make N^F (equally spaced) financial transactions during the month, the dollar value of the revenues collected between two consecutive transactions is given by,

$$\int_0^{1/N^F} e^{\varepsilon[h-(1/N^F)]}(y_t^T+p_t y_t^N)\, dh = \varepsilon^{-1}(1 - e^{-\varepsilon/N^F})\ (y_t^T+p_t y_t^N)$$

So the producer chooses N^F so as to maximize total monthly revenues,

$$(3) \qquad N^F = \underset{N}{\text{argmax}} \left\{ N\varepsilon^{-1}(1-e^{-\varepsilon/N^F})(y_t^T+p_t y_t^N)-Nq_t^F \right\}$$

again, it is simple to verify that this problem is well defined.

If we assume that the transaction costs are proportional to the volume of transactions, that is if $q_t^H = q^H \cdot (g_t^T + p_t g_t^N)$ and $q_t^F = q^F \cdot (y_t^T + p_t y_t^N)$ then the dollar cost of the household's absorption and of the producer's revenues will be proportional to $(g_t^T + p_t g_t^N)$ and $(y_t^T + p_t y_t^N)$ respectively and the factors of proportionality will be a function of the devaluation rate ε and of the "unit" transaction costs q^H and q^F. That is, in this case we could write,

$$
(4) \qquad \begin{aligned} &\text{dollar cost of household's purchases} = d^H(\varepsilon_t, q^H) \cdot (g_t^T + p_t g_t^H) \\ &\text{dollar value of producer's revenues} \;= d^F(\varepsilon_t, q^F) \cdot (y_t^T + p_t y_t^H) \end{aligned}
$$

At the end of the month the producer converts his dollars into pesos, pays for the services of labor and capital and sends profits home.

Also at the end of each month the members of the household reunite, pool income and consume[4]. In order to avoid the typical effects of inflation on the leisure-effort decision, I will assume that labor is supplied inelastically. Another way of dealing with this issue is to assume (as in Christiano and Eichenbaum (1992) and Fuerst (1992)) that labor income can be used to purchase goods in the same period in which labor services are supplied. We can then rewrite the budget constraint (1) in the following way,

$$
(5) \qquad \begin{aligned} & b_{t+1}^H + d^H(\varepsilon_t, q^H) \cdot (g_t^T + p_t g_t^N) \le \\ & (1+r^*) b_t^H - \Big[w_{t-1}(H_{t-1}^T + H_{t-1}^N) + (k_{t-1}^{Td} r_{t-1}^T + k_{t-1}^{Nd} r_{t-1}^N) + \\ & - d^F(\varepsilon_{t-1}, q^F) \cdot [F^T(k_{t-1}^{Td}, H_{t-1}^T) + p_{t-1} F^N(k_{t-1}^{Nd}, H_{t-1}^N)] \Big] \\ & + \Big[(r_{t-1}^T k_{t-1}^T + r_{t-1}^N k_{t-1}^N) \Big] + w_{t-1} H_{t-1} + \tau_t \qquad\qquad t \ge 0 \end{aligned}
$$

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4 In the way proposed by Fuerst (1992) and Lucas (1990).

where $F^T(k,H)\equiv k^{\alpha T}H^{1-\alpha T}\equiv y^T$ and $F^N(k,H)\equiv k^{\alpha N}H^{1-\alpha N}\equiv y^N$ are the production functions of the traded and nontraded goods respectively ($\alpha_T,\alpha_N\in(0,1)$). The first term on the right hand side of (5) is the gross return from the household's holdings of the foreign asset; the second denotes the profits of the intermediate-good producers, carried over from the previous period; the third denotes the income of the capital-good producer from renting capital, the fourth is the income of the worker and the last one is the lump-sum money transfer (tax if negative) of τ_t units of traded goods. This budget constraint shows the similarity of this model with the transaction cost model of Kimbrough (1986) and Reinhart and Vegh (1993).

The objective function of the household is the expected value of

$$(6)\qquad \sum_{t=0}^{\infty} \gamma_t\, U(c_t)$$
$$\gamma_{t+1} = \gamma_t\,(1+c_t)^{-\beta} \qquad \beta>0$$

Where $U(c)=c^{1-\sigma}/(1-\sigma)$ ($\sigma>1$). The endogenous discount factor makes the deterministic steady state of the model independent of the initial wealth (see Uzawa (1968), Obstfeld (1981) and Mendoza (1991)). An alternative way to obtain this is by assuming a positive probability of death as in Blanchard (1985), Helpman and Razin (1987) and Cardia (1991).

The way in which traded and nontraded goods are aggregated and split between consumption and investment is reflected in the following constraints,

$$(7)\qquad g_t = \Lambda(g_t^T, g_t^N)$$

$$(8)\qquad g_t \geq i_t + c_t$$

where i_t is total investment and $\Lambda(\cdot,\cdot)$ is an "Armington aggregator function" introduced above and assumed to be Cobb-Douglas with a traded-absorption elasticity of θ. I will assume that the investment processes are subjected to both adjustment costs and time-to-build. Adjustment costs seem to be important in modeling the dynamics of small open economies in which agents have frictionless access to a financial asset issued abroad and whose return process is exogenous to the domestic economy (here this kind of asset corresponds to b_t^H); in this case domestic investment is too volatile when, for example, the economy is subject to technology shocks or to shocks to the return of the financial asset (see Mendoza (1991), Cardia (1991) and Schmitt-Grohé (1992)). In the model I am presenting here, the volatility of sectorial investments will also be too high in the absence of adjustment costs if the economy is shocked by elements that change the relative return of sector-specific investment, as will be the case with the stabilization experiments described below.

The time-to-build feature, besides being a plausible assumption is incorporated to show its potential usefulness in modeling the initial dynamics of stabilization programs for the kind of economies I am describing here.. I will assume, as in Kydland and Prescott (1982) that 1 unit of capital available J periods from now requires 1/J units of investment for J consecutive periods starting now.

These considerations are reflected in the following equations for the evolution of investment and the capital stocks:

$$(9) \qquad i_t \geq i_t^T + i_t^N$$

$$(10) \qquad i_t^T \geq J^{-1} \sum_{h=0}^{J-1} s_{t-h}^T$$

$$(11) \qquad i_t^N \geq J^{-1} \sum_{h=0}^{J-1} s_{t-h}^N$$

$$(12) \qquad (1-\delta)k_{t+J-1}^T + s_t^T - \phi^T/2\ (k_{t+J}^T - k_{t+J-1}^T)^2/k_{t+J-1}^T \geq k_{t+J}^T$$

$$(13) \qquad (1-\delta)k_{t+J-1}^N + s_t^N - \phi^N/2\ (k_{t+J}^N - k_{t+J-1}^N)^2/k_{t+J-1}^N \geq k_{t+J}^N$$

where i_t^T and i_t^N denote sectorial investments, s_{t-h}^i denotes the number of investment projects in sector i (i=T,N) in period t that are J-h periods from completion, $\delta \in (0,1)$ is the (common) depreciation rate and ϕ^T and ϕ^N are adjustment cost coefficients.

2.2. THE GOVERNMENT'S BUDGET CONSTRAINT.

I will assume that the Central Bank follows a nominal exchange rate rule by which it sets the devaluation rate, ε, at the beginning of each month and commits itself to sell foreign currency in exchange for domestic currency at the ongoing nominal exchange rate. I will also assume that the government consumes no goods, but performs lump-sum transfers in cash. Let b^G_{t+1} denote the amount of the foreign bond held by the government at the beginning of period t (and after the private sector made its portfolio reallocations).

The sources of these reserves are: (i) the gross return from bond holdings from the previous period, $b^G_t\cdot(1+r^*)$, (ii) the previous period's net exports, $y^T_{t-1}-g^T_{t-1}$. I am assuming that the transactions between the Central Bank and exporters or importers are made in foreign cash (not bonds) and that the movements in reserves generated by this source are invested in the interest bearing asset at the beginning of the next period; this explains the lag in the variables representing the trade balance. (iii) foreign currency held by the households during t-1 and exchanged for domestic currency during that period to perform purchases, fc_{t-1}, (iv) Adjustments in the household's portfolio at the beginning of the current period $-(m_t-dc_t-\tau_t$ and (v) financial services paid to foreign brokers by consumers and producers $-N^F_{t-1}q^F_{t-1}-(N^H_{t-1}-1)q^H_{t-1}-q^H_t$ (I am assuming that brokers are paid in domestic cash and exchange the proceeds for dollars right away, so,since this accounting is made *after* the household operated in the financial market, there is a cost term dated at t.)

There are at least two alternative treatments of the transaction costs: one is to assume that they represent pure rents of some member of the household (maybe due to imperfect competition generated by government regulations in the financial system) and so they generate no wealth effects in the aggregate; this alternative is taken in Reinhart and Vegh (1992); another is to assume that they are mainly time costs of traveling to the financial market to get or get rid of foreign currency; this treatment is similar to the one applied here in the sense that it introduces wealth effects (see Guidotti (1989)). The qualitative features of the initial dynamics of the stabilization experiment analyzed below are not affected by the way in which this cost is treated (an important exception could be private consumption), but the quantitative response of the model might be affected especially if the reduction in inflation is significant[5]. In the next section I deal with these possibilities by defining a variable z that denotes the fraction of the financial transaction cost returned to the household in a lump-sum manner, so, for example, if z=100% then no income effects are generated by this type of cost cost. The baseline simulations use z=90% but I also show simulations with z=0 and z=100%.

The evolution of bond holdings by the government can then be written as,

$$(14)\qquad b^G_{t+1} = (1+r^*)b^G_t + (y^T_{t-1}-g^T_{t-1}) - N^F_{t-1}q^F_{t-1} + fc_{t-1} - (N^H_{t-1}-1)q^H_{t-1} + (dc_t-m_t-\tau_t)$$

I will assume that the government is subject to a borrowing constraint that prevents it from engaging in Ponzi-type schemes[6].

2.3. Competitive Equilibrium.

I will define a competitive equilibrium for this economy as a set of initial conditions m^H_0, b^H_0, b^G_0, k^T_0, k^N_0 and stochastic processes for $\{c_t,\ \gamma_{t+1},\ b^H_{t+1},\ b^G_{t+1},\ m^H_t,\ H^T_t,\ H^N_t,\ k^{Td}_{t+1},\ k^{Nd}_{t+1},\ k^T_{t+1},\ k^N_{t+1},\ g^T_t,\ g^N_t,\ N^H_t,\ N^F_t,\ \tau_t\}^\infty_{t=0}$ and prices $\{e_t,\ p_t,\ w_t,\ r^T_t,\ r^N_t\}^\infty_{t=0}$, such that:

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[5]In Vegh's and Reinhart's paper it does not make a big quantitative difference which treatment is given to this cost since they concentrate in plans that are temporary, so it is reduced for only a finite period of time and then goes back to a high level forever. The reason for their choice is just analytical convenience.

[6]Since the government sets the time path of the nominal exchange rate, this implies that the real value of the transfer has to depend on the level of reserves in the Central Bank (for example if $\tau_t=\tau(b^G_t)$ where b^G_t denotes the amount of reserves in the Central Bank, then $\tau'>r^*$ will allow the government to keep its reserves stationary.

i) The government budget constraint (14) is satisfied for all $t \geq 0$ and the government is constraint not to enter in ponzi games.

ii) Given the stochastic processes for prices and transfers $\{e_t, p_t, w_t, r_t^T, r_t^N, \tau_t\}_{t=0}^{\infty}$ and initial conditions m_0^H, k_0^T, k_0^N, the stochastic processes $\{c_t, \gamma_{t+1}, b_{t+1}^P, b_{t+1}^N, M_t^H, H_t^T, H_t^N, k_{t+1}^{Td}, k_{t+1}^{Nd}, \theta_t, g_t^T, g_t^N, N_t^H, N_t^F\}_{t=0}^{\infty}$ maximize the expected value of (1) subject to (2)-(5), (7)-(13) and to a borrowing constraint that prevents households from engaging in Ponzi-type games.

iii) The markets for physical capital and labor clear:

$$k_t^{Td} = k_t^T$$

$$k_t^{Nd} = k_t^N$$

$$H_t^T + H_t^N = H$$

These conditions imply that the market for nontradables also clears: $y_t^N = g_t^N$.

3. CALIBRATION.

The parameters of this model are the transaction costs, q^H and q^F, the capital elasticities of output in the traded and nontraded sectors, α_T and α_N, the depreciation rate δ, the elasticity of the aggregator function with respect to traded absorption, θ, the semi-elasticity of the discount factor with respect to consumption, β, the intertemporal elasticity of substitution in consumption, σ, the adjustment cost parameters, ϕ^T and ϕ^N, and the time required to complete an investment project, J. The aggregate labor endowment, H, is normalized to one and the international interest rate is set to 6.5% per year (this is the number King et. al. (1988) obtained for the average equity return in the US for the period 1958-81). Using an endowment model in which money is motivated by transaction costs, Reinhart and Vegh (1993) estimated for Argentina an intertemporal elasticity of substitution, of around 5, so this is the value I am going to use for σ.

Following King et. al. (1988), Kydland and Prescott (1982) and many other authors in the equilibrium business cycle literature, I will use long-run empirical relations and model restrictions to identify the rest of the underling parameters of the model. I will use data for the Argentinean economy for the two decades preceding the Convertibility plan, 1970-90. The main characteristic of this period is a high level of inflation, which averaged 11% per month (this rate is the one used for ε in the calibration exercise described below; see Table 2).

The non-stochastic steady state of this model implies the following restrictions involving α^T and α^N:

$$\alpha^T = 1 - \frac{w\ H^T}{y^T}\ d^F(\varepsilon,q^F)^{-1}$$

$$\alpha^N = 1 - \frac{w\ H^N}{p\ y^N}\ d^F(\varepsilon,q^F)^{-1}$$

wH^T/y^T and wH^N/py^N are the labor shares in the traded and nontraded sectors. The way in which these two sectors were defined and the data sources are described in the appendix. The numbers obtained for these two ratios are 0.46 and 0.63 respectively. These numbers seem consistent with the idea that, at least for LDC countries, the nontraded sector, which includes most of the services generated in these economies, is more labor intensive than the traded sector. Given a number for q^F we could be able to identify the two capital elasticities of output.

The trade balance/GDP ratio averaged 2.7% in the period considered. In the model's steady state this variable (which I will call tb) is given by

$$tb = \theta^T(1-N^F q^F)-(1-\theta^T)\left[(g^T/pg^N)(1+N^H q^H)+N^F q^F+N^H q^H\right]$$

where θ^T is the share of traded output over GDP, which for the period considered averaged approximately 42%. The aggregator function is assumed to be Cobb-Douglas[7] with traded absorption elasticity θ, so the optimal mix of traded and nontraded goods in the production of the composite good is given by $g^T/pg^N=\theta/(1-\theta)$. This expression together with the previous one and values for q^H and q^F can be used to identify θ.

The share of investment in GDP, s_i, which averaged 17% during the period considered, can be used to identify the depreciation rate δ, which is assumed to be the same in both sectors; by definition s_i is given by

$$s_i = (P^A i^T/y^T)\cdot(y^T/y) + (P^A i^N/py^N)\cdot(py^N/y)$$

where $P^A=\theta^{-1}\cdot(g^T/g^N)^{1-\theta}$ is the price of the composite good in terms of the traded good. The steady state of the first order condition for the optimal accumulation of physical capital implies the following relation between the rental price of capital and the price of the composite good,

$$(1+r^*)^J = 1 + \frac{J\, r^T\, r^*}{d^H(\varepsilon,q^H)(r^*+\delta)P^A}$$

where $r^T=d^F(\varepsilon,q^F)\alpha^T y^T/k^T$ is the steady-state value of the rental price of capital in either sector (in a non-stochastic steady state r^T equals r^N); in turn k^T is given by i^T/δ and k^N by i^N/δ. These relations imply the following restriction on the depreciation rate

[7] An alternative strategy, followed by Stockman and Tesar (1990), is to assume a CES aggregator function, set the share parameter (called θ below) to 1/2 and calibrate the elasticity of substitution between traded and nontraded goods in producing the composite good. This exercise wouldn't require additional restrictions and gives a calibrated value of around .4 which is very similar to Stockman's and Tesar's estimation. The simulation results are not significantly affected in this case. They might, though, if both the share parameter and the elasticity of substitution were calibrated by adding more data restrictions.

$$s_1 = \frac{r^* \delta d^F(\varepsilon, q^F) J}{d^H(\varepsilon, q^H)(r^*+\delta)((1+r^*)^J - 1)} \cdot \left[\theta^T \alpha^T + (1-\theta^T)\alpha^N\right]$$

Given values for q^H and q^F and the restrictions above, we can now solve the steady state of the model for all endogenous variables, including the level of consumption, c. Then the semi-elasticity of the discount factor with respect to consumption, β, is given by

$$\beta = \ln(1+c)/\ln(1+r^*)$$

I will assume that households and firms bear the same proportional transaction cost for financial operations, i.e., $q^H = q^F \equiv q$ and calibrate q so as to match the average monetization rate during the period considered. In order to do this I will fix the inflation rate at the average level prevailing during the calibration period, 1970-90, and get the model's prediction for the steady state monetization level (money/GDP) as a function of the transaction cost, q. I will then choose the level of q that delivers a monetization rate approximately equal to the observed one.

In order to get the monetization level corresponding to the average inflation rate, I ran an OLS regression of the natural log of monetization on its own lags, current and lagged inflation rates, a constant, and seasonal dummies[8]. The result is the following

Dependent Variable my_t	
Quarterly Data From 71:03 To 90:04	
Centered R^2	0.97
adjusted R^2	0.96
Regression F(16,61)	144.91
Durbin-Watson Statistic	1.86
Q(19)	20.06
Significance Level of Q	0.39

Variable	Coeff.	Std. Error
Constant	-0.0527	0.0765
my_{t-1}	0.9031	0.1247
my_{t-2}	0.1808	0.1763
my_{t-3}	-0.2128	0.1842
my_{t-4}	-0.0509	0.1947
my_{t-5}	-0.1968	0.1985
my_{t-6}	0.3231	0.1336
π_t	-0.2496	0.0492
π_{t-1}	0.0265	0.0665
π_{t-2}	0.1516	0.0657
π_{t-3}	-0.1484	0.0805
π_{t-4}	0.0344	0.0954
π_{t-5}	-0.0740	0.1051
π_{t-6}	0.0659	0.0987
II.qtr.	-0.0756	0.0387
III.qtr.	-0.1118	0.0344
IV.qtr.	-0.0668	0.0372

[8]These regression results will, in general, be affected by the classical endogeneity problem. This problem would not be important if the government had followed a nominal exchange rate rule during the period considered, and if this rule had been completely independent of the state of the economy (in such a case the correct regressor should have been the nominal devaluation rate.) But this was definitely not the case for the entire period considered.

my_t is the natural logarithm of the ratio of M1 over quarterly nominal GDP expressed in annual rate (so my_t denotes the log of the number of years of GDP held in M1 in quarter t), and π_t is the quarterly inflation rate (continuously compounded) as measured by the CPI index, which averaged 29.1% in the period 1970-90. The expression above shows that if the quarterly inflation rate was constant at 29.1% the "steady state" average monetization rate would be 3.96% per year. The theoretical model predicts approximately this steady state level of monetization when the transaction cost, q, is 0.0088. It also predicts that for these levels of transaction cost and inflation households and firms go to the bank to exchange currencies around twice a month. The values obtained for the calibrated parameters and the long-run empirical relations used to obtain them are all summarized in table 1

4. The Short Run Dynamics of a "Permanent" Stabilization Plan

4.1. An Empirical Example: The Argentinean Convertibility Plan of April 1993

In april 1991 the Argentinean government ended a hyperinflationary period by launching a plan that pegged the local currency to the US dollar. 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 plan had been 288.5%.

The initial effects of the plan were also important on the real side of the economy. 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 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 3). Figure 4 shows the behavior of another measure of the real exchange rate: the one given by the nominal exchange rate times the foreign CPI divided by the domestic CPI. 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 Whole Sale Price Index: the CPI increased by 38.2% in the first six quarters of the plan while the WPI did it by only 7.4% (see figure 5). Since the CPI covers many more services, which are typically non-traded goods, it also supports the idea that the relative price of traded goods went down as a result of the stabilization program.

The trade balance, in turn, declined sharply since the Convertibility plan was launched. Figure 6 shows that in 1991 the trade Balance in goods declined by more than 50% with respect to the previous year. In November of 1991 it became negative for the first time in ten years and stayed so until January 1993 (last figure available at the time this draft was updated, May 1993) with the exception of June 1992 when it was slightly positive. A similar pattern shows the trade Balance in goods and services (figure 7). Imports grew by 64% in 1991 and by 63% in 1992. This measure of the trade balance also became negative for the first time since the "tablita" plan of Martinez de Hoz in the early 80s.

Figure 6 (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 billions 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 the upper left picture of figure 7). 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 absorption expanded during the first two years of the plan (see figure 7 again). Gross domestic investment 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 80's. Total consumption, in turn, increased by 12.6% in 1991 and by 10.8% in 1992.

The plan had, as a crucial ingredient, an important fiscal reform that took place right from the outset. The fiscal deficit of federal government (before income from privatization) averaged 8.4% of GDP in the period 1985-90 and only 1.5% in the period 1991-92 (see figure 8). These facts make it hard to think of credibility problems to explain the real effects associated with the stabilization experiment and motivate the search for alternative explanations.

4.2. The Simulated Response of the Model

In this subsection I will consider the short run response of the model presented above to a permanent reduction in the devaluation rate ε. In order to deal with this task, I log-linearized the equilibrium conditions (as in King et. al. (1988)) and numerically solved the resulting linear system. The exercise is basically to analyze the dynamics of the model from a high-inflation steady state to a low-inflation one.

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 subsidy on investment in the foreign bond) because local firms receive only cash for their sales of goods and because money enters as working capital in the production of investment goods. Second higher inflation induces firms and consumers to spend more resources in trying to evade it.

The first source is evident from looking at the first order conditions for the optimal accumulation of domestic and foreign assets. Consider, for instance, the case of a traded-good-producing firm; it will hire capital k_t^T, so as to satisfy the following conditions

$$r_t^T = F_K^T(k_t^T, H_t^T)\cdot d^F(\varepsilon_t, q)$$

where, as discussed above, $d^F(\varepsilon_t, q)$ is less than one and decreasing in ε_t, so the demand for capital services is decreasing in the inflation rate. This tax, imposed on the use of domestic capital services, will be reflected in its price. Let λ_t^T denote the value, in terms of present utility, of one unit of capital productive in period t+J in the traded sector. Let λ_t be the marginal utility of consumption in period t, ψ_t the marginal utility of one dollar held at the beginning of period t and $\beta_t \equiv \gamma_{t+1}/\gamma_t$ the discount factor in t. The capital good producer will choose to initiate investment projects until the value of one unit of capital productive in period t+J, λ_t^T, equals the cost of producing it which is the sacrifice of 1/J units of the composite good (whose value is λ_t) for J consecutive periods, that is, until the following expression is satisfied

$$\lambda_t^T = J^{-1} \sum_{j=0}^{J-1} E_t \left\{ \left(\prod_{h=0}^{j} \beta_{t+h-1} \right) \lambda_{t+j} \right\}$$

On the other hand the value assigned by the capital producing firm to one unit of capital productive in t+J equals the (present discounted value of the) sum of the value of the rent it will get from it in period t+J, $r^T_{t+J} \cdot \psi_{t+J}$, plus the value of the undepreciated part which can be sold in period t+J+1, $(1-\delta) \cdot \lambda^T_{t+1}$. This is reflected in the following first order condition (in which the adjustment costs involved in changing the productive capacity have been taken into account),

$$\lambda_t^T = \beta_t \frac{E_t \left\{ \left[(1-\delta) + \phi^T/2 [(k^T_{t+J+1}/k^T_{t+J})^2 - 1] \right] \lambda^T_{t+1} + \left(\prod_{j=1}^{J} \beta_{t+j} \right) r^T_{t+J} \; \psi_{t+J} \right\}}{1 + \phi^T \dfrac{(k^T_{t+J} - k^T_{t+J-1})}{k^T_{t+J-1}}}$$

One can integrate this expression forward and interpret the value of capital as the present discounted value of the stream of rents it can generate.

The value of one dollar, ψ_t, and of one unit of the composite good, λ_t are, in turn related by the following condition,

$$\psi_t = \lambda_t A_1 (g_t^T, g_t^N) / d^H(\varepsilon_t, q)$$

where $d^H(\varepsilon_t,q)$ is the dollar cost of one unit of traded good in period t; it is bigger than one and increasing in inflation; this expression has to be interpreted in the following way: one dollar buys only $1/d^H(\varepsilon_t,q)$ units of the traded good; in turn a unit of traded good can generate $A_1(g_t^T,g_t^N)$ units of the composite good ($A_1(g_t^T,g_t^N)$ is the "marginal productivity" of traded goods in producing composite goods) and finally each additional unit of final good increases utility by λ_t.

The three expressions above can be combined to see that the accumulation of domestic physical capital will be negatively affected by inflation both because its production requires money as working capital (this is reflected in the terms involving $d^H(\varepsilon_t,q)$) and because the firms which use its services require money in the distribution process of the final goods (this shows in those terms involving $d^H(\varepsilon_t,q)$).

On the other hand, the decision rule for the household's holdings of the foreign asset is not directly affected by the expected rate of inflation:

$$\psi_t = \beta_t(1+r^*)\ E_t\{\psi_{t+1}\}$$

From this considerations it is plausible to expect that a permanent decrease in the expected inflation rate will cause aggregate domestic investment to increase (this will be true, as we will see below, both in the short and in the long run); the time-to-build feature will add short-run persistence to the demand expansion and the adjustment cost will make this expansion to take place slowly over time. More on this below.

Next I will 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 for the four years preceding the Convertibility Plan (see table 2). These simulations correspond to the log-linear approximation of the model. Figure 9 shows the response of seven key macroeconomic variables to the permanent reduction in the devaluation rate described above. The figures were constructed using an adjustment cost parameter of 10 in each sector and 24 time-to-build lags (some sensitivity analysis about these two parameters is shown below).

This figure shows that as a response to the permanent decrease in the devaluation rate, the real exchange rate falls continuously for two years; moreover most of the decrease in the relative price in the traded good is concentrated at the beginning of the plan which is consistent with the observed pattern. Note that since the nominal exchange rate is fixed, the first two years are characterized by a moderate inflation, which is also consistent with the data presented above. It also shows that the trade balance deteriorates during this period and that the stabilization program induces an expansion in real activity, in particular in GDP and total investment. Again all these responses are consistent with the evidence shown above. The lower left picture shows that the increase in investment is generated mainly in the nontraded-sector. Finally the model also "correctly" predicts capital inflows during the initial phase of the stabilization experiment.

The intuition behind these results might go as follows: As shown before, the lower expected inflation increases the demand for capital in the traded and non-traded industries; given the aggregate stocks of capital, the rental prices r^T and r^N go up, inducing an increase in new investment projects, so given the real exchange rate, this generates an expansion in the demand for both traded and nontraded goods. For a given stock of capital, the marginal product of labor is decreasing in labor so the home-good market will clear only if the real exchange rate goes down. This appreciation of the real exchange rate, in turn, makes investment in the production of k^N even more attractive (and less so in the other sector). Since the demand for traded goods increases and its domestic supply decreases (because labor is shifted towards the nontraded sector and capital is fixed), a trade deficit also arises.

The separate effects of time-to-build and adjustment costs can be visualized from figures 10 and 11. Figure 9 shows the importance of adjustment costs in two-sector models in which no irreversibility constraints are imposed on investment, especially if the equilibrium is affected in such a way that the relative profitability of the two sectors is significantly changed. We can see that when the adjustment cost in each sector is set close to zero, physical capital is initially shifted from the traded sector to the nontraded sector as a response to the increase in the relative price of the nontraded good. Two years later capital is shifted back to the traded sector as the real exchange rate improves. As a result gross sectorial investment can go negative or increase at implausible rates. Figure 11 shows that if the number of months required to complete an investment project is made very low (in this case it was set to only two months) the initial jump in nominal prices right after the announcement of the plan is followed by a long period of (mild) deflation, exactly contrary to the observed pattern of prices.

Figure 12 shows that the dynamics of the real exchange rate and the traded balance are not driven by the wealth effects originated in the lower financial-transaction costs due to the reduction in inflation. In the first part of this figure it is assumed that all the transaction cost is returned in a lump-sum way to the household; in the second part non of it is returned. The most affected variable seems to be (no surprisingly) private consumption.

Finally, table 3 compares quantitatively the response of the model with the observed response of the Argentinean Plan of April 1991. The model predictions where computed for different values of the fraction of the financial transaction cost which is recovered by some member of the household, (z). The model predicts changes in the trade balance and in investment of similar magnitude as those observed. It under predicts the response of the real exchange rate and of GDP and it is way below in the prediction for the response of consumption.

The predicted response of the real exchange rate might be affected by the assumption of a Cobb-Douglas Aggregator function. A more satisfactory approach would be to add more data restrictions and obtain a calibrated value for the elasticity of substitution between traded and non-traded goods. With respect to the response of consumption, an important ingredient missing in its specification is durability. Unfortunately Argentina does not produce disaggregated data for consumption. There are two things, though, that seem clear: first, adding durability will increase the initial response of consumption (suppose, as an example that the desired stock of durables increases, 2% and that the depreciation rate per month is .01, then the required increase in *purchases* of durables would be around 200%) and second the consumption booms that generally follow the announcement of the stabilization programs of the type we are analyzing here are generally booms in durables (an evident case is the israeli program of 1985).

5. Conclusions

In this paper I presented a Baumolian Model of a dollarized small open economy that explains the stylized facts of exchange-rate-based stabilization programs without resorting to neither credibility problems nor to gradual desinflation of the nominal exchange rate in order to induce the required initial expansion in aggregate demand.

The model's predictions are qualitatively right for most of the variables of interest, real exchange rate, trade balance, real activity, capital inflows, etc.). The method used to simulate the response to a stabilization plan, although, is appropriate to quantitatively analyze the transitional dynamics of an economy moving from one steady state to another, only if these two long-run equilibria lay not very far apart from each other. So an immediate and obvious step for future research is to implement a computational method to numerically solve for these transitional dynamics in a more precise way.

After an initial period of expansion in economic activity, the model predicts a deceleration in output and aggregate demand, a real exchange rate appreciation (which under a fixed exchange rate regime means deflation in nontradables) 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 time-to-build, so the supply of home goods increases. 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 are very different from other hypothesis that propose an opposite causality, namely that both the initial real exchange rate appreciation and the subsequent deflation are due to exogenous capital inflows which are temporary in nature (see Calvo, Leiderman and Reinhart (1993) on this interpretation).

I also presented new empirical evidence on the initial real effects of exchange-rate-based stabilization plans. Specifically I presented data from the Argentinean Convertibility Plan of April 1991. These data are consistent with those arising from many other permanent and (ex-post) transitory plans.

This desinflation episode has two appealing features: the important fiscal reform by which it was accompanied provides some elements of credibility and second it consisted in setting the the devaluation rate at zero right from the outset, as opposed to announcing a gradual convergence as is the case in most of the exchange-rate-based stabilization episodes.

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Table 1

(A) Long-run data relations used to calibrate the model

Inflation rate (monthly)	10.25%
Monetization rate (M1/(CPI/GDP), yearly)	3.96%
Return on foreign asset (yearly)	6.50%
Trade balance / GDP	2.67%
Total Investment / GDP	17.0 %
Traded GDP / Nontraded GDP	41.86%
Labor share in traded GDP	48.0 %
Labor share in nontraded GDP	63.0 %

(B) Calibrated Parameters

β	(minus) semilasticity of the discount factor with respect to consumption	0.0041
$1-\sigma$	elasticity of the period utility function with respect to consumption	-4.0
θ	elasticity of the aggregator function with respect to traded absorption	0.38
$1-\alpha_T$	labor elasticity of traded output	0.51
$1-\alpha_N$	labor elasticity of nontraded output	0.66
δ	depreciation rate (yearly)	6.0%
q	proportional cost of one financial transaction	0.88%

(C) Non-calibrated parameters
(subject to sensitivity "tests")

J	number of gestation lags	24
$\phi^T=\phi^N$	adjustment cost parameters in sectoral investment	10
z	Fraction of the financial transaction cost returned in a lump-sum manner	90%

Table 2

Average Monthly Inflation Previous to the Convertibility Plan

years before the Plan	Monthly Inflation (%)
1	19.1
2	37.9
3	30.0
4	24.8
5	21.0
10	17.1
20	11.3

Source: Indicadores de Coyuntura (FIEL)

Table 3

Initial Real Effects of a Stabilization Program that Lowers the Devaluation Rate from 24% to 0% per Month

	Trade Balance	Real Exchange Rate	GDP (in terms of tradables)	Investment. (in terms of the composite Good)	Consumption (in terms of the composite Good)
Model: z=90%	−6.2	−6.7	4.8	36.6	0.8
Model: z=100%	−6.1	−6.5	4.6	38.1	0.2
Model: z=0	−7.8	−8.4	6.0	22.0	5.6
Data	−7.1	−22.8	14.0	29.1	20.4

Notes: (1) For GDP, Consumption and Investment the figures reported correspond to the percentage distance between the second year of the program and the average of the 4 years preceeding the program. (2) For the trade balance it corresponds to the difference between the trade balance of the second year after stabilization and the average trade balance in the four years previous to stabilization as a percentage of the average of GDP for the four years preceeding the plan. (3) For the real exchange rate it corresponds to the percentage difference between April 1993 and March 1991 (this exceptionwas made to avoid the effects of the outliers corresponding to months of the hyperinflations of 1989−90).

Figure 1
ARGENTINA: Monthly Inflation (%)

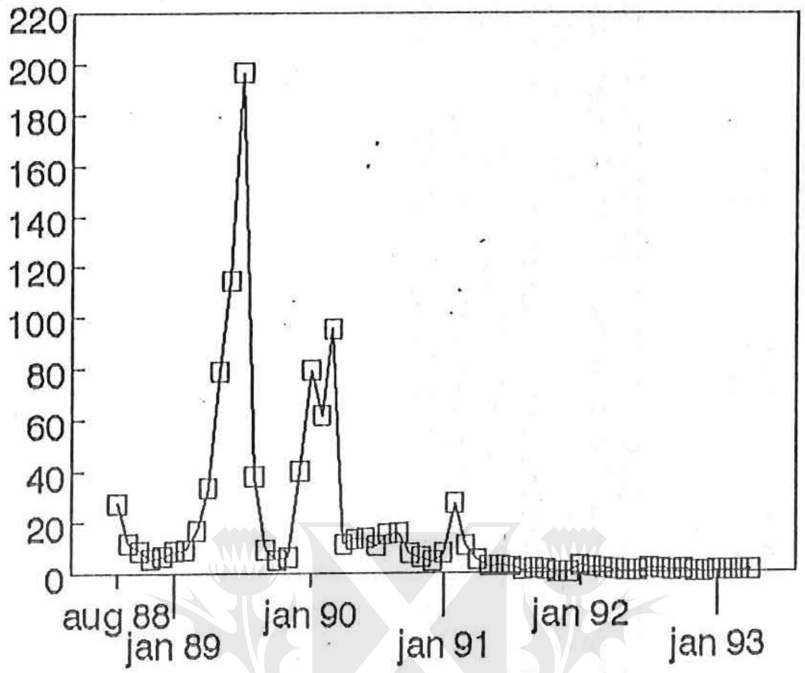


Figure 2
ARGENTINA: Inflation and Devaluation
(% monthly)

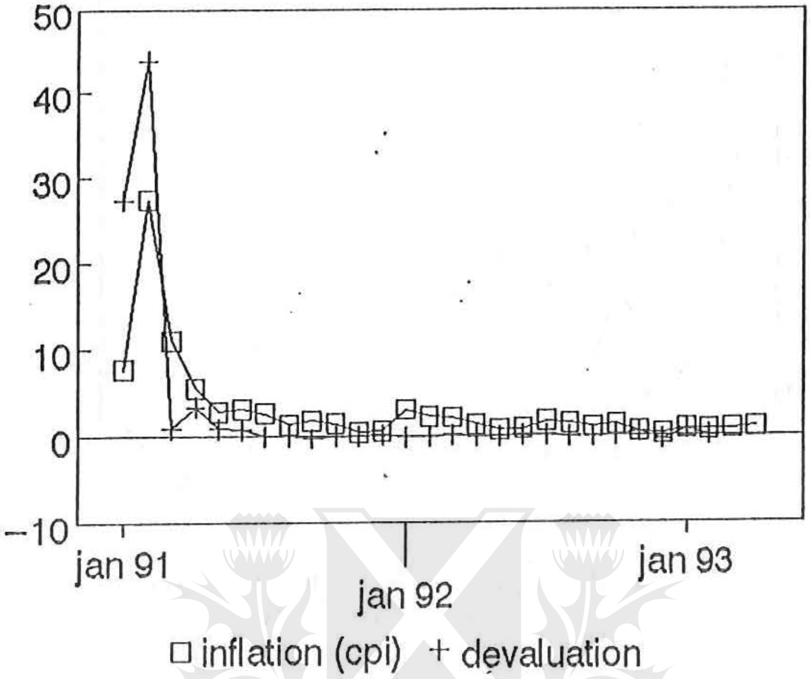


Figure 3
ARGENTINA: Real Exchange rate
Nominal exchange rate / CPI

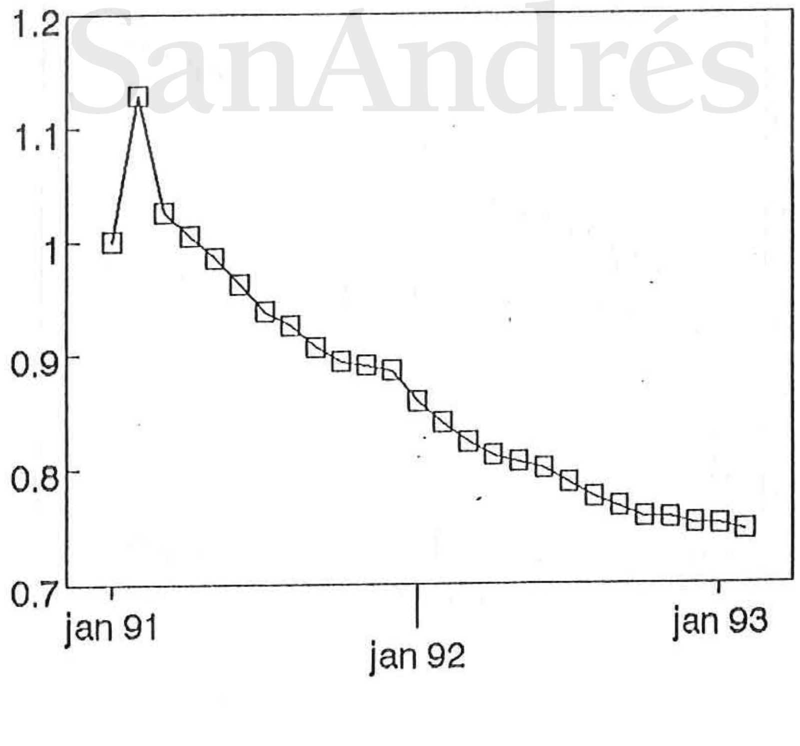


Figure 4

ARGENTINA: REAL EXCHANGE RATE
(deflated by CPI, base dec76=100)

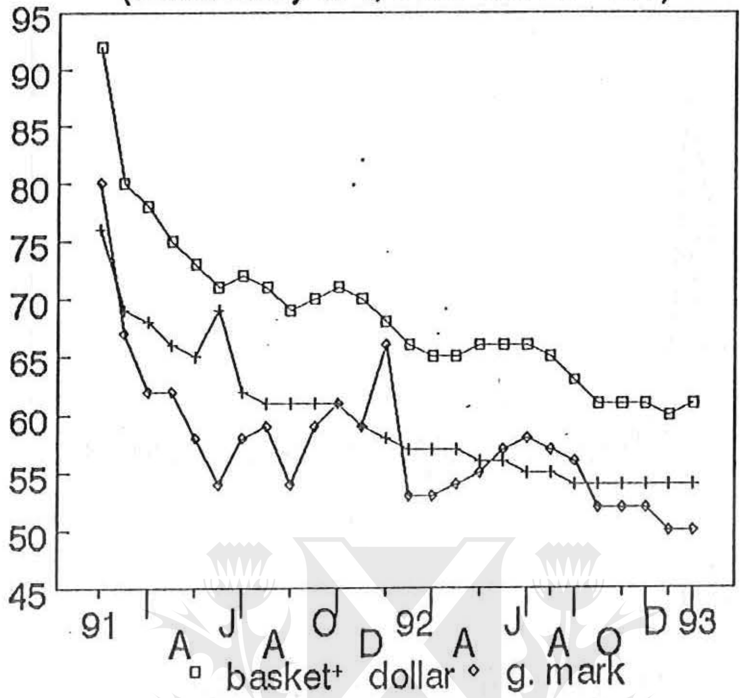


Figure 5

ARGENTINA: cpi and wpi
(Jan 1991=1.0)

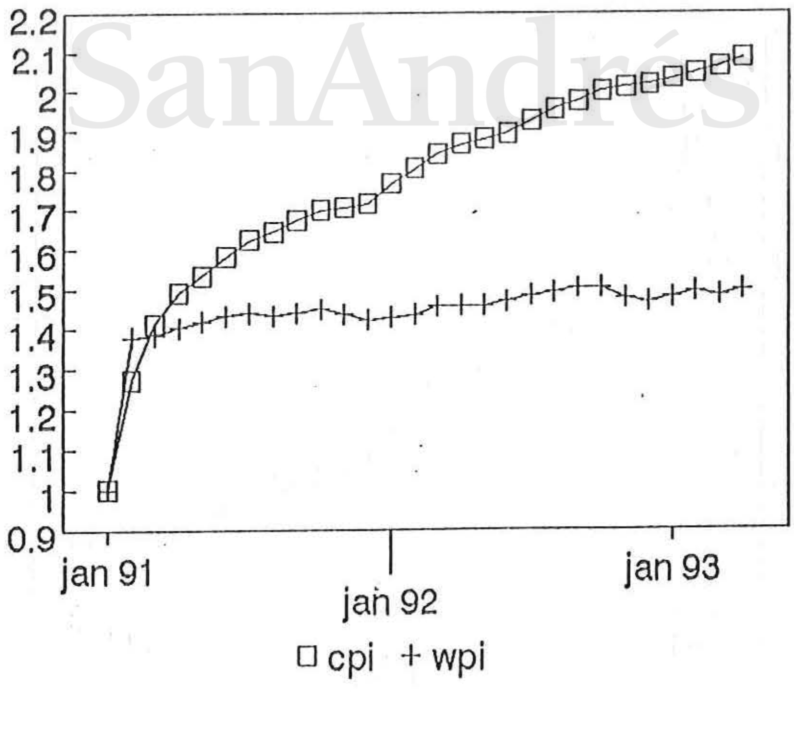
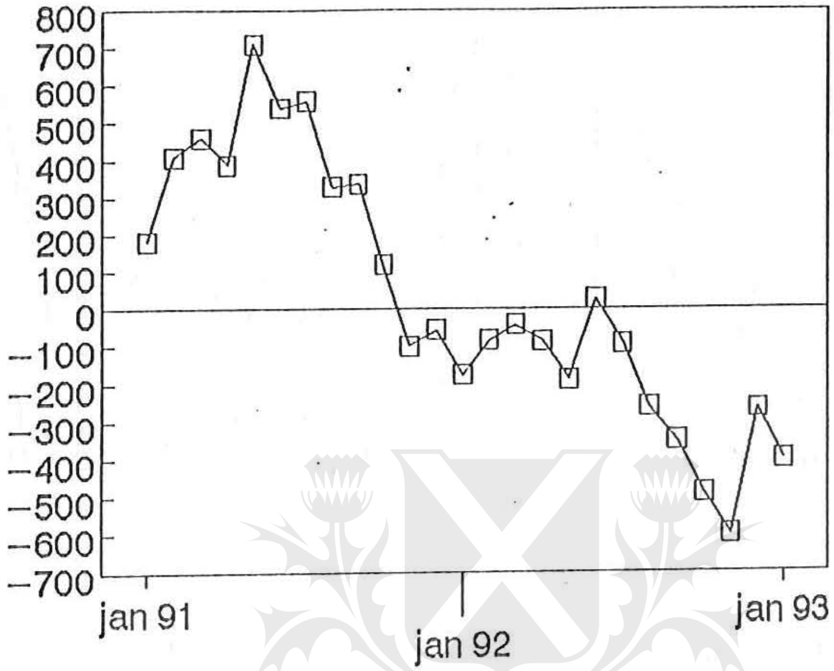


Figure 6

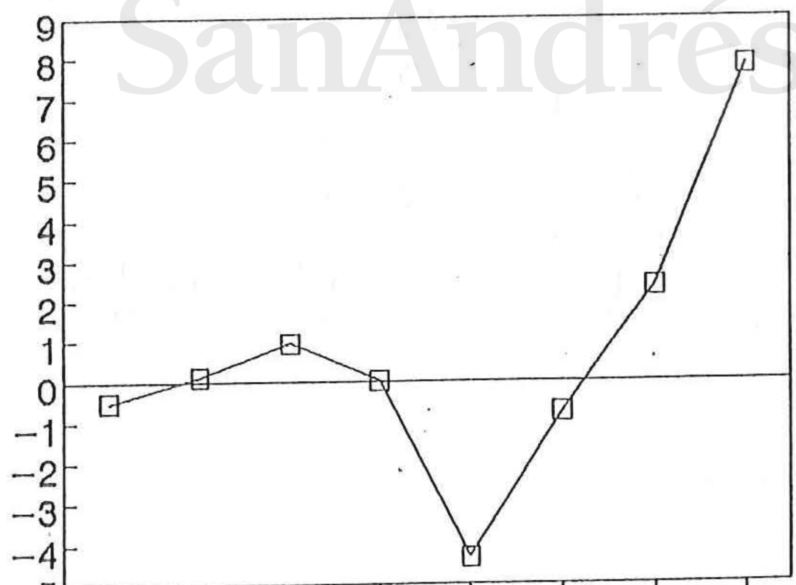
(a)

ARGENTINA: Trade Balance in Goods
(Millions of dollars)



(b)

PRIVATE CAPITAL INFLOWS
(billions of dollars)

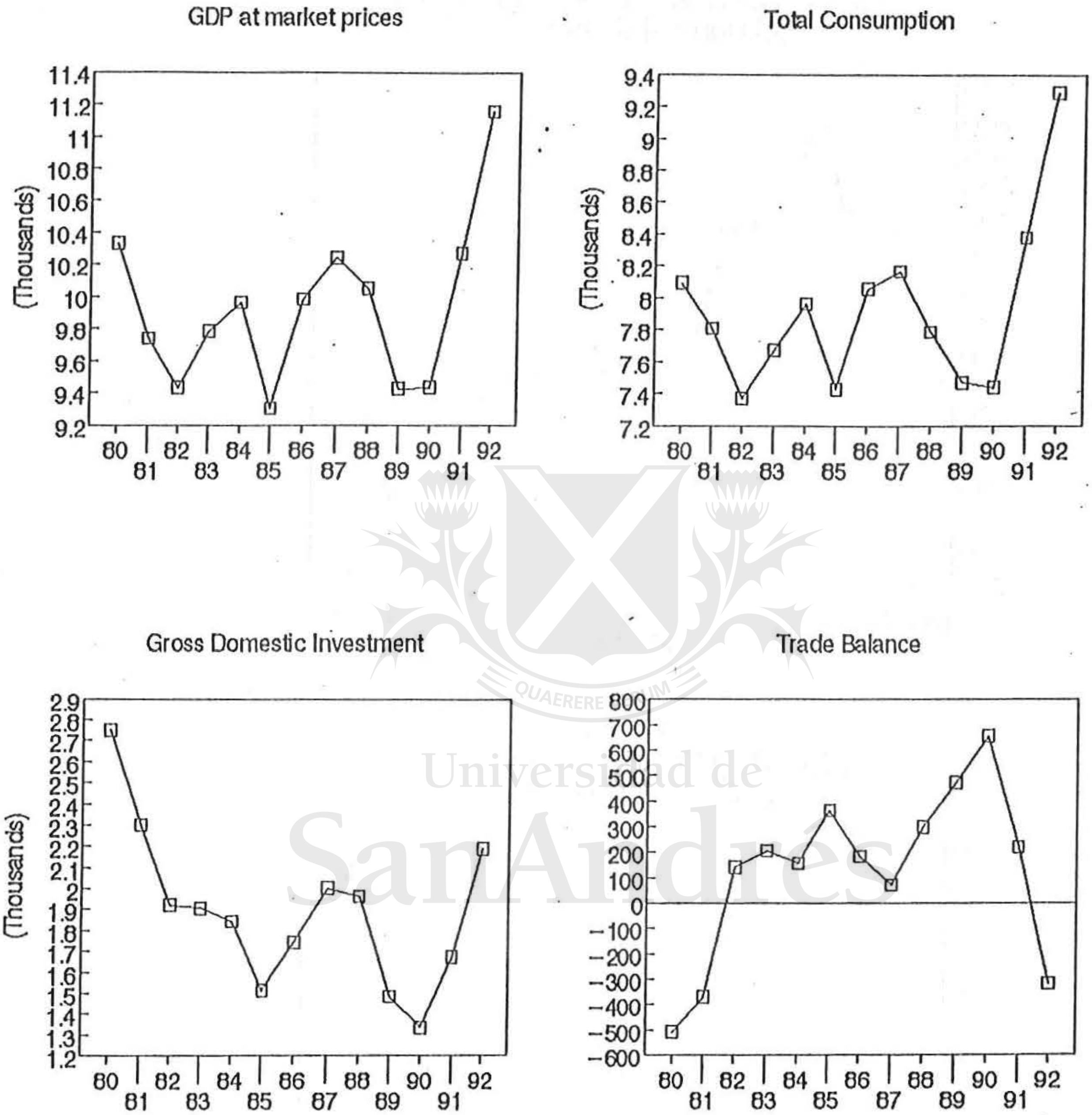


Source: (a) Fiel; (b) Broda & Asoc.

Figure 7

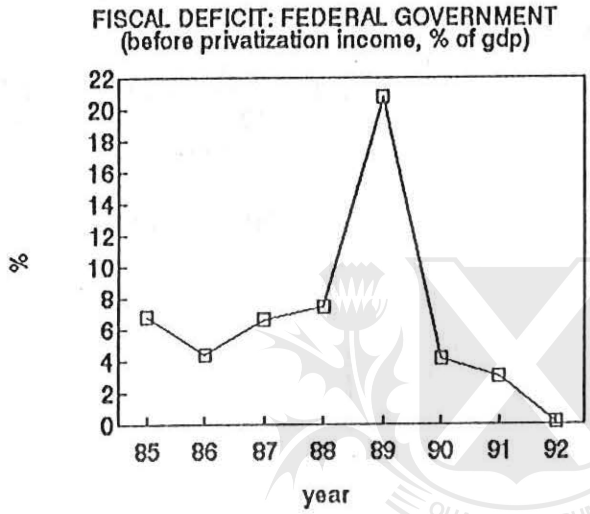
INITIAL EFFECTS OF THE CONVERTIBILITY PLAN ON AGGREGATE SUPPLY AND DEMAND

(in thousends of Pesos of 1986)



Source: Central Bank of Argentina

Figure 8



Source: Argentinean Ministry of Economics

Figure 9

STABILIZING THE MODEL ECONOMY: INITIAL EFFECTS (z=90%).

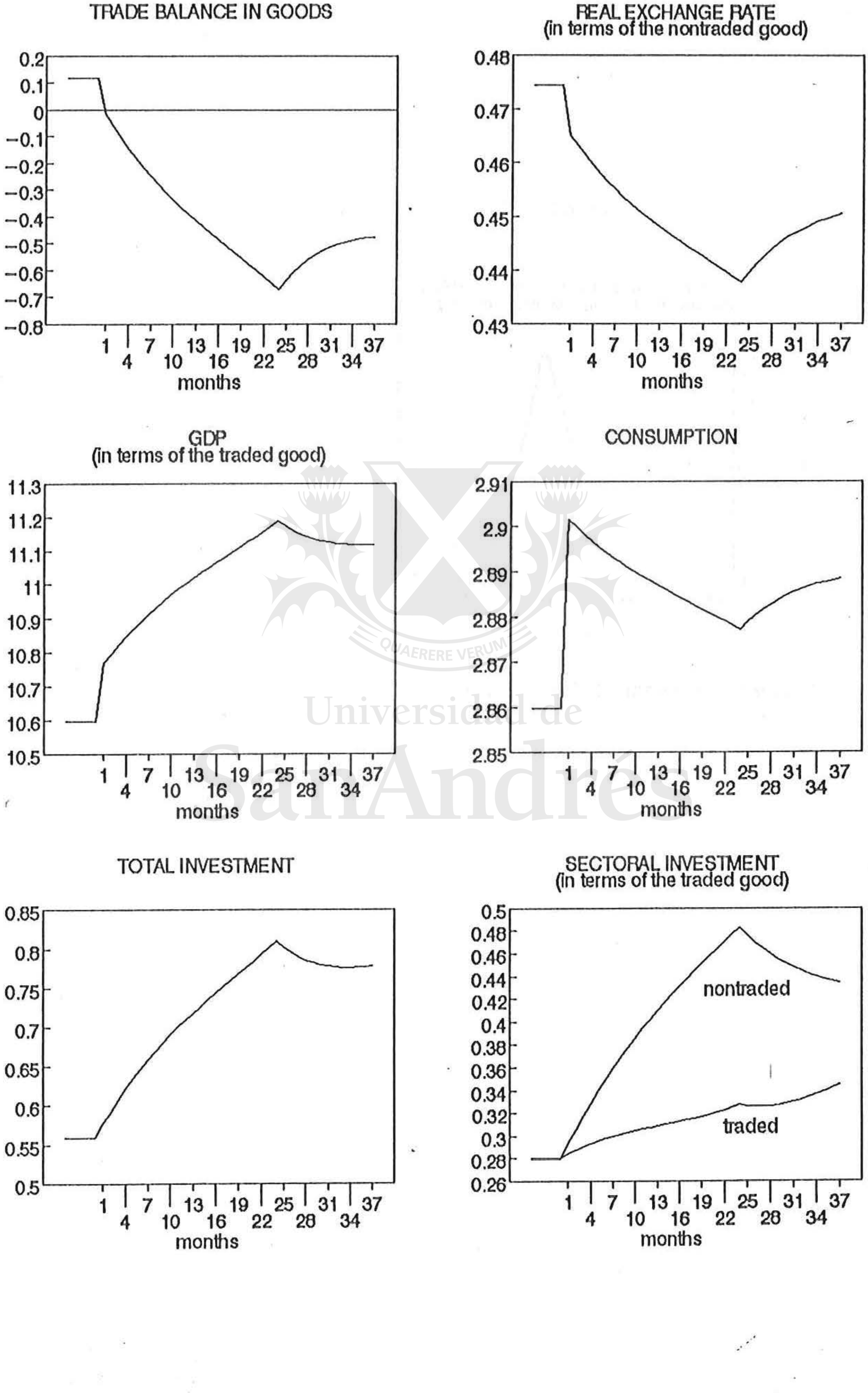


Figure 9 (continued)

CAPITAL INFLOW

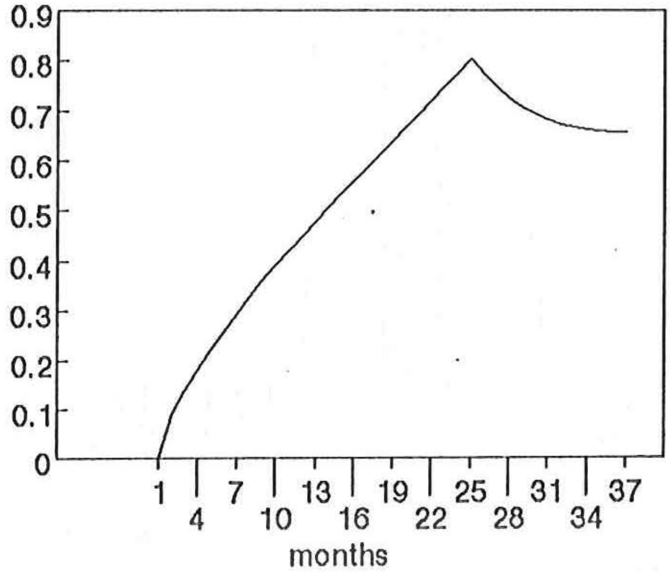


Table 10

SENSITIVITY OF THE INITIAL DYNAMICS TO THE SIZE OF THE ADJUSTMENT COST: PHI=0

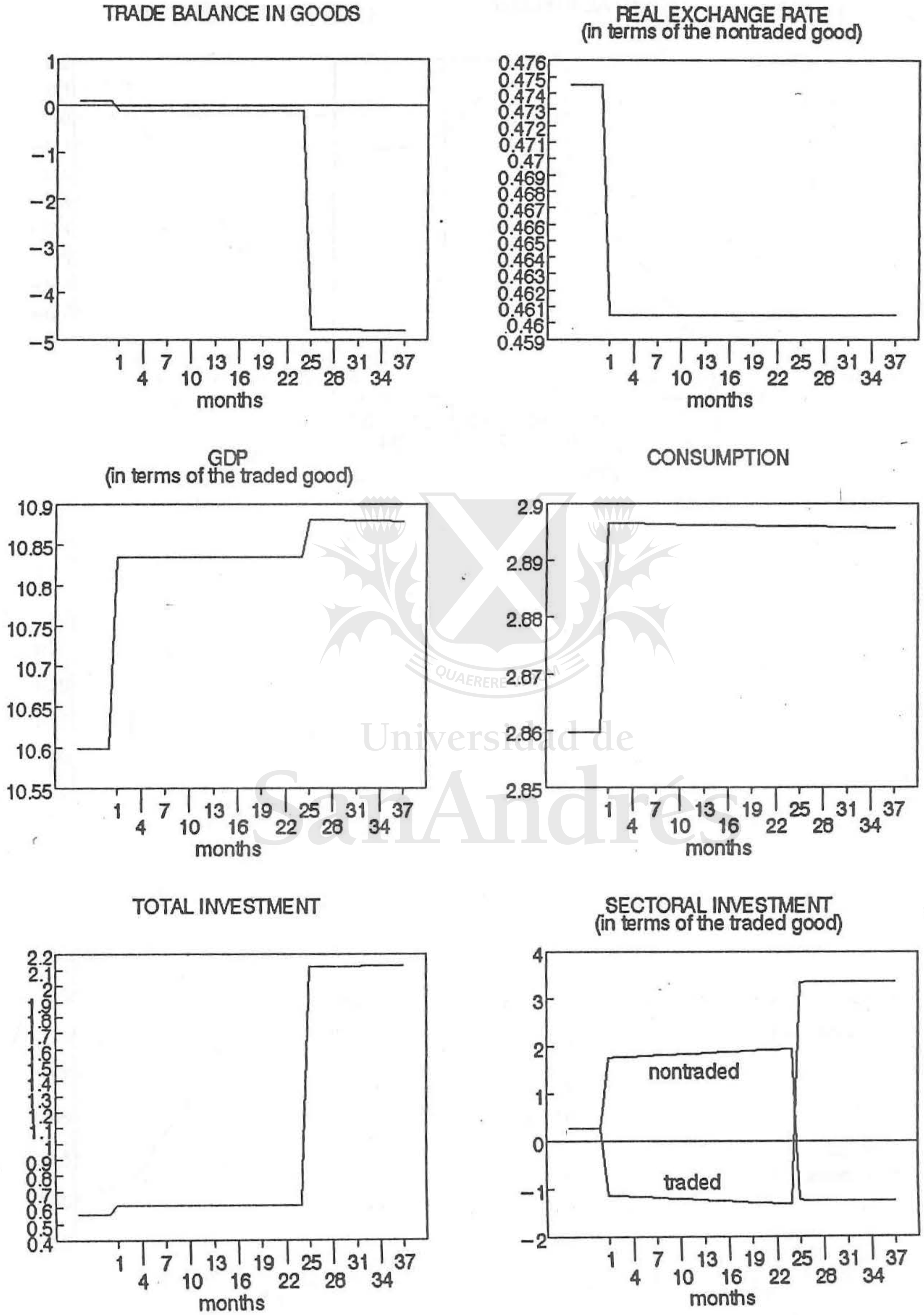


Figure 11

SENSITIVITY OF THE INITIAL DYNAMICS TO THE NUMBER OF GESTATION LAGS: J=2

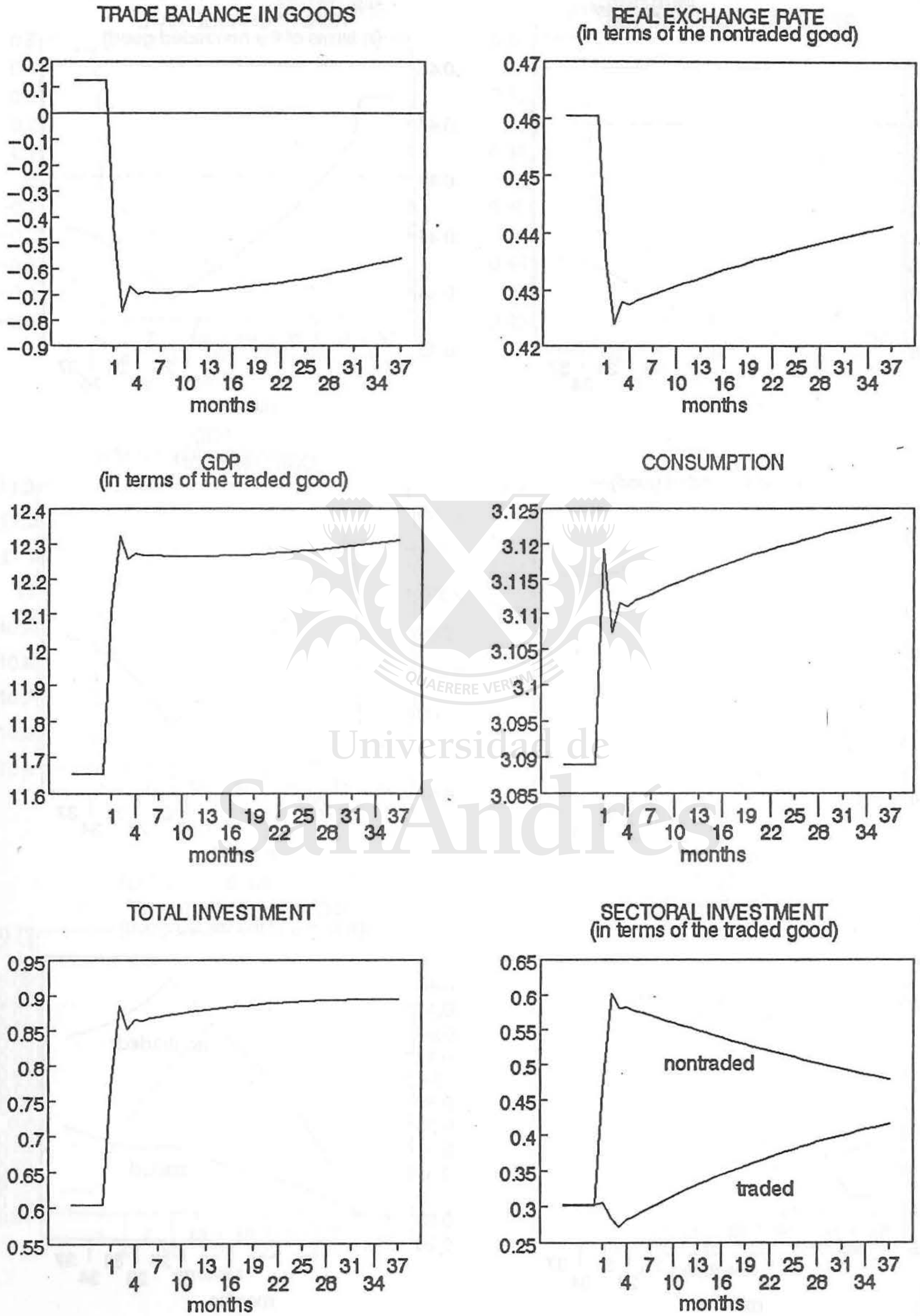


Figure 12
ALL OF THE FINANCIAL TRANSACTION COST IS RETURNED
TO THE HOUSEHOLD IN A LUMP-SUM MANNER: (z=100).

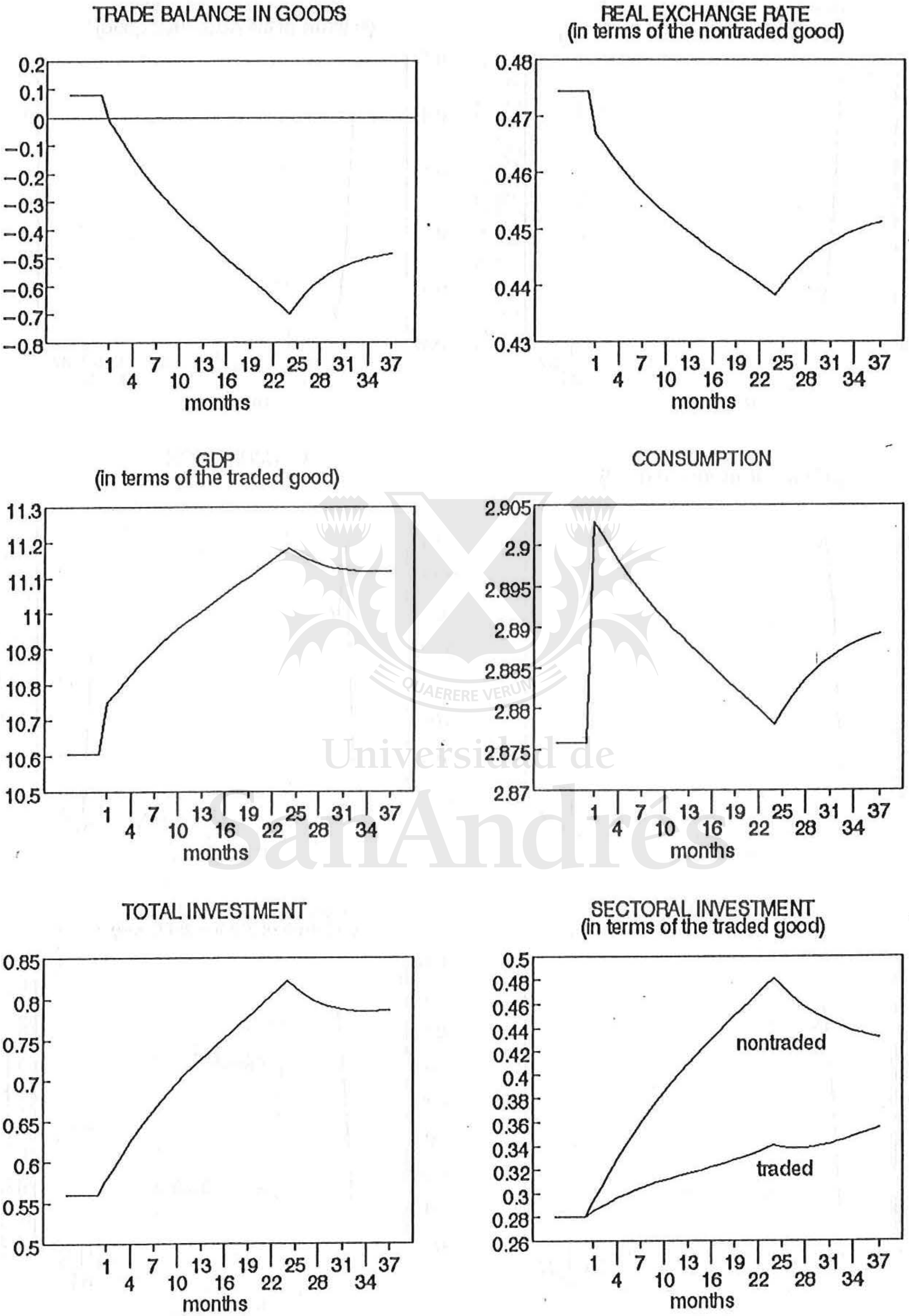


Figure 12 (continued)
THE FULL FINANCIAL TRANSACTION COST IS BORN BY THE ECONOMY (z=0)