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Dollar Strength, Peso Vulnerability to Sudden Stops: A Perfect Foresight Model of Argentina's Convertibility

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This paper presents a model designed to study the dynamic response of the economy under a fixed peg to the dollar to an international (and exogenous) real appreciation of the dollar, when there is wage and price stickiness, perfect capital mobility subject to sudden stops, and predominantly dollar denominated foreign debts with predominantly non-dollar trade. Assuming perfect foresight, we take the simple case in which the world is composed of the U.S.A., Europe, and Argentina and while all foreign debts are dollar denominated, all foreign trade is done with Europe. Hence, an important parameter in the model is the exogenous euro/dollar real exchange rate. PPP prevails in the export sector and there is monopolistically competitive price setting in the domestic sector and monopolistically competitive wage setting by households. Both are subject to adjustment cost functions that generate stickiness and domestic price and wage gaps, which result in 'Phillips curve' equations for domestic prices and wages, respectively. Money demand is generated by a transactions technology. The first order conditions for firms and households under symmetric monopolistic competition equilibriums and the budget constraints result in a four dimensional dynamical system in the multilateral real exchange rate (MRER), the real wage, the rate of domestic price inflation and the rate of wage inflation. This system has a saddle-path stable equilibrium which is dependent on the marginal utility of wealth. Under the assumption that the economy is what is called a Domestically Biased Economy in Production relative to Consumption (DBE), it is seen that strong dollar shocks, which require an inter-temporally smoothened fall in consumption (and hence an increase in the marginal utility of wealth), have perverse impact effects. The peso appreciates in real terms and the real wage increases. These effects generate foreign indebtedness and increased vulnerability to (exogenous and unexpected) sudden stops. The DBE assumption essentially entails that real depreciations require reductions in the real wage to preserve (long run) labor market equilibrium. A story is developed to explain the main features of the functioning and ultimate collapse of Convertibility in Argentina, by assuming a strong dollar shock which is believed to be temporary and has the effect of generating unemployment, recession and debt accumulation. But before the new steady state is reached it is revealed that the shock is permanent, which triggers a sudden stop, a default, a devaluation, a debt restructuring, fiscal reform, and the return to capital market access. A more flexible exchange regime could avoid the debt accumulation that triggers the sudden stop, as well as the long period of unemployment, recession, and deflation.

Key words: multilateral real exchange rate, fixed exchange regime, strong dollar shock, sudden stops

JEL: F41, F31, E52, E32

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Dollar strength, Peso vulnerability to Sudden Stops: a perfect foresight model of Argentina's Convertibility [1]

Guillermo Escudé

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"Non ridere, non lugere, neque detestari, sed intelligere". Spinoza

I. Introduction

Argentina's experience with Convertibility, a very hard peg to the U.S. dollar, ended in catastrophe after very significant shocks that were not adequately addressed through credible policy changes. In the initial phase of the monetary/exchange regime, disinflation was achieved quickly (after two bouts of hyperinflation) with no output cost. Quite the contrary, high rates of output growth were quickly achieved, giving the regime an aura of success that made it exceedingly popular both domestically and abroad. The initial phase ended with the Tequila crisis, a pure contagion effect that triggered a run on the currency and the banking system, putting the regime's resilience to test. After a three quarter recession, the economy was growing briskly again, and this increased the domestic consensus on the merits of the regime. However, during its second phase, the Convertibility regime had to face a much more severe test through a series of shocks that eventually led to the regime's collapse. The most significant of these shocks were 1) the dollar appreciation after mid-1995, which had an especially dramatic impact when Argentina's main trade partner, Brazil, devalued in January 1999, but when looked at with historical perspective was just a blip in a period of real appreciation of the peso (Figure A5), 2) the reduction in the availability of external funds for emerging market economies since 1996, and especially after the Russian crisis in August 1998, which increased yield spreads over U.S. Treasury bonds of emerging sovereign bonds (Figure A2[2]), and 3) the fall in the price of agricultural commodities subsequent to the Asian crisis in 1997 which generated a significant

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[2] As this figure illustrates, there is a strong negative correlation (ρ=0,75) between the strength of the US dollar and the volume of total capital flows to emerging market economies.

deterioration in Argentina's terms of trade. This shock, however, was much less persistent than the other two.

After three and a half years of recession, there was a sudden stop in the roll-over of public debt amortizations and a massive run on the banking system and the currency. Convertibility of deposits to cash was suspended, causing furious street demonstrations that ultimately led to the resignation of the President (the Vice-President had resigned 6 months earlier), the declaration of default on the government debt, a devaluation, and the administrative conversion (to pesos) of the currency denomination of dollar bank loans and deposits. Unemployment, which had been steadily increasing since the early 90s, reached a peak of 21.5%. This figure, however, does not completely reflect the magnitude of the social tragedy. When converted to reflect the hourly underemployment of those employed, the unemployment rate reaches more than 30% (Figure A3). Real manufacturing wages, which had been relatively constant during the 90s, fell dramatically after the devaluation (Figure A4). Most of the growth experienced during the initial phase of the regime was subsequently undone through the protracted recession that began in the second half of 1998.

Much has been said trying to determine the principal culprits of the crisis. Many have emphasized the role of fiscal policies (Mussa (2002)). It is certainly true that some fiscal looseness (including court decisions on past claims on the government) as well as the up-front costs of the 1994 pension reform and the effects of the long recession on tax collection increased the public debt from 29% of GDP in 1993 to 51% in 2001, and that this increased the vulnerability of the economy to the external shocks that it was facing. But there is increasing consensus on the importance of the monetary/exchange rate regime in explaining the run up to the crisis through the severe handicap it generated as to the possibility of correcting for the gradual but steady loss of competitiveness.

As Figure A8 shows, there was a very significant real appreciation of the peso during the first three years of Convertibility that was mostly due to inflation inertia. After a period of real depreciation of the peso achieved through lower inflation than its trade partners (especially Brazil in the aftermath of the Real Plan), the strong dollar shock came to the fore (particularly when Brazil devalued). Hence, both the initial stabilization dynamics based on the exchange rate anchor and the later strong dollar shock had significant influences on the appreciation of the peso.[3] The dynamics of the former has been studied, for example, by Calvo and Végh (1992). But the consequences of strong dollar shocks on competitiveness under inflation inertia and dollar pegs is seldom even mentioned even though it is very relevant empirically.

This paper presents a model designed to study the dynamics of a fixed exchange (or fixed crawling peg) regime under wage and price stickiness and to address some of the principal characteristics of an economy such as Argentina's: a small open economy that faces parametric prices in trade and is highly dependent on external finance; an economy which was financially highly dollarized but where the origin and destiny of its trade is highly diversified; an economy which, after a decade of high inflation in the 80s, by means of an exchange rate anchor returned to a more normal situation of "sticky" nominal wages and prices. To streamline the asymmetry between the diversification of trade partners (and currencies) and the financial dollarization, we take the extreme case in which the world is composed of the U.S.A., Europe, and Argentina, and while all of Argentina's foreign debts are dollar denominated, all its trade is done with Europe.[4] Hence, an important parameter in the model is the exogenous euro/dollar bilateral real exchange rate, ρ, which can empirically be measured by the Fed's Real Broad Dollar Index. The latter typically presents long phases of appreciation and depreciation (Figure A1). Hence, when the strong dollar phase begins it is probable that the appreciation will get gradually more pronounced and that this will persist during a number of years. Producers in a country that peg their currency to the dollar hence find it increasingly difficult to compete domestically with imported goods or in foreign markets unless their increase in productivity is sufficiently fast to compensate for the real appreciation (or trade policy is specially geared to compensate for this). The importance of the parameter ρ ("dollar strength") is highlighted by the Argentine experience during the last two periods in which it pegged to the dollar: the "tablita" experience of 1979-81 and the extended Convertibility experience in 1991-2001 (Figure A5). In both episodes, international dollar appreciations combined with a domestic

[3] As Figures A5 and A7 show, the "tablita" experience of the late 70s, in which there was a crawling peg to the dollar, took place in the midst of an important strong dollar shock. Although the episode was shorter, the real appreciation was even bigger than under Convertibility and the experience also ended with a triple crisis (as well as the Malvinas/Falklands war and the concomitant demise of the military regime).

[4] It is noteworthy that at end-2001 72% of the federal government debt of Argentina was dollar-denominated (and only 3% was peso-denominated) whereas only 15% of trade was with the dollar area.

predetermined exchange rate regime that pegged the peso to the dollar, as well as with a process of financial liberalization, ended in an abrupt triple crisis (debt, currency and banking).

This paper shows that for a country with asymmetry in the currency denomination of its financial vis a vis trade transactions, the exogenous bilateral real exchange rate between its partners (ρ) is one of the fundamental determinants of the multilateral real exchange rate (MRER). In the application to Argentina, permanent dollar appreciations have the effect of requiring a more depreciated peso, in real terms, in the long run. But a hard peg to the dollar obstructs a timely adjustment of the MRER in the required direction if there are sticky prices and wages, as is typically the case. Even worse, in economies where labor market clearing gives an inverse relation between the MRER and the real wage (economies labeled Domestically Biased in Production relative to Consumption –DBEs- in this paper) the impact effects of permanent real dollar appreciations are perverse, in the sense that they go in the wrong direction: while they appreciate the peso in real terms and increase the real wage, the opposite occurs with the steady state values of these variables.

We call DBEs those economies in which a real currency depreciation requires a lower real wage to clear the labor market because the resulting shift of labor from the domestic to the export sector is smaller than the shift of consumption from imports to domestic goods. Hence, in such economies a real depreciation of the currency, given the real wage, reduces total labor demand, requiring a reduction in the real wage to attain labor market equilibrium. We prove that in such economies an increase in the marginal utility of wealth, which is a direct consequence of the inter-temporal adjustment of households to a strong dollar shock, has the unequivocal effect of increasing the steady state value of the MRER and reducing the steady state value of the real wage, i.e. the opposite to the impact effects of the strong dollar shock. Hence, even if the strong dollar shock is temporary, due to its negative wealth effect it has perverse long run effects on the MRER and the real wage.

It is assumed that PPP prevails for producers in the export sector and that there is price setting in the domestic sector based on monopolistic competition. There is also monopolistic competition by households, which set the wage rate so as to maximize utility. Furthermore, these prices and wages are subject to price and wage adjustment costs that make domestic sector firms and households adjust prices and wages gradually towards their desired long run levels. These long run levels are those that prevail in the benchmark economy of fully flexible prices and wages (cfr. Woodford (2003)). The corresponding dynamical equations can be interpreted as Phillips curves, for domestic prices and wages, respectively. This results in a four dimensional dynamical system which has a saddle-path stable equilibrium. The eigen-values are necessarily all different, but they may be real or complex. The system is graphed in two dimensions using the dominant eigen-vector method used by Calvo (1987).

With this scaffolding, a story is developed in order to explain the main features of the evolution and ultimate collapse of Convertibility in Argentina, within the limitations imposed by a perfect foresight model. We assume there is a first shock which is unanimously considered to be temporary: an appreciation of the dollar vis a vis the euro. This has the effect of generating unemployment and recession and putting the economy on a path that slowly leads to the new steady state and during which capital markets are used to finance the transition. However, before this (long) process is over there is a new shock, which is the revelation that the dollar appreciation is more persistent than was expected. To simplify, we assume that it is revealed that the shock is permanent. This triggers a sudden stop in finance, since all debts are assumed to be of instant maturity and investors are not willing to finance the much bigger shock without forcing a substantial change in domestic policies. This change comes about through a default, a haircut on foreign debts, the government assumption of certain inter-private debts, a devaluation, and fiscal reform. This disruption, however, has the consequence of making international capital markets again accessible to the domestic economy.

The model implies that it is far better to devalue right after the initial shock, avoiding the long period of unemployment and recession financed with foreign debt. With such a timely policy change that avoids increased indebtedness, the second shock might fail to trigger a sudden stop, if what triggers the sudden stop is a threshold foreign debt level that is only known to foreign investors (or not even known to any one of them individually). Given the credibility problems with soft pegs, the model also has the implication that a fixed exchange rate regime, and especially to a single currency, should be avoided in this kind of economy, particularly when international capital markets are prone to sudden stops, since such a regime is inferior to more flexible exchange regimes where changes in the nominal exchange rate compensate for much of the wage and price stickiness. Indeed, if the 'hard fix corner" is optimal for any economy (cfr. Fischer (2001) and Edwards (2000)), it is certainly sub-optimal for DBEs that have a marked asymmetry in the currency denominations of financial and trade transactions, as the Argentine experience painfully illustrates.

II. The model

II.1. The recessionary and debt generating consequences of dollar appreciations in a nutshell

Households and the government are assumed to consume imported and domestic goods (i.e. goods that are produced domestically and only consumed domestically). Hence, it is convenient to define the (consumption) multilateral real exchange rate (MRER) as the relative price between Argentine imports (M) and Argentine domestic goods (N). To simplify, it is assumed that all trade is done with Europe (which stands for all trade partners other than the U.S.A.). Hence, the MRER is reduced to Argentina's bilateral real exchange rate with Europe:

(1) $e \equiv P_M/P_N \equiv (E/\rho)P_M^*/P_N = E/(\rho P_N).$ $(P_M^* = 1)$

where E is Argentina's nominal exchange rate (pesos per dollar), ρ is Europe's nominal exchange rate (euros per dollar), P_M^* is the European (exports) price index (which is assumed to stay at 1), and P_N is the peso price of domestic goods. It is convenient to express Argentina's nominal exchange rate with the euro as E/ρ because we assume that all foreign debts of Argentines are dollar denominated (making the peso's exchange rate with the dollar very important) and ρ (which represents the dollar's strength) is an exogenous variable for Argentina. The definition of e shows that US dollar appreciations (increases in ρ) generate deflationary pressure in the peso price of imported goods, creating an incentive for substitution in consumption towards imported goods and away from domestic goods. Note that e is the relevant relative price for the allocation of consumption between imported and domestic goods.

Let P_X* be the price index of European imports from Argentina. Then the external terms of trade is defined as $\phi \equiv P_X^*/P_M^*$ and, due to the assumption that $P_M^*=1$, it is actually the price of exports measured in euros P_X^*. Since firms produce export and domestic goods, ϕe is the relevant relative price for output decisions:

$$\phi e = (P_X^*/P_M^*)(EP_M^*/\rho P_N) = (E/\rho)P_X^*/P_N.$$

Hence, US dollar appreciations also generate and incentive to switch production from export to domestic goods.

The Consumer Price Index will be a Cobb-Douglas index of imported and home goods

(2) $$P \equiv (E/\rho)^{\theta} P_N^{1-\theta}.$$

Then the real wage in terms of the consumption basket ω is

(3) $$\omega \equiv W/P = (W/P_N)/(E/(\rho P_N))^{\theta} = (W/P_N)/e^{\theta},$$

where W is the nominal wage, W/P_N is the product wage in the domestic sector and the product wage in the export sector is

(4) $$w \equiv W/(\phi E/\rho) = \omega(\phi e^{1-\theta}).$$

Hence, US dollar appreciations, through their impact on e, tend to increase both the real wage and the product wage in the export sector. Then, if 1) the export sector is competitive and 2) there is price setting in the domestic sector (and hence output there is demand determined) and 3) there is high capital mobility but the possibility of sudden stops, and 4) the exchange rate is very firmly pegged to the dollar, we have all the ingredients for showing the potential damage that dollar strength can produce. The reason is that dollar appreciations have clearly recessionary consequences, the effects of which can be ameliorated through debt finance. The peso appreciation that the strong dollar produces substitutes demand away from domestic goods, reducing domestic sector output, while exports fall because the product wage declines in this competitive sector. Hence, output and employment fall in both sectors. But the private sector can smoothen out the negative effects of the shock on income and finance the increased demand for cheapened imports by using debt finance. Therefore, the economy becomes more vulnerable to a sudden stop, at least if there is an unknown threshold for debt beyond which sudden stops are triggered.

II.2. Transaction costs and sectoral budget constraints

Households

We assume that holding money diminishes the cost of transactions in terms of goods.[5] Let M stand for the nominal stock of currency in circulation, which is the only kind of money considered in this paper. Then $m \equiv M/E$ is the dollar value of the stock of money and ρm is its euro value. Hence, if c is the euro value of total consumption, $\rho m/c$ is the money to consumption ratio. We henceforth assume that transactions involve the (non utility generating) consumption of real resources (produced goods) and that these transaction costs (per unit of consumption) are a function τ of the money/consumption ratio:

$$\tau(\rho m/c) \qquad\qquad (\tau' < 0,\ \tau'' > 0).$$

We assume that when the money to consumption ratio increases, the transactions cost (per unit of consumption) decreases at a decreasing rate, reflecting a diminishing marginal productivity of money in reducing transaction costs. To obtain private savings we must subtract $(1+\tau)c$ from disposable income (instead of c). Also, for simplicity, we assume that the government can avoid these transaction costs.

Households hold financial net wealth that is composed of domestic money (M), peso denominated nominal claims on the government (B), and net dollar denominated foreign debt (d_H). There also exist inter-household dollar debts (that were actually intermediated by the banking system in Argentina) that only play a (minor) role when, upon devaluation, the government converts the currency denomination of these debts to pesos in an asymmetric way. The foreign debt (as well as the government foreign debt we consider below) is assumed to mature instantly and hence has a constant nominal value. It is a predetermined variable. The fact that foreign debts mature instantly implies that a sudden stop in refinancing actually forces a restructuring if (as we assume) the net foreign debt is always positive. It also forces a devaluation through a speculative attack: we assume that in the case of a sudden stop, the Central Bank does not attempt to defend the peg by selling

[5] This way of modeling money demand has been used by Kimbrough (1992), Agénor (1995) and Montiel (1997), among others.

international reserves because it knows they would be depleted instantly. Expressed in dollars, household wealth is:

(5) $$a = m + b - d_H,$$

where $b \equiv B/E$. The household's flow budget constraint is:

(6) $$\dot{a} = \dot{m} + \dot{b} - \dot{d}_H = [y - t - (1+\tau(\rho m/c))c]/\rho - r\, d_H + i\, b - \delta(m+b), \quad (\delta \equiv \dot{E}/E),$$

where y is pre-tax income (output) expressed in euros, t is the euro value of lump sum taxes net of transfers, r is the interest rate on the foreign debt, i is the domestic interest rate, and δ is the rate of nominal depreciation of the peso against the dollar. Note that the euro value of primary savings (gross of interest payments and net of transaction costs τc) must be converted to dollars by dividing by ρ. Furthermore, net interest payments on the debt rd_H-ib must be subtracted from primary savings, as well as the capital losses on the dollar value of the stock of money and peso claims on the government due to currency depreciation.

To simplify, we assume perfect capital mobility, except for eventual sudden stops (that only last an instant). Hence, there is no country risk premium and, by arbitrage, the domestic peso-denominated interest rate i must equal the interest rate on dollar debts (r), which is assumed to be constant, plus the rate of depreciation:

(7) $$i = r + \delta.$$

Note that i is the opportunity cost of holding money. Using (5) and (7) gives an alternative expression for the household budget constraint:

(8) $$\dot{a} = [y - t - (1+\tau(\rho m/c))c]/\rho + ra - im.$$

The household's inter-temporal solvency is guaranteed by a 'No Ponzi Game" condition:

(9) $$\lim_{T\to\infty} a \exp\left(-\int_0^T r\, ds\right) = \lim_{T\to\infty} a\, e^{-rT} \geq 0,$$

which in the household optimum holds with equality. Integrating (8) forward and using (9) gives the inter-temporal budget constraint: the present value of future consumption (gross of transactions consumption) must be equal to the present value of disposable income plus initial (non-human) wealth (a_0).

(10) $a_0 + \int_0^{\infty} [y - t - (1+\tau(\rho m/c))c]/\rho - im]\, e^{-rs}\, ds = 0.$

The public sector

The Central Bank has M (=mE) as its sole liability and international reserves, R, as its sole asset, which are assumed to be invested in U.S. bonds. Furthermore, the Central Bank is assumed to have a policy of maintaining a full backing of its monetary liabilities. Hence, M=ER, or:

(11) $m = R.$

This implies that 1) capital gains or losses on R due to the nominal depreciation of the peso are kept in the Central Bank, 2) interest gained on international reserves rR (where r is both the nominal and real international interest rate, since international inflation is assumed to be zero) are transferred to the Government.

The Central Bank mechanically follows a "currency board" policy by which it purchases (sells) private sector excess supply (demand) of foreign exchange at the current exchange rate (which grows at the policy rate $\overline{\delta}\geq 0$), while it passes the interest earned on R to the government:

(12) $\dot{M} = E\dot{R}.$

Hence, its budget constraint is:

(12') $\dot{m} - \dot{R} = -\delta R,$

where earned interests are not included since they are passed on to the Government.

Let G (g) be the primary expenditures in pesos (euros):

$$G = (E/\rho)g_M + P_N\, g_N, \qquad g = g_M + g_N/e$$

where g_M and g_N are the quantities of imported and domestic goods the government purchases, respectively. Then the dollar value of primary expenditures is:

$$G/E \equiv g/\rho = (g_M + g_N/e)/\rho.$$

We assume that g_M and g_N are always held constant. Hence, a US dollar appreciation increases g (through e) and reduces G and G/E whereas a devaluation increases G and reduces g and G/E.

The Government can finance its primary expenditures and its interest payments through lump sum taxes (net of transfers), interests gained on Central Bank reserves, and (foreign and domestic) debt financing. Hence, the government's flow budget constraint is:

$$\text{(13)} \qquad \dot{b} + \dot{d}_G = (g - t)/\rho + r(b+d_G-R),$$

where t is the euro value of (lump sum) tax receipts and d_G is the government's foreign debt. Define the consolidated government's net (non-contingent) liabilities (including money) as

$$\text{(14)} \qquad h = m - R + b + d_G.$$

Then the budget constraint of the consolidated public sector is obtained by adding (12') and (13):

$$\text{(15)} \qquad \dot{h} = (g - t)/\rho + r(b+d_G) - (r+\delta)R = (g - t)/\rho + rh - im,$$

where we have used (7) and (11) for the second equality.

It is assumed that the public sector always plans to be solvent, which implies that it expects to comply with a "no -Ponzi game condition":

$$\text{(16)} \qquad \lim_{T\to\infty} h \exp\left(-\int_0^T r\, ds\right) = \lim_{T\to\infty} h\, e^{-rT} = 0.$$

This condition implies that the public sector's net debt must eventually grow at a rate that is lower than the interest rate. Integrating (15) forward and using (16) gives the public sector's inter-temporal budget constraint: the present value of its primary expenditures plus its initial debt must be equal to the present value of its revenues (including the interest on the international reserves and seigniorage due to the effect of currency depreciation on monetary liabilities):

(17) $$h_0 = \int_0^{\infty} [(t - g)/\rho + im]\, e^{-rs}\, ds.$$

We assume that there is unanimity that in the event of a sudden stop in foreign financing there will be a devaluation (but not a monetary policy regime change), a tax reform, a government assumption of certain inter-household private debts (the government's contingent liabilities), and a debt restructuring with a haircut on the foreign debt that preserves solvency. We will specify this in section II.9.

The foreign sector

Due to the assumption of perfect capital mobility (with the possible exception of a sudden stop), the public and the private sector have full access to foreign savings at the international rate r. Let us define the country's net foreign debt as:

(18) $$d \equiv d_H + d_G - R = h - a.$$

Then, subtracting (15) from (8) gives the country's budget constraint, or balance of payments:

(19) $$-\dot{d} = [y - g - (1+\tau(\rho m/c))c]/\rho - rd.$$

The country's net foreign position expressed in dollars (-d) evolves according to primary savings (net of transaction costs) minus interest payments on the country's net debt. Also, (10), and (17) give the country's inter -temporal budget constraint: the present value of future trade surpluses must equal the initial foreign debt.

(20) $$d_0 = \int_0^{\infty} [y - g - (1+\tau(\rho m/c))c]/\rho\, e^{-rs}\, ds.$$

II.3. The price and wage setting framework

We assume that there is monopolistic competition in the supply of labor services by households and in the supply of goods by firms in the domestic sector. However, these wages and prices are sticky, which means that the desired wage and domestic price cannot be attained instantly because there are price and wage adjustment costs which must be taken into account. We use adjustment cost functions similar to those in Rotemberg (1982,

1995) and Sbordone (1998). These adjustment costs aren't "menu costs", but reflect costs related to optimal decision making, such as information gathering, negotiation, evaluation, etc of information gathering,. Firms' present value of profits maximization and households' inter-temporal utility maximization in symmetric equilibriums lead to well defined "Phillips curves" for domestic price inflation and wage inflation, respectively. These equations reflect a gradual adjustment of domestic prices and wages, respectively, towards their long-run desired levels, which are the monopolistic competition mark-up over marginal cost and marginal rate of substitution of wealth for leisure, respectively. The resulting dynamic model has as steady state a benchmark economy of full wage and price flexibility, i.e. one in which there are no price and wage adjustment costs. However, off the steady state, the use of resources is constrained by the existence of adjustment costs for prices and wages. The benchmark, flexible price and wage, model is similar to Blanchard and Kiyotaki (1987), and the dynamic system is similar to Erceg et al (2000), Sbordone (2001), and Woodford (2003), except that instead of a Calvo type staggered pricing framework we have price and wage inertia due to explicit price and wage changing costs. Also, we have a two sector open economy model while all the above models are one sector and closed economy.

II.4. Firm decisions

There are two production sectors that produce exportable (X) and domestic (N) goods, respectively. Capital is fixed in each sector and labor is perfectly mobile between sectors but immobile internationally. There is a representative firm in the export sector and a continuum of monopolistically competitive firms in the domestic sector, each of which is characterized by the good type $i \in [0,1]$ it produces. Output in each sector is given by production functions: $y_X = F_X(L_X)$, $y_{Ni} = F_N(L_N)$, that have positive and diminishing marginal labor productivities, where L_X and L_N are aggregates of the complete range of labor types $j \in [0,1]$, as we will see in the next section. We assume that there is a single labor market, where all firms (whether in the domestic or export sector) hire the same CES aggregate of all types of labor and face the same wages. As in Erceg et al (2000), assume that there is a competitive "employment agency" (or "representative labor aggregator") that combines households' labor types in the same proportion that firms would choose. Define the aggregate of labor types by

$$(21) \qquad L = \left\{ \int_0^1 L_j^{(\psi-1)/\psi}\, dj \right\}^{\psi/(1-\psi)} \qquad\qquad (\psi>1)$$

We will refre to L as 'labor'. The employment agency's demand for each labor type j is equal to the sum of all firms' demand. It minimizes the cost of producing a given level of L. Hence, it minimizes

$$(22) \qquad \int_0^1 W_j L_j \, dj$$

subject to (21) with a given value of L, where W_j is the wage rate set by the monopolistic supplier of labor type j. This gives the agency's demand (and the aggregate demand of all firms) for labor type j as

$$(23) \qquad L_j = L\,(W_j/W)^{-\psi}$$

where W is the aggregate wage index, defined as:

$$(24) \qquad W = \left\{ \int_0^1 W_j^{1-\psi}\, dj \right\}^{1/(1-\psi)},$$

and ψ is the wage elasticity of demand for all types of differentiated labor services. The higher ψ is, the lower is the monopolistic power of households, because the varieties of labor serves are closer substitutes. Total labor cost is given by

$$(25) \qquad \int_0^1 W_j L_j \, dj = WL.$$

The export sector is assumed to be competitive and has a profit maximizing representative firm that chooses the labor input each instant so that its marginal productivity is equal to the product wage (4):

$$(26) \qquad F_X'(L_X) = W/(\phi(E/\rho)) = \omega/\phi e^{1-\theta},$$

where W is the wage index for the complete range of labor types (24).

The domestic sector, however, has a continuum of monopolistically competitive firms, each producing a distinct variety i. Let us temporarily drop the sub-index N, for ease of notation. Changing price is assumed to be costly. For simplicity, we assume that this activity requires the non utility generating consumption of the good the price of which is to be adjusted. In a continuous time analogy to Sbordone (1998), let $x(\pi_i)$ represent the cost per unit sale of changing P_i at the rate $\pi_i \equiv d\ln P_i/dt$. We assume that this adjustment cost function is twice continuously differentiable and has the following properties:

(27) $\quad x(0) = x'(0) = 0, \qquad x''(0) = a_F > 0.$

Each firm in the domestic sector is constrained by its technology and by the demand function it faces for its distinct variety i:

(28) $\quad F(L_i)= y_i, \qquad y_i = y(P_i/P)^{-\nu}$

The demand function for domestic goods will be derived in the next section.

Firm i chooses π_i to maximize the present value of future profits:

$$\int_0^\infty \{\, yP^\nu P_i^{1-\nu}(1 - x(\pi_i)) - WF^{-1}(yP^\nu P_i^{-\nu}) \,\}\, e^{-rs}\, ds,$$

subject to the fact that

(29) $\quad \dot{P}_i = P_i\, \pi_i.$

Hence, its undiscounted Hamiltonian is:

$$H^i = yP^\nu P_i^{1-\nu}(1 - x(\pi_i)) - WF^{-1}(yP^\nu P_i^{-\nu}) + \lambda_i P_i \pi_i,$$

where $\lambda_i \equiv \lambda_i^* e^{rt}$ represents the marginal net present value of price increase (and λ_i^* is the corresponding co-state variable). Firm i's first order conditions are:

(30) $\qquad H^i_{\pi i} = 0, \qquad \dot{\lambda}_i - \beta\lambda_i = -H^i_{Pi}.$

The first of these conditions gives:

(31) $\qquad \lambda_i = x'(\pi_i)y_i.$

For the second one, it is convenient to define the marginal cost as the wage rate divided by the marginal productivity of labor (1/z):

(32) $$Wz(y_i) \equiv Wd(F^{-1}(y_i))/dy_i$$

Hence,

$$H^i_{P_i} = yP^{\nu}\,(1-\nu)P_i^{-\nu}(1 - x(\pi_i)) - Wz(y_i)(-\nu)yP^{\nu}\,P_i^{-\nu-1} + \lambda_i\,\pi_i,$$

and therefore, using (31):

$$\dot{\lambda}_i/\lambda_i = \beta - H^i_{P_i}/\lambda_i = \beta + [(\nu-1)/x'(\pi_i)]\{\,1-x(\pi_i)-\pi_i\,x'(\pi_i)/(\nu-1) - \nu/(\nu-1)(W/P_i)z(y_i)\,\}.$$

On the other hand, (31) implies

$$\dot{\lambda}_i/\lambda_i = x''(\pi_i)\dot{\pi}_i\,/x'(\pi_i) + \dot{y}_i/y_i\,.$$

Therefore, the last two equations imply:

$$x''(\pi_i)\dot{\pi}_i\,/x'(\pi_i) + \dot{y}_i/y_i = \beta + [(\nu-1)/x'(\pi_i)]\{\,1-x(\pi_i)-\pi_i\,x'(\pi_i)/(\nu-1) - \nu/(\nu-1)(W/P_i)z(y_i)\,\},$$

which can be rearranged to:

(33) $$\dot{\pi}_i \;=\; [x'(\pi_i)/x''(\pi_i)]\,[\,\beta - \dot{y}_i/y_i\,] + {}$$

$$+\,[(\nu-1)/x''(\pi_i)]\{\,1-x(\pi_i)-\pi_i\,x'(\pi_i)/(\nu-1) - \nu/(\nu-1)(W/P_i)z(y_i)\,\}.$$

In a neighborhood of a steady state with zero inflation (i.e. one where there is a fixed exchange rate: $\overline{\delta}$=0), (27) applies, and hence (33) reduces to

(34) $$\dot{\pi}_i \;=\; [(\nu-1)/a_F]\,\{\,1 - \nu/(\nu-1)(W/P_i)z(y_i)\,\}.$$

Since all domestic firms face the same problem, they all set the same price and inflation rate, so we may drop the subscript i from (35) (but again insert the subscript N) to obtain a domestic price ‘Phillips Curve” equation:

(35) $$\dot{\pi}_N \;=\; -\gamma_F\,G^P(W/P_N,y_N) \qquad (\,\gamma_F \equiv (\nu-1)/a_F\,),$$

where we defined the percentage gap between the actual domestic price and the benchmark (flex-price) domestic price as:

(36) $$G^P(W/P_N,y_N) \equiv [\mu_P(Wz(y_N) - P_N]/P_N \;=\; \mu_P(W/P_N)z(y_N) - 1 \qquad (\,\mu_P \equiv \nu/(\nu-1)\,).$$

Whenever the price gap is positive, the domestic price level is below the desired one (which is the usual mark-up over marginal cost), and firms gradually increase their price ($\pi_N>0$) but at a decreasing rate ($d\pi_N/dt<0$).

II.5 Household decisions

Households are also assumed to be monopolistic competitors. They set the wage rate and face wage adjustment costs that make them adjust the wage rate gradually towards the benchmark (flex-wage) nominal wage. Let $x(\pi_{Wj})$ represent the cost of changing W_j at the rate $\pi_{Wj} \equiv d\ln W_j/dt$. We use the same symbol as for firms' cost of adjustment function only for ease of notation. Assume that this function has the following properties:

(37) $x(0) = x'(0) = 0, \qquad x''(0) = a_H > 0.$

Household $j\in[0,1]$ supplies labor of type j and maximizes an inter-temporal utility function which is additively separable in consumption and leisure:

(38) $\int_0^\infty \{ u(c_M,c_N)^{1-\sigma}/(1-\sigma) - v(L_j) \} e^{-\beta s} ds,$

where c_M is the consumption of imported goods, c_N is the composite consumption of domestic goods, and L_j is labor exertion. The consumption part of the instantaneous utility expression is of the constant relative risk aversion (CRRA) family, where $\sigma>0$ is the inverse of the of the inter-temporal elasticity of substitution (as well as the coefficient of relative risk aversion[6]). In (38), u(.) is a private goods consumption sub-utility index, v(.) is the disutility of labor ($v'>0$, $v''>0$), [7] and β is the inter-temporal discount factor.

In analogy to the 'employment agency', assume that there is a 'commercial agency' (or 'representative consumption aggregator') that combines the different goods into a single product, that we will refer to as 'domestic good' in the proportions dictated by households' preferences. The commercial agency's composite c_N is defined by:

[6] Observe that if $u(c)=c^{1-\sigma}/(1-\sigma)$, the coefficient of relative risk aversion is $-cu''(c)/u'(c)= \sigma$. We generally assume below that $\sigma\geq 1$. In some cases we find it useful to specialize to logarithmic utility (where $\sigma=1$).

[7] We could include and additively separable sub-utility index $\upsilon(g_M,g_N)$ representing the utility obtained by the household from the quantities of public goods produced by the government (measured through the quantities purchased by the government). However, since g_M and g_N are not decision variables for the household and will be held constant throughout, $\upsilon(.)$ would not play any significant role except as a reminder that government expenditures do generate household utility.

$$(39) \qquad c_N = \left\{ \int_0^1 c_N(i)^{(\nu-1)/\nu}\, di \right\}^{\nu/(1-\nu)} \qquad (\nu>1).$$

For any level of the composite c_N the agency minimizes expenditures, given the prices P_{Ni} set by the domestic sector firms. Hence, it minimizes

$$(40) \qquad \int_0^1 P_{Ni}\, c_{Ni}\, di$$

subject to (39) for a given value of c_N. This gives total consumption demand for c_{Ni} as:

$$(41) \qquad c_{Ni} = (P_{Ni}/P_N)^{-\nu}\, c_N$$

where the Lagrange multiplier P_N is the (dual) Dixit-Stiglitz price index for domestic goods

$$(42) \qquad P_N = \left\{ \int_0^1 P_{Ni}^{1-\nu}\, di \right\}^{1/(1-\nu)},$$

and ν is the price elasticity of demand for all types of (differentiated) goods. The higher ν is, the lower is the market power of firms because the varieties are closer substitutes. Furthermore, total expenditure on domestic goods is

$$(43) \qquad \int_0^1 P_{Ni}\, c_{Ni}\, di = P_N\, c_N.$$

For concreteness, assume that u(.) is Cobb-Douglas:[8]

$$(44) \qquad u(c_M,c_N) \equiv c_M^{\theta} c_N^{1-\theta}.$$

where θ is the intra-temporal elasticity of substitution in consumption between imported and domestic goods, and is also the share of imported goods in total consumption, as shown below. Total consumption expenditure measured in euros is:

$$(45) \qquad c = c_M + c_N/e,$$

The consumer price index defined by (2) corresponds to the dual of (44). Then minimizing (45) subject to a constant (and arbitrary) level of utility $u_0=c_M^{\theta}c_N^{1-\theta}$ gives:

[8] This follows Montiel (1999). The model can easily be extended to a CES sub-utility index (cfr. Calvo and Végh (1992), or Obstfeld and Rogoff (1996), for example). However, it does not seem to add much in the present context while it complicates the formulas.

(46) $\qquad ec_M/c_N = \theta/(1-\theta)$

independently of u_0. Note that (45) and (46) imply

(47) $\qquad c_N = (1-\theta)ec, \qquad\qquad c_M = \theta c,$

(48) $\qquad c_M^{\theta}c_N^{1-\theta} = \kappa_0\, e^{1-\theta}c \qquad\qquad (\ \kappa_0 \equiv \theta^{\theta}(1-\theta)^{1-\theta}\ ).$

As the two expressions in (47) show, consumption demands for N and M are easily obtained from c and e, so we will prefer to work with the latter. Using (48) in (44) gives the following expression for (38):

(49) $$\int_0^{\infty} \{\ \kappa_1(e^{1-\theta}\, c)^{1-\sigma}/(1-\sigma) - v(L_j)\ \} e^{-\beta s}\, ds \qquad\qquad (\ \kappa_1 \equiv \kappa_0^{\ 1-\sigma}\ ).$$

Let $Y = (E/\rho)\phi y_X + P_N\, y_N$ be aggregate output measured in pesos. Then the dollar value of aggregate output is $Y/E \equiv y/\rho\ = [\phi y_X + y_N/e]/\rho$, where y is the euro value of aggregate output. Real peso aggregate profits are $\Pi/P \equiv (E/\rho)\phi y_X + P_N y_N(1-x(\pi_N))-\omega L(1-x(\pi_{Wj})$. We assume that firm ownership is distributed evenly among households. Hence, j's dollar income is $\Pi/E + (W_j/E)L_j$ and the flow budget constraint (8) may equivalently be expressed as

(8') $$\dot{a} = (W_j/E)L_j\,(1 - x(\pi_{Wj}))\ + \Pi/E\ - [t + (1+\tau(\rho m/c))c]/\rho + ra - im.$$

The household is also constrained by the demand function it faces for its distinct labor variety j (23) and the fact that

(50) $$\dot{W}_j = W_j\, \pi_{Wj}.$$

Hence, the household maximizes (49) subject to (23), (50), (8') and its 'ho Ponzi -game" condition (9). Its control variables are c, m, and π_{Wj}, and it takes as given the future paths of ω, e, t, and i, as well as the values of the parameters involved. Due to the assumption of perfect foresight, unless there is an unexpected shock to any of the parameters (as we will have below for ρ), those expected paths will be the actual ones.

The non-discounted Hamiltonian of household j is:

(51) $$H^j = \kappa_1(e^{1-\theta}\, c)^{1-\sigma}/(1-\sigma) - v(LW^{\Psi}W_j^{-\Psi}) + \lambda_j\{\ LW^{\Psi}W_j^{1-\Psi}(1 - x(\pi_{Wj}))/E$$

$$+ \Pi/E - [t + (1+\tau(\rho m/c))c]/\rho + ra - im\} + \mu_j W_j \pi_{Wj},$$

where $\lambda_j \equiv \lambda_j^* e^{\beta t}$ represents the marginal utility of wealth (and λ_j^* is the corresponding co-state variable) and $\mu_j \equiv \mu_j^* e^{\beta t}$ represents the marginal utility of wage increases (and μ_j^* the corresponding co-state variable). The necessary conditions for an optimum (and also sufficient under standard assumptions) are:

$$(52) \qquad H^j_c = 0, \qquad H^j_m = 0, \qquad H^j_{\pi wj} = 0,$$

$$\dot{\lambda}_j - \beta\lambda_j = -H^j_a, \qquad \dot{\mu}_j - \beta\mu_j = -H^j_{wj}$$

that is,

$$(53) \qquad \kappa_1 e^{(1-\theta)(1-\sigma)} c^{-\sigma} = \lambda_j \varphi(\rho m/c)$$

$$(54) \qquad -\tau'(\rho m/c) = i,$$

$$(55) \qquad \mu_j = x'(\pi_{Wj})\lambda_j L_j/E,$$

$$(56) \qquad \dot{\lambda}_j/\lambda_j = \beta - r$$

$$(57) \qquad \dot{\mu}_j/\mu_j = \beta - \{ \psi v'(L_j)(L_j/W_j) + (1-\psi)\lambda_j(L_j/E)(1-x(\pi_{Wj})) + \mu\pi_{Wj} \}/\mu_j$$

along with the transversality condition

$$(58) \qquad \lim_{t\to\infty} a\lambda_j e^{-\beta t} = 0.$$

To alleviate notation, we have defined the function φ that gives the effect of a marginal increase in utility generating consumption c on savings:

$$(59) \qquad \varphi(\rho m/c) \equiv 1+\tau(\rho m/c)-(\rho m/c)\tau'(\rho m/c), \qquad \varphi'(\rho m/c) = -(\rho m/c)\,\tau''(\rho m/c) < 0.$$

We will call φ the marginal savings function.

Equation (53) shows that in equilibrium the utility of a marginal increment in consumption (left side of the equality) must be equal to the marginal disutility of the reduction in wealth that it generates. The latter is equal to the marginal utility of wealth, λ, times the marginal reduction in savings, φ. Observe in (59) that φ varies inversely with $\rho m/c$ and that the reduction in savings generated by a marginal increase in c is given by the increase in consumption gross of existing transaction costs, $1+\tau$, plus the increase in transaction costs due to the reduction in the money/consumption ratio.

Equation (54) shows that in the optimum money holdings must be such that the reduction in transaction costs generated by a marginal increase in money holdings equal the opportunity cost of holding money (i). Inverting $-\tau'$ gives the following demand function for money:

(60) $\quad m^D = h(i)c/\rho \qquad (h \equiv (-\tau')^{-1} , h'<0).$

Observe that this implies that in terms of domestic goods the demand for money is $M/P_N = h(i)ec$.

Equation (56) shows that over time the rate of growth of the marginal utility of wealth must be equal to the difference between the inter-temporal discount rate, β, and the interest rate. This implies that the more impatient the household is (the greater is β), the faster the marginal utility of wealth must increase, that is, the faster the household must reduce its wealth through increased consumption. However, given that β and r are both exogenous constants, in order to have a steady state we make the usual simplifying assumption that β=r. Hence, λ_j is constant as long as there are no unanticipated shocks that make the household re-evaluate its inter-temporal decision, in which case λ_j may face a discrete jump, as will be the case below upon shocks to ρ.

Taking the derivative of (55) with respect to time and using (57) gives an expression entirely analogous to the one obtain for the firm's problem

$$\dot{\pi}_j = [x'(\pi_{Wj})/x''(\pi_{Wj})] [\dot{\bar{\delta}} - L_j/L_j + \beta - \pi_j] +$$

$$+ [(\psi-1)/x''(\pi_{Wj})]\{ 1-x(\pi_{Wj}) - \pi_{Wj}x'(\pi_{Wj})/(\psi -1) - \psi/(\psi-1)v'(L_j)/[\lambda_j(W_j/E)] \}.$$

In a neighborhood of a steady state with zero inflation, this expression (by (35)) reduces to

(61) $\quad \dot{\pi}_{Wj} = [(\psi-1)/a_H] \{ 1 - \psi/(\psi-1)v'(L_j)/[\lambda_j(W_j/E)] \}.$

Since all households face the same problem, they all set the same wage and wage inflation rate, so we can drop the subscript j from (61) to obtain a wage 'Phillips Curve" equation:

(62) $\quad \dot{\pi}_W = -\gamma_H G^W(W/E,L) \qquad (\gamma_H \equiv (\psi-1)/a_H),$

where L represents total (domestic and export sectors') demand for the labor aggregate as well as wage adjustment costs and we defined the percentage gap between the actual wage and the benchmark (flex-wage) wage as:

(63) $G^W(W/E,L) \equiv [\mu_W v'(L)E/\lambda - W]/W = \mu_W v'(L)/[(W/E)\lambda] - 1 \qquad (\mu_W \equiv \psi/(\psi-1)$.

Whenever the wage gap is positive, the nominal wage is below the desired one, which is a mark-up over the marginal rate of substitution of wealth for leisure. Whenever this is the case, households gradually increase the nominal wage ($\pi_W>0$), but at a decreasing rate ($d\pi_W/dt<0$). [9]

The first four of the first order conditions, along with the budget constraint, the Phillips curve (62) and the No Ponzi Game condition, jointly determine the paths of c, m, W, π_W, a and λ, given the values of exogenous parameters such as ρ and ϕ, and the paths of policy variables such as t and endogenous variables such as ω, e, y, and i.

II.6. <u>The dynamical system</u>

We assume that the Central Bank has a fixed crawling peg regime. Hence, it stands ready to purchase or sell the amount of dollars necessary to keep the nominal exchange rate with the dollar growing at the fixed rate $\overline{\delta}$. A fixed exchange rate policy, as in Argentina's Convertibility, is the particular case in which $\overline{\delta}=0$, and is the case we consider henceforth to simplify the 'Phillips curves". (However, we have all the elements needed for the general case.) The Central Bank ensures that the money market clears at all times. Hence, (60) gives the endogenous stock of money as proportional to aggregate consumption:

(64) $M = h(i)ecP_N$.

By (7) and the assumption that r is an exogenous constant, the domestic nominal interest rate is constant as long as the Central Bank does not modify the rate of crawl, as we assume throughout this paper. This implies that h, and hence τ, φ, and $\rho m/c$ are actually constant. Since P_N is predetermined, when the Central Bank devalues there must be a one time change in the nominal stock of money so as to accommodate the required change in e as well as whatever discrete jump in c may take place. By our assumption on the full backing

[9] Note that all households are exactly the same except for the particular type of labor they produce. This explains why we omitted a subscript j from the household budget constraint from the beginning.

of m (11), this implies a one time discrete exchange market intervention (apart from the usual flow interventions) that will be specified in section II.10 below.

Expressions (47) and (53) give household demand for domestic goods as a function of e and λ:

(65) $c_N = (1\text{-}\theta)\kappa_2\lambda^{-1/\sigma}e^{\theta+(1-\theta)/\sigma} \equiv c_N(e,\lambda)$ $\quad$ ($c_{Ne}>0$, $c_{N\lambda}<0$, $\kappa_2\equiv(\kappa_1/\varphi)^{1/\sigma}$).

To simplify, assume that government demand for each type of domestic good is a fraction g of private consumption demand for that good $g_{Ni} = g\, c_{Ni}$. Hence, total demand for domestic good i is

$$y_{Ni} = \mathcal{k}c_{Ni}/(1\text{-}x(\pi_{Nj}))$$

where $\mathcal{k} \equiv (1+g)(1+\tau)$ is a factor that includes transaction costs and government demand, and $\mathcal{k}c_{Ni}$ must be grossed up to include the real resources used in the price adjustment decision process. Since every firm has the same decision process, the use of (41) yields the domestic goods demand functions (28) used in section II.4. Aggregating over domestic goods as in (39) gives domestic good output:

(66) $y_N(e,\pi_N,\lambda) = \mathcal{k}c_N(e,\lambda)/(1\text{-}x(\pi_N))$.

Also, the first expression in (28) gives firm i's demand for labor as $L_{Ni} = F_N^{-1}(y_{Ni})$. Since all domestic sector firms produce the same amount (of their specific type of goods), they all produce $y_N(e,\lambda)$ using the same combination of labor types L_N. Hence, aggregating over i as in (21) gives labor demand in the domestic sector:

(67) $L_N(e,\pi_N,\lambda) = F_N^{-1}(y_N(e,\pi_N,\lambda))$ $\quad$ ($L_{Ne}>0$, $L_{N\lambda}<0$)

From (26), labor demand by the export sector is:

(68) $L_X(\omega/(\phi e^{1-\theta})) \equiv F_X^{-1}(\omega/(\phi e^{1-\theta}))$ $\quad$ ($L_X'<0$)

Therefore, total labor demand can be defined as:

(69) $L(\omega,e,\pi_N,\pi_W,\lambda) \equiv [L_N(e,\pi_N,\lambda) + L_X(\omega/(\phi e^{1-\theta}))]/(1\text{-}x(\pi_W))$

($L_\omega<0$, $L_e>0$, $L_\lambda<0$).

From (4), the wage in dollar terms is $W/E = \omega/(\rho e^{1-\theta})$. Therefore, the wage gap (63) can be written as:

(70) $$G^W(\omega,e,\pi_N,\pi_W,\lambda;\rho) = \mu_W\,[\rho e^{1-\theta}/\lambda\omega]\,v'(L(\omega,e,\pi_N,\pi_W,\lambda)) - 1,$$

$$(G^W_\omega<0,\ G^W_e>0,\ G^W_\lambda<0,\ G^W_\rho>0).$$

The product wage in the domestic sector is $W/P_N = \omega e^\theta$. Therefore, the price gap (36) is:

(71) $$G^P(\omega,e,\pi_N,\lambda) = \mu_P\omega e^\theta z(y_N(e,\pi_N,\lambda)) - 1 \qquad (G^P_\omega>0,\ G^P_e>0,\ G^P_\lambda<0).$$

Furthermore, the rates of change of ω and e are given by

(72) $$\dot{\omega}/\omega = \pi_W - \pi,$$

(73) $$\dot{e}/e = \bar{\delta} - \pi_N,$$

and (2) implies:

(74) $$\pi = \bar{\delta}\theta + \pi_N(1-\theta).$$

Then under our assumption that $\bar{\delta}=0$, the complete dynamical system is:

(75) $$\dot{\omega}/\omega = \pi_W - (1-\theta)\pi_N,$$

$$\dot{e}/e = -\pi_N.$$

$$\dot{\pi}_N = -\gamma_F G^P(\omega,e,\pi_N,\lambda) \qquad (G^P_\omega>0,\ G^P_e>0,\ G^P_\lambda<0).$$

$$\dot{\pi}_W = -\gamma_H G^W(\omega,e,\pi_N,\pi_W,\lambda;\rho) \qquad (G^W_\omega<0,\ G^W_e>0,\ G^W_\lambda<0,\ G^W_\rho>0).$$

Note that in the steady state, due to (27) and (37), the partial derivatives of G^P with respect to π_N and of G^W with respect to π_N and π_W are zero.

For the linear approximation to this system it is convenient to define the vectors of relative prices and inflation rates

$$p' \equiv (\omega,e)' \quad \Pi' \equiv (\pi_N, \pi_W)', \qquad x' \equiv (p, \Pi)'$$

(where the apostrophe means transposition) and define the matrices

$$A \equiv \begin{bmatrix} -(1-\theta)\omega & \omega \\ -e & 0 \end{bmatrix}$$

$$B \equiv \begin{bmatrix} -\gamma_F G^P{}_\omega & -\gamma_F G^P{}_e \\ -\gamma_H G^W{}_\omega & -\gamma_H G^W{}_e \end{bmatrix}$$

$$C \equiv \begin{bmatrix} 0 & A \\ B & 0 \end{bmatrix}. \qquad D \equiv AB, \qquad F \equiv BA.$$

The elements of A and B are all evaluated at their steady state values. Then the linearized system can be written as:

(76) $\dot{x} = C(x-x^{\bullet}).$

It may be of some interest to note that due to the peculiar structure of C (76) may be written as a pair of second order differential equations in relative prices and inflation rates, respectively:

(77) $\ddot{p} = D(p - p^{\bullet}) \qquad \ddot{\Pi} = F(\Pi-\Pi^{\bullet}).$

Equivalently:[10]

(78) $\ddot{x} = C^2(x-x^{\bullet}).$

Stability

Note that the determinant of C is the same as the determinant of D and is positive:

$$\det(C) = \det(D) = \det(A)\det(B) = \gamma_F \gamma_H\, \omega e[G^P{}_\omega G^W{}_e - G^P{}_e G^W{}_\omega] > 0.$$

Also, the characteristic equation of the linearized system is:

(79) $\lambda^4 - \mathrm{tr}(D)\lambda^2 + \det(D) = 0,$

where

[10] Except for the fact that our matrix C^2 is not symmetric, such systems are typical in physics and engineering for linear oscillatory systems without dissipation. In fact, if A and B were numbers instead of matrices, (76) would be the equation of a linear spring. Cfr.Pipes (1958).

$$\mathrm{tr}(D) = (1\text{-}\theta)\gamma_F\, \omega G^P_\omega - \gamma_H \omega G^W_\omega + \gamma_F\, e G^P_e \quad > 0.$$

Define $\mu \equiv \lambda^2$. Then (79) can be written as

(80) $$\mu^2 - \mathrm{tr}(D)\mu + \det(D) = 0,$$

which has the solutions

(81) $$\mu_1 = (1/2)\{\ \mathrm{tr}(D) + [\ \mathrm{tr}(D)^2 - 4\det(D)\ ]^{1/2}\ \}$$

$$\mu_2 = (1/2)\{\ \mathrm{tr}(D) - [\ \mathrm{tr}(D)^2 - 4\det(D)\ ]^{1/2}\ \}.$$

These solutions may be real or complex, according to the sign of the discriminant (in square brackets). Since G^W_e is in det(D) but not in tr(D) it is readily seen that if G^W_e is sufficiently large the μ_i are complex conjugates. If they are real, then

(82) $$0 < \mu_2 < \mu_1 < \mathrm{tr}(D).$$

The four characteristic roots of C are then:

(83) $$\lambda_n = -(\mu_1)^{1/2}\ ,\ \ \lambda_d = -(\mu_2)^{1/2}\ ,\ \lambda_3 = +(\mu_1)^{1/2}\ ,\ \ \lambda_4 = +(\mu_2)^{1/2}\ ,$$

where the sub-index d stands for "dominant" and the sub-index n stands for "non-dominant". The real parts of these roots satisfy the following inequalities:

(84) $$\mathrm{Re}(\lambda_n) < \mathrm{Re}(\lambda_d) < 0 < \mathrm{Re}(\lambda_3) = -\mathrm{Re}(\lambda_d) < \mathrm{Re}(\lambda_4) = -\mathrm{Re}(\lambda_n).$$

Hence, as long as the discriminant is non-zero, all four roots are different, and they are either all real or they are two pairs of complex conjugates. Variables ω and e are predetermined, because of wage and price setting by households and domestic sector firms, respectively, and nominal exchange rate fixing by the Central Bank. On the other hand, the inflation rates π_N and π_W are jump variables. Hence, since there is the same number of roots with negative real parts as there are predetermined variables and the same number of roots with positive real parts as there are jump variables, the equilibrium is saddle-path stable.

If the roots are complex, (ω,e) spirals around and towards the steady state. The condition for real roots is:

$$\mathrm{tr}(D)^2 - 4\det(D) = [(1\text{-}\theta)\gamma_F\, \omega G^P_\omega - \gamma_H \omega G^W_\omega + \gamma_F\, e G^P_e\ ]^2 - 4\gamma_F\gamma_H\ \omega e[G^P_\omega G^W_e - G^P_e G^W_\omega] =$$

$$= [(1\text{-}\theta)\gamma_F\, \omega G^P_\omega]^2 + [\gamma_H \omega G^W_\omega + \gamma_F\, e G^P_e\ ]^2 + 2(1\text{-}\theta)\gamma_F\, \omega G^P_\omega\, [\gamma_F\, e G^P_e - \gamma_H \omega G^W_\omega] -$$

$- 4\gamma_F \gamma_H \omega e G^P_\omega G^W_e > 0.$

Hence, a sufficient condition for real roots is:

(85) $$G^W_e \equiv \mu_W (\rho/(\lambda\omega e^\theta)[v''(L_N)z(y_N)ey_{Ne} + (1-\theta)v'(L_N)] < \{ [(1-\theta)\gamma_F \omega G^P_\omega]^2 +$$

$$+ [\gamma_H \omega G^W_\omega + \gamma_F eG^P_e]^2 + 2(1-\theta)\gamma_F \omega G^P_\omega [\gamma_F eG^P_e - \gamma_H \omega G^W_\omega] \}/[4\gamma_F \gamma_H \omega e G^P_\omega].$$

Note that the both the numerator and the denominator of the expression after the inequality sign are positive, Hence, a sufficient condition for real roots is that the marginal disutility of work v' be neither too high nor too increasing in the steady state, so that a real depreciation does not have too high an effect on the wage gap. Henceforth, we assume that the roots are real, without loss of generality.

Fortunately we can graph the dynamic system in two dimensions. For this we use the fact that the two jump variables always jump to their unique equilibrium paths, enabling us to leave them out of the picture. The fact that near the steady state the two predetermined variables asymptotically tend towards the line that in two dimensions represents the corresponding section of the dominant characteristic vector (which corresponds to the dominant characteristic root) allows us to represent the predetermined part of the system in two dimensions (cfr. Calvo (1987) and Calvo et al (2003)). Let $(z^i)' = (z^i_\omega, z^i_e, z^i_3, z^i_4)'$ be the eigenvector that corresponds to root λ_i (i=n,d,3,4). Then $Cz^i = \lambda_i z^i$. Since we are assuming that all roots are real, so are their corresponding characteristic vectors.

Because all roots are distinct, the solution to (76) may be expressed as (cfr. Bellman (1965)):

$$x - x^\bullet = c_1 z^d e^{\lambda_d t} + c_2 z^n e^{\lambda_n t} + c_3 z^3 e^{\lambda_3 t} + c_4 z^4 e^{\lambda_4 t}.$$

And because we must choose $c_3 = c_4 = 0$ to pinpoint the saddle path, near the steady state we must have:

$$(e-e^\bullet)/(\omega-\omega^\bullet) = [c_1 z^d_e e^{\lambda_d t} + c_2 z^n_e e^{\lambda_n t}]/[c_1 z^d_\omega e^{\lambda_d t} + c_2 z^n_\omega e^{\lambda_n t}] =$$

$$= [c_1 z^d_e + c_2 z^n_e e^{(\lambda_n-\lambda_d)t}]/[c_1 z^d_\omega + c_2 z^n_\omega e^{(\lambda_n-\lambda_d)t}]$$

where the values of c_1 and c_2 depend on initial conditions. The last expression tends to z^d_e/z^d_ω when t tends to infinity. Hence, this ratio gives the slope of the straight line towards which (ω,e) tends asymptotically in a ω-e plane (which is simply the projection on this plane of the dominant eigenvector), as long as (ω,e) does not start precisely on the non-dominant eigenvector, in which case (ω,e) tends to the steady state along the line that represents the projection of the non-dominant eigenvector. Note that $Cz^i = \lambda_i z^i$ implies $C^2z^i = (\lambda_i)^2 z^i = \mu_i z^i$, and that the upper part of the latter equation is $Dz^i_p = \mu_i z^i_p$ where $z^i_p{}' \equiv (z^i_\omega, z^i_e)'$. Hence, z^d_p and z^n_p are the eigenvectors of D corresponding to μ_2 and μ_1, respectively, where $\mu_1>\mu_2>0$:

$$D_{11}z^d_\omega + D_{12}z^d_e = \mu_2 z^d_\omega$$
$$D_{21}z^d_\omega + D_{22}z^d_e = \mu_2 z^d_e$$

$$D_{11}z^n_\omega + D_{12}z^n_e = \mu_1 z^n_\omega$$
$$D_{21}z^n_\omega + D_{22}z^n_e = \mu_1 z^n_e$$

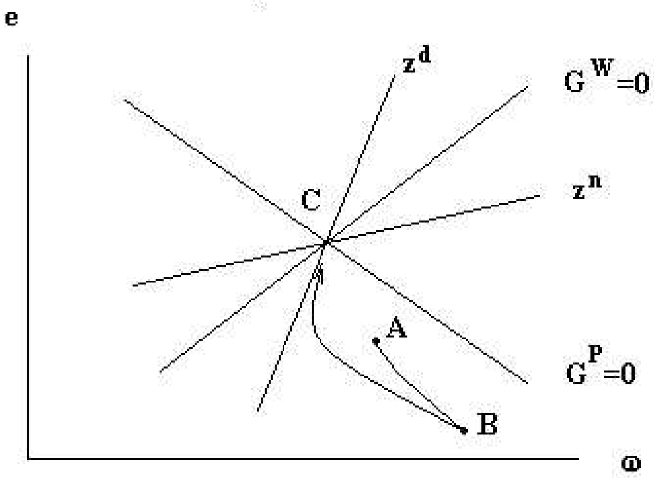
Note that because D_{21} and D_{22} are positive and neither z^d nor z^n can be zero vectors, the second of each pair of equations imply that none of the elements of z^d and z^n can be zero. The eigenvectors are unique up to a constant factor so we may normalize the z^i with $z^d_\omega = z^n_\omega = 1$. Using the second of each of the above equation pairs as well as the expressions for the D_{ij} gives:

(86) $\quad z^d_e = (\gamma_F e G^P_\omega)/(\mu_2 - \gamma_F e G^P_e) \qquad z^n_e = (\gamma_F e G^P_\omega)/(\mu_1 - \gamma_F e G^P_e)$

The signs of z^d_e and z^n_e depend on the signs of the denominators in these expressions. Because $\mu_2<\mu_1$, we have three possible cases: 1) $z^n_e<z^d_e<0$, 2) $0<z^n_e< z^d_e$, 3) $z^d_e<0<z^n_e$, giving the three possible combinations of signs for the slopes of the vectors z^d_p and z^n_p in the ω-e plane. We conclude that whenever both slopes have the same signs, the dominant eigenvector has the greatest sign, whereas it is possible the dominant eigenvector have a negative slope and the non-dominant eigenvector a positive slope.

Furthermore, since the slope of the line $G^P(.)=0$ is $-G^P_\omega/G^P_e$ (<0), (86) implies that if the slopes of z^d_p or z^n_p is negative, it must be more negative than the slope of $G^P(.)=0$. Also, note that D_{12} is positive if and only if $G^W_e < (1-\theta)\gamma_F e G^P_e/\gamma_H$, which, as in (85), essentially entails that the marginal disutility of work v' be neither too high nor too increasing in the steady state. In that case, D is a positive matrix, and hence, indecomposable. We can therefore use the Perron-Frobenius theorem on non-negative, indecomposable matrices (cfr. Nikaido (1960)). This theorem ensures that μ_1 is the unique Perron-Frobenius eigenvalue $\mu(D)$ to which corresponds a strictly positive eigen-vector ($z^n{}_p>0$). Furthermore, the theorem also affirms that $Dz=\mu z$, $\mu\geq 0$, $z>0$ has the unique solution $\mu=\mu(D)$, which implies that $z^d{}_p$ cannot also be positive. Since none of the elements of this vector can be zero, as we have seen, if we normalize $z^d{}_\omega=1$ as above, $z^d{}_e$ must be negative. Hence, we have proved that whenever $G^W{}_e$ is sufficiently small to make D_{12} positive, we necessarily have case 3). Figure 1 arbitrarily chooses the case where both slopes are positive and illustrates a path towards the steady state that begins in A.

Figure 1
Local dynamics after shock



The steady state

In the steady state, the rates of wage and domestic goods inflation are constant. They are also zero, because of the fact that we made the linear approximation for a fixed exchange rate (zero rate of crawl). Then the respective gaps from the fully flex-wage-price economy must be zero:

(87) $\mu_P\ \omega e^{\theta} z(y_N(e,0,\lambda)) = 1$

(88) $\mu_W\ [\rho e^{1-\theta}/\lambda\omega]\ v'(L(\omega,e,0,0,\lambda)) = 1$

From (87) and the definition of z(.) we obtain:

(89) $F_N'(L_N(e,0,0,\lambda)) = \mu_P\omega e^{\theta}$

which implies:

(90) $L_N(e,0,0,\lambda) = (F_N')^{-1}(\mu_P\omega e^{\theta}) \equiv L_N^{n}(\mu_P\omega e^{\theta})$.

The last term is the definition of the domestic sector's labor demand function in the benchmark economy where, since there are no price adjustment costs, labor demand corresponds to the marginal product of labor, corrected by the monopolistic price setting wedge μ_P. Furthermore, using (87) in (65)-(68) gives the domestic goods market clearing condition:

(91) $(1-\theta)\kappa_3\,\lambda^{-1/\sigma}\,e^{\theta+(1-\theta)/\sigma} = F_N(L_N^{n}(\mu_P\omega e^{\theta})) \equiv y_N^{n}(\mu_P\omega e^{\theta})$ $\quad (\kappa_3 \equiv \acute{k}\kappa_2)$,

where the last term is the definition of the domestic supply function in the benchmark economy. (91) is just an alternative way of expressing the steady state $G^P(.)=0$ condition.

On the other hand, using the zero wage gap condition (88) and the definition of total labor demand (69) gives:

(92) $L_N(e,0,\lambda) + L_X(\omega/\phi e^{1-\theta}) = (v')^{-1}(\lambda\omega/\rho e^{1-\theta}\mu_W) \equiv \bar{L}(\lambda\omega/\rho e^{1-\theta}\mu_W)$.

where the last term defines the labor supply function. This expression shows that, in the steady state, labor supply is equal to actual labor demand. But using (90), which was derived from the zero domestic price gap condition, shows that in the steady state actual labor demand is the flex wage and price labor demand in the benchmark economy:

(93) $L^n(\omega, e) = \bar{L}(\lambda\omega/\rho e^{1-\theta}\mu_W)$,

where aggregate labor demand in the benchmark economy is defined as:

(94) $L^n(\omega, e) \equiv L_N^{n}(\mu_P\omega e^{\theta}) + L_X(\omega/(\phi e^{1-\theta}))$.

Note that (94) is not just the $G^W(.)=0$ condition, since its derivation also used the $G^P(.)=0$ condition. It represents the balance between the labor supply and the benchmark economy labor demand, so we may call it the zero labor gap condition: $G^L(.)=0$, where we define the labor gap as:

(95) $G^L(\omega,e) \equiv L^n(\omega, e) - \bar{L}(\lambda\omega/\rho e^{1-\theta}\mu_W)$.

Conditions (91) and (93) constitute the steady state conditions for the domestic goods and labor markets, respectively. Jointly they define the long run equilibrium values of ω and e, as graphed if Figure 2.

The (log) slopes of the two lines are the following:

(96) $$(\omega/e)(de/d\omega)\,|_{\,GP=0} \;=-\{\;\theta + (y_N z'/z)(ey_{Ne}/y_N)\;\}^{-1}<0,$$

(97) $$(\omega/e)(de/d\omega)\,|_{\,GL=0} \;=\; -\{\;\varepsilon - (1\text{-}\theta)\;\}^{-1},$$

where ε is the elasticity of the export sector product wage w ($\equiv\omega/(\phi e^{1-\theta})$) with respect to e along the zero labor gap condition:[11]

(98) $$\varepsilon \equiv -(e/w)/(dw/de) = \phi eL_N'/[L_X'+\phi eL_N' - \bar{L}'\lambda\phi/\mu_W] = [1/\varepsilon^* + \xi]^{-1} \in (0,1),$$

$$\varepsilon^* \equiv \phi eL_N'/[L_X'+\phi eL_N'] \in (0,1),$$

$$\xi \equiv \bar{L}'\lambda/[\mu_W\,\rho e(-L_N')]>0,$$

Note that $1/\varepsilon$ is the sum of $1/\varepsilon^*$ (the inverse of the analogous elasticity when labor supply is held constant) and ξ. The steady state condition for domestic goods clearly has a negative slope in the e-ω plane but the slope of the labor market balance equation is ambiguous and crucially depends on the sign of ε-(1-θ). As we show in section II.8, under the assumption that our economy is what we call a Domestically Biased Economy in Production relative to Consumption (DBE, for short), the slope is negative. This condition essentially implies that when e increases, the increased demand for labor in the export sector and the lower labor supply do not compensate for the lower demand for labor in the domestic sector, and hence ω must fall to clear the market. Since under the DBE assumption both lines have negative slopes, it remains to determine which is the most negative. This is important because it determines the effect that a change in the marginal utility of wealth λ has on the steady state values of ω and e. Since the unexpected strong dollar shock that is the main subject of this paper requires a downward adjustment in consumption in our financially dollarized and trade euroized economy (as we argue in section II.9), λ will shift up whenever such a shock occurs. Furthermore, an increase in λ shifts G^P=0 to the right and G^L=0 to the left in Figure 2. Hence, if the slope of the labor market balance condition is more negative than the slope

[11] We elaborate on this in section II.8 below.

of the domestic goods balance condition, an increase in λ generates a fall in the steady state value of ω and an increase in the steady state value of e. The opposite occurs when the relation between the slopes is reversed.

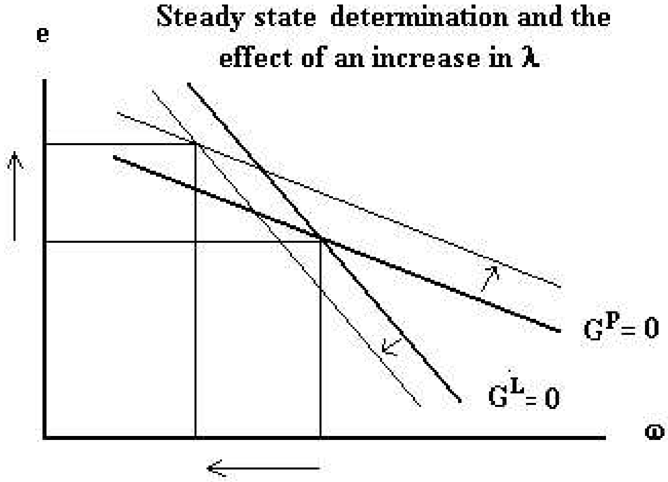
From (96) and (97) it follows that the slope of $G^L=0$ is more negative than that of $G^P=0$, because:

$$(99) \qquad (\omega/e)(de/d\omega)\big|_{GL=0} = -\{\theta + (\varepsilon-1)\}^{-1} < -1/\theta <$$

$$< -\{\theta + (y_N z'/z)(ey_{Ne}/y_N)\}^{-1} = (\omega/e)(de/d\omega)\big|_{GP=0}.$$

We conclude that the slope of $G^L=0$ is more negative than that of $G^P=0$ if and only if we have a DBE, as we assume, and as depicted in Figure 2. As the figure shows, in a DBE an increase in λ has the effect of increasing the steady state value of e and lowering that of ω.

Figure 2
Steady state determination and the effect of an increase in λ



II.7. <u>The dollar appreciation and its impact on the economy</u>

The economy unexpectedly receives a strong dollar shock that is expected to be transitory. At t=0, ρ increases and is expected to return to its initial level at t=T. Hence, the steady state value of ρ does not change. However, because of the currency mismatch between dollar debts and euro trade, households must reduce their future consumption, which implies a rise in their marginal utility of wealth, λ. As we have seen in Figure 2, under the

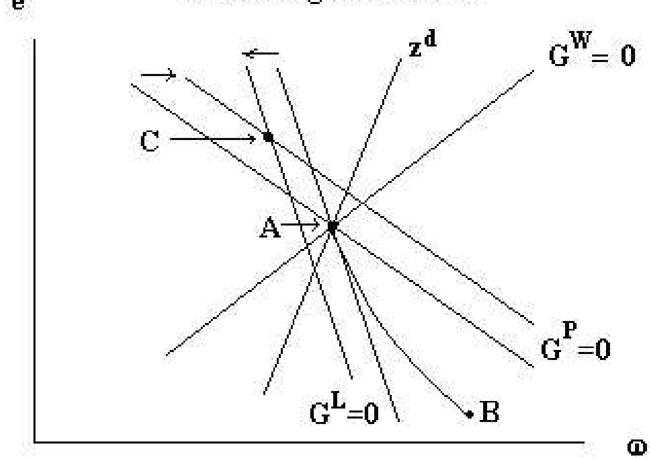
DBE assumption this increases the steady state value of e and reduces the steady state value of ω. In Figure 3, if the economy was initially at the steady state A, the new steady state is at C (with the steady state inflation rates staying at zero). But what is the impact effect? The definition of e ($=E/(\rho P_N)$) guarantees that the increase in ρ makes e fall on impact. Furthermore, since $\omega=(W/P_N)/e^{\theta}$ and W and P_N are predetermined, the rise in ρ makes ω increase on impact, through the effect of the fall in import prices, which are flexible, on the price level. Hence, the economy moves to point B in Figure 3. It is rather perverse that the impact effects are precisely opposite to the long run effects. And it is especially perverse that a negative shock should have the effect of increasing the real wage!

We can be more precise about the impact effect of the unexpected and temporary strong dollar shock. The effect on ω and e must be such that the product wage in the domestic sector ωe^{θ} maintain its initial value $(W/P_N)_0$, and hence must be on a curve as the one depicted in Figure 3. The (log) slope of this curve at the steady state is $-1/\theta$. But this slope is necessarily between the slopes of $G^L=0$ and $G^P=0$, as (107) proves. This implies that the shock takes the economy to the area where at the initial steady state A there was a negative price gap ($G^P<0$), a negative wage gap ($G^W<0$), and a negative labor gap ($G^L<0$). Because (as we have seen) $G^P=0$ shifts to the right, $G^L=0$ shifts to the left and, therefore, $G^W=0$ also shifts to the left, the economy also has all three gaps negative with the new steady state C. This means that: 1) the supply of labor is greater than the benchmark labor demand ($G^L<0$), 2) the demand for labor is lower than in the benchmark economy ($G^W<0$), and 3) the demand for domestic goods is lower than in the benchmark economy ($G^P<0$). Note that 1) and 2) jointly imply that there is unemployment.

Because the price gap is negative, the domestic price is greater than marginal cost. Hence, firms in the domestic sector start to lower their price, which implies that π_N jumps from zero to a negative value. And the price Phillips curve implies that π_N gradually increases, starting from that negative value. Analogously, because the wage gap is negative, the nominal wage rate is greater than the marginal rate of substitution between leisure and wealth. Hence, households start to lower the wage they set, which makes π_W jump from zero to a negative value. The wage Phillips curve implies that π_N gradually increases, starting from that negative value. The stability of the steady state equilibrium makes (ω,e) gradually evolve towards C in Figure 3 along a path similar to the one in Figure 1.

This means that the economy must traverse a rather lengthy path with deflation, unemployment, and recession before it can reach the new steady state. Even if capital markets were perfect and financed the whole process there would be adverse welfare effects due to the loss of employment, output and domestic income. However, in a global context in which capital flows can suddenly reverse and precipitate a severe crisis the welfare losses can be much more acute, as we develop below.

Figure 3
Impact and long run effects of a strong dollar shock



The story we want to tell for the case of the collapse of Convertibility in Argentina is that after an initial strong dollar shock that is expected to last until t=T,and which makes domestic agents incur in debt finance to smoothen the effect on consumption, there is another shock that precipitates a sudden stop in finance, a default, a devaluation, a debt restructure (with a haircut) and a government assumption of certain inter-private debts. We assume that at some time during the long transition from B to C, say at t=T’<T, there is new information that implies that the shock to ρ was not as transitory as expected. For simplicity, we take the extreme case, and assume that the new information is that the shock is permanent. Hence, at t=T’ there is a new displacement of the steady state to a point that

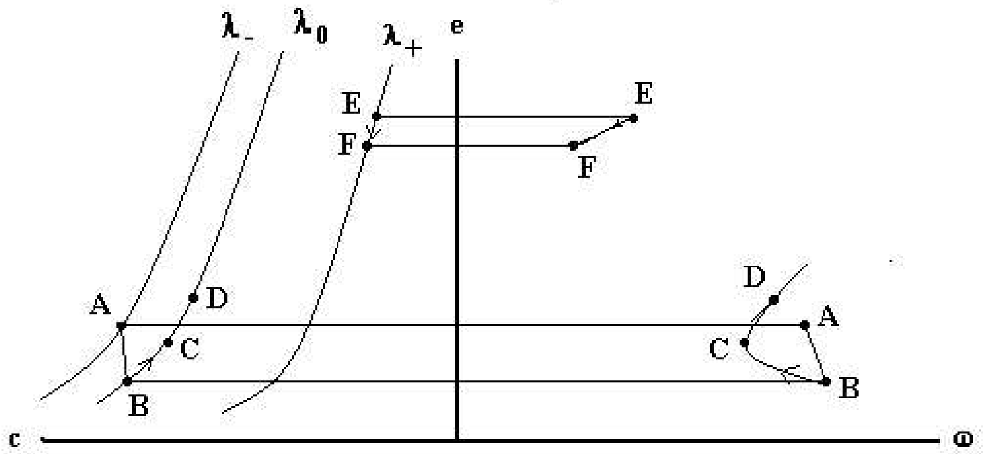
is further to the northwest than C in Figure 3, as F in Figure 4.[12] But this purely informational shock triggers another, simultaneous, shock. Foreign creditors were willing to finance the debt accumulation generated by the temporary shock, but when the news arrives that the shock is permanent, they are not willing finance the further debt accumulation that would be needed to get to the new steady state without a devaluation. They prefer to take the haircut on the debt that everyone unanimously expects will result from a sudden stop in financing and the resulting devaluation. Expectations are that if and only if a sudden stop occurs, the government will default, devalue, restructure the debt, assume certain inter-private debts and incur in a major fiscal reform. But since the temporary nature of the dollar appreciation was expected with certainty by everyone, the conditional expectation was devoid of any implication with respect to any further adjustment in consumption. Also, everyone is assumed to believe (rightly) that the government is not willing or able to make a sufficiently profound direct fiscal reform, in the absence of devaluation and default, that would allow it to avoid further indebtedness. It prefers to devalue, default and restructure its debt, face the realization of contingent liabilities, and force a combination of fiscal reform and debt forgiveness that is accepted by the population and international creditors, in view of the catastrophic situation. The devaluation in turn implies a sudden fall in the real wage in our domestically biased economy, one that is certainly greater than the perverse initial increase.

Figure 4 shows the whole story. The initial steady state is at A in both panels. The rise is ρ takes the economy to B on impact, and then gradually along the path that is expected to lead to D. On the left hand panel, the graph shows that λ increases from $\lambda\_$ to λ_0 on impact, so that the consumption path shifts to the right, which implies lower consumption. On arriving at C, however, the second shock shifts the steady state to F and the devaluation takes the economy to E along a curve as the one depicted in Figure 3. The shift in the steady state is achieved through a new increase in λ to λ_+, that again shifts the consumption

[12] Note that in this case the change in ρ (which has become permanent) directly affects the steady state through the labor market clearing condition) in the opposite direction as the change in λ. The change in the steady state from D to F in Figure 4 reflects the net effect of the changes in both ρ and λ. In general, λ/ρ can move in either direction, but we assume that labor supply is sufficiently inelastic that the shift in G^L=0 in Figure 2 (which depends on λ/ρ) is rather small in comparison to the rightward shift in G^P=0. Hence, even in the case in which λ/ρ decreases, the steady state effects are as shown for the temporary strong dollar shock depicted in Figure 2 (in which only λ changes in the steady state).

path to the right. From E, which in the particular case shown in Figure 4 implies overshooting in e and undershooting in ω, there is again a path that leads to the final steady state F.

Figure 4
The whole story



It is noteworthy that the size of the haircuts on the foreign debt is one of the determinants of the location of the final steady state F, and hence of the real depreciation and real wage reduction that are necessary. The larger these haircuts are, *ceteris paribus*, the smaller is the necessary reduction in long run consumption and hence the smaller is the necessary increase in the marginal utility of wealth λ. As we have seen, increases in λ shift the long run equilibrium to the north-west. Hence, large haircuts imply a smaller increase in λ and a smaller long run real depreciation and smaller real wage and consumption reductions.

The assumption of inter-private debts by the government, on the other hand, is basically a redistribution of wealth and income among nationals. In Argentina, bank debtors, whose dollar debts were transformed to peso debts at the pre-devaluation rate benefited from the net effect of the debt reduction and the amounts that they would have been able to pay without this change in denomination, while dollar depositors, whose claims were transformed to pesos at a rate 40% above the pre-devaluation rate lost the difference between this amount and the peso value of their dollar deposits at the finally stabilized exchange rate (190% above the pre-devaluation rate). The government, local banks and ultimately Argentine tax-payers and foreign creditors (through the haircut), will have to pay for the net fiscal cost of the designers of Convertibility's dogmatic neglect of the huge currency mismatches generated by the banking system.

II.8. <u>The meaning of the DBE assumption</u>

The DBE assumption (that $\varepsilon>1-\theta$) played a crucial role above in the characterization of the long run effects on ω and e of an increase in λ. This section explains its exact meaning. Labor demands in the benchmark economy are derived from (26) and $(F_N')^{-1}(\mu_P\omega e^{\theta})$ (as in (89)) as decreasing functions of the respective product wages. We may express them as $L_X(w)$ and $L_N^n(\mu_P w\phi e)$ where w ($\equiv\omega/(\phi e^{1-\theta})$) is the export sector product wage and $w\phi e$ ($\equiv\omega e^{\theta}$)) is the domestic sector product wage. Labor market clearing in the benchmark economy is hence:

(100) $\quad L_X(w) + L_N^n(\mu_P w\phi e) = \overline{L}(\lambda w\phi/\rho\mu_W)$.

Where labor supply was defined in (92). Equation (100) gives an inverse relation between w and e:

(101) $\quad w(e) \qquad\qquad\qquad (\ w'<0\ )$.

The elasticity of w with respect to e is positive and less than unity, as in (98). Note that ε^* in (98) is the elasticity of w with respect to e when labor supply is held constant. Hence, ε^* is a term related to the structure of labor demand whereas ξ captures the sensitivity of labor supply to w. Also, L_X is increasing with e whereas L_N is decreasing (because $\varepsilon<1$).

Using (101), the supply functions for goods in the benchmark economy are:

(102) $\quad y_X = F_X(L_X(w(e))) \equiv y_X(e), \qquad\qquad (\ y_X'>0\ )$

$\quad y_N = F_N(L_N(w(e)\phi e))) \equiv y_N(e), \qquad\qquad (\ y_N'<0\ )$.

As e increases, labor shifts from the domestic to the export sector.

We can alternatively use the variables ω and e to express labor market equilibrium in the benchmark economy:

(100') $L_X(\omega/(\phi e^{1-\theta})) + L_N^n(\mu_P \omega e^{\theta}) = \overline{L}(\lambda\omega/\rho e^{1-\theta}\mu_W)$.

Totally differentiating we obtain the elasticity of ω with respect to e:

$$-(e/\omega)(d\omega/de) = \varepsilon - (1-\theta).$$

Hence, the full employment condition in the benchmark economy is such that ω and e vary inversely if and only if $\varepsilon > 1-\theta$ which, considering (98), is equivalent to $1/\varepsilon^*+\xi < 1/(1-\theta)$. Note that when labor supply is constant ($\xi=0$) this condition reduces to $\varepsilon^*>1-\theta$, which is the necessary and sufficient condition for L^n_e to be positive:

$$L^n_e = (\omega/e^{1-\theta})\,(L_N'/\varepsilon^*)(\varepsilon^*+\theta-1).$$

From the definition of ε^* (in (98)) we see that

$$\varepsilon^*>1-\theta \;\Leftrightarrow\; (1-\varepsilon^*)/\varepsilon^* = L_X'/\phi e L_N' \;<\; \theta/(1-\theta).$$

Bearing in mind that w is a function of e and that $1-\varepsilon$ is the elasticity of $e\phi w(e)$ with respect to e, the last inequality can be expressed as:

(103) $(dL_X/d\ln w)/[-dL_N/d\ln(\phi e w)] < \theta/(1-\theta)$.

Thus, $\varepsilon^*>1-\theta$ means that the increase in labor demand in the export sector due to a marginal increase in e (that reduces w), in relation to the marginal reduction in labor demand in the domestic sector (through the increase in $e\phi w$), is less than the reduction in imported goods consumption (θ) in relation to the increase in domestic goods consumption ($1-\theta$). More prosaically, an increase in e generates a shift of labor from the domestic to the export sector that is smaller than the shift of consumption from imports to domestic goods. And the stronger condition $\varepsilon>1-\theta$ essentially means that the sensitivity of labor supply to its argument is not so large as to make $1/\varepsilon^*+\xi$ greater than $1/(1-\theta)$.

We now show sufficient conditions for ε^* to be a strictly decreasing function of e, in which case the domain of e separates in two segments which respectively define the DBEs and EBEs. Using (101) in the definition of ε^* shows that

(104) $1/\varepsilon^*(e) = h(e) + 1$

where the function h(e) is defined as

$$h(e) = L_X'(w(e))/[\phi e L_N'(\phi e w(e))].$$

Then the elasticity of h with respect to e is:

$$eh'(e)/h(e) = \varepsilon\, \varepsilon_X + (1\text{-}\varepsilon)\, \varepsilon_N - 1$$

where ε_X and ε_N are the elasticities of L_X' and L_N':

$$\varepsilon_X \equiv wL_X''/(-L_X'), \qquad \varepsilon_N \equiv e\phi wL_N''/(-L_N').$$

Then ε^* is a strictly decreasing function of e if and only if

(105) $$\varepsilon\, \varepsilon_X + (1\text{-}\varepsilon)\, \varepsilon_N > 1 = \varepsilon + (1\text{-}\varepsilon).$$

Therefore, a sufficient condition for ε^* to be decreasing in e is that L_X' and L_N' be elastic.

<u>The Cobb-Douglas case</u>

For concreteness, consider the case in which the production functions and the disutility of work v(.) are all Cobb-Douglas:

$$F_X = a_X L_X^{b_X}, \qquad F_N = a_N L_N^{b_N}, \qquad v = a_L\, \bar{L}^{b_L}, \qquad (b_X<1,\, b_N<1,\, b_L>1).$$

Hence, labor demands and supply are:

$$L_X = (a_X b_X/w)^{c_X}, \qquad L_N = (a_N b_N/\mu_P \phi e w)^{c_N}, \quad \bar{L} = (\lambda\phi w/\rho\mu_W\, a_L b_L)^{c_L},$$

where

$$c_i \equiv 1/(1\text{-}b_i), \qquad i = N, X, \qquad c_L \equiv 1/(b_L\text{-}1)$$

are the respective elasticities. Inserting these expressions in (100) gives e as a decreasing function of w:

(101') $$e = \{ A_N/[w^{C_N+C_L}(A_L - A_X w^{-(C_X+C_L)})] \}^{1/C_N},$$

where

$$A_L \equiv (\phi\lambda/\rho\mu_W a_L b_L)^{C_L}, \qquad A_X \equiv (a_X b_X)^{C_X}, \qquad A_N \equiv (a_N b_N/\phi\mu_P)^{C_N}.$$

Then, using (101) and (98) gives:

(106) $$1/\varepsilon^*(e) = 1 + (A_X c_X/A_N c_N) e^{C_N}\, w(e)^{C_N - C_X},$$

$\xi(e) = (A_L c_L / A_N c_N) e^{C_N} w(e)^{C_N + C_L}$

In this particular case one can prove that ε^* is strictly decreasing if and only if $c_N \varepsilon + c_X (1-\varepsilon) > 0$, which necessarily holds because $0<\varepsilon<1$.[13] Also, ξ is increasing if and only if $\varepsilon < c_N/(c_N+c_L)$. Furthermore, a sufficient condition for $\varepsilon(e)$ to be decreasing everywhere is $c_L < c_N - 1$. Since L_N is elastic ($c_N > 1$), this means that a sufficiently inelastic labor supply implies that $\varepsilon(e)$ is everywhere decreasing, which we henceforth assume.

Figure 5
DBE and EBE economies

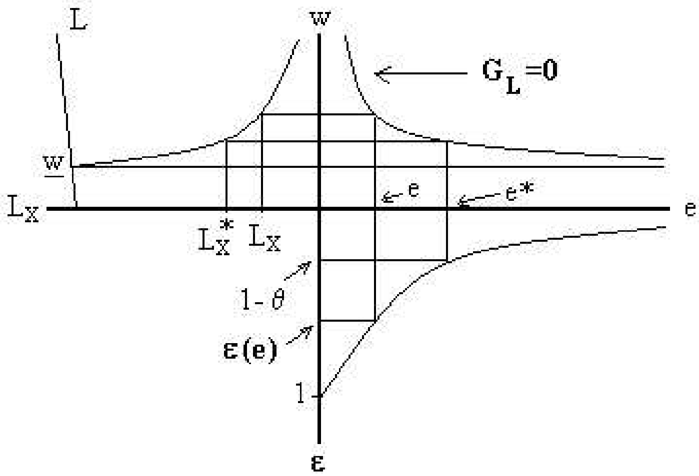


Figure 5 shows (101') in the northeast quadrant, $\varepsilon(e)$ in the southeast quadrant and the export sector labor demand curve as well as the labor supply curve in the northwest quadrant. Note that labor demand in the domestic sector is also (implicitly) represented as the distance $\bar{L}$-L_X. There is a unique e* at which $\varepsilon(e^*) = 1-\theta$. And $\varepsilon(e)$ is greater than $1-\theta$ if and only if e is lower than e*. Hence, e* clearly separates the domain of e (which is $(0,\infty)$) into two segments. Whenever we have a benchmark economy for which e<e* for all relevant steady states we have a DBE.

The condition $\varepsilon^* > 1-\theta$ implies that the share of the domestic sector in employment is high in relation to its share in consumption. And the stronger condition $\varepsilon > 1-\theta$ holds when the supply of labor is sufficiently inelastic (c_L sufficiently low). We denominate economies that

[13] Note that in this case $\varepsilon_X = c_X + 1$ and $\varepsilon_N = c_N + 1$, so (114) necessarily holds.

satisfy $\varepsilon>1-\theta$, Domestically Biased Economies in Production relative to Consumption, or DBEs, and economies which exhibit the opposite inequality Externally Biased Economies in Production relative to Consumption, or EBEs. We have assumed that the economy we are dealing with is a DBE both before and after whatever shock it may experiment. In particular, this implies that in the benchmark fully flexible price and wage economy there is an inverse relation between e and ω.[14]

II.9. <u>The inter-temporal adjustments to consumption and taxation under the two shocks</u>

<u>The temporary strong dollar shock</u>

In this section we take a more analytical look at the adjustment of the private and public sectors to the two shocks. Assume the economy starts in a steady state and that there is an unexpected dollar appreciation that is expected to be temporary. For simplicity, assume that initially $\rho=1$ and at $t=0$ there is an unexpected increase of ρ to ρ_+ that is expected to last until $t=T$ and then revert to the initial level. The household's non -financial wealth is negatively affected by the temporary shock, which requires a fall in consumption. But this also implies smaller seigniorage gains to the government. We assume that the government's inter-temporal solvency is planned to be preserved by higher lump sum taxes in euros after the end of the transitory shock (say, when there will be another administration!). This has an additional negative effect on the household. Hence, the household must adjust its consumption plan downwards, which implies an increase in the marginal utility of wealth, λ.

To keep things simple, take the logarithmic utility case in which $\sigma=1$. In Figure 4 (which has been drawn under the assumption that $\sigma>1$) this would imply that the consumption lines are vertical, so that when λ shifts, the consumption level immediately jumps to its new steady state level. In this case the household's first order condition for consumption (53) reduces to:

(53') $\quad c = (\kappa_1/\varphi)/\lambda.$

[14] We may note that all that is required for our results is that we have a DBE in all relevant steady states.

Hence, in this simple case c immediately jumps to its new steady state level, once the initial negative shock occurs. Also, with $\rho=1$, the household's savings are:

$$y - t - (1+\tau)c - ih(i)c = y - t - \kappa/\lambda \qquad (\kappa \equiv (1+\tau+ih(i))(\kappa_1/\varphi)).$$

Then, because the story begins in a steady state and the international (and domestic) interest rate is assumed to be constant, the initial levels of household wealth, and government and national debts, respectively, are:

$$a^{\bullet}_{\_} = (1/r)(\kappa/\lambda_{\_} + t - y^{\bullet}_{\_})$$

$$h^{\bullet}_{\_} = (1/r)(t - g^{\bullet}_{\_} + \kappa''/\lambda_{\_})$$

$$d^{\bullet}_{\_} = (1/r)(y^{\bullet}_{\_} - \kappa'/\lambda_{\_} - g^{\bullet}_{\_}) = (1/r)(\phi y^{\bullet}_{x\_} - \theta\kappa'/\lambda_{\_} - g_M),$$

where black dots denote steady state values, minus subscripts denote pre-initial shock levels, and we have defined

$$\kappa' \equiv (1+\tau)(\kappa_1/\varphi), \quad \kappa'' \equiv ih(i)(\kappa_1/\varphi), \quad \kappa \equiv \kappa' + \kappa''.$$

To save on notation below, define the present values of y and g as:

$$Y(t,t') = \int_t^{t'} y\, e^{-r(s-t)}\, ds, \qquad G(t,t') = \int_t^{t'} g\, e^{-r(s-t)}\, ds,$$

and similarly for other functions. (Note that although g_M and g_N are constant throughout, $g = g_M + g_N/e$ varies with e.) Immediately after the dollar appreciation, household financial wealth is:

$$(107) \quad a^{\bullet}_{\_} = a_0 = \int_0^T (1/\rho_+)[\kappa/\lambda_0 + t - y]\, e^{-rs}\, ds + \int_T^{\infty} [\kappa/\lambda_0 + t_+ - y]\, e^{-rs}\, ds =$$

$$= \{ (1/\rho_+)[\kappa/\lambda_0 + t](1 - e^{-rT})/r - Y(0,T) \} + \{ [\kappa/\lambda_0 + t_+]e^{-rT}/r - Y(T,\infty) \}$$

Analogously, the government and national debts immediately after the shock are:

$$(107b) \quad h^{\bullet}_{\_} = h_0 = (1/\rho_+)\{ [t+\kappa''/\lambda_0](1 - e^{-rT})/r - G(0,T)\} + \{ [t_+ + \kappa''/\lambda_0]e^{-rT}/r - G(T,\infty) \}$$

$$(107c) \quad d^{\bullet}_{\_} = d_0 = (1/\rho_+)\{ Y_X(0,T) - [g_M + (\theta\kappa'/\lambda_0)](1 - e^{-rT})/r \} + \{ Y_X(T,\infty) - [g_M + (\theta\kappa'/\lambda_0)]e^{-rT}/r \}.$$

Comparing the national debt before and after the shock, (107c) shows that a greater trade balance compensates for the strong dollar shock: the present value of future exports

$Y_X(0,\infty)$ is higher than $y_X{}^{\bullet}{}_{\_}$ because the new steady state level of e is higher, which eventually shifts resources to the export sector, even though during an initial period exports actually decline because of the perverse impact effects. It also shifts consumption towards domestic goods. The fall in the euro value of consumption c (through an increase in the marginal utility of wealth λ) reduces the consumption of imports. However, because the effect on λ is relatively small (because it is spread out over the whole future), the current account becomes negative, so there is an accumulation of national debt. (107b) shows that the reduction in consumption (through and increase in λ) reduces seigniorage revenues while the temporary increase in ρ reduces the dollar value of the euro primary surplus cum seigniorage. Because of the perverse impact effect on e, the euro value of government expenditures actually increases, and the resulting deficit is debt financed. The planned future tax rate t_+ must necessarily be greater than the initial one, but will ultimately be irrelevant, as we see below. Similarly, (107) shows that the household must compensate for the strong dollar shock and the future increase in the tax rate through a reduction in the euro value of consumption (through a rise in λ). In conclusion, debts grow because agents use international capital markets for inter-temporal smoothing.

The informational cum sudden stop shock

We assume that at time T'<T, it is revealed that the strong dollar shock is permanent, which comes as a complete surprise. Also, domestic agents learn that foreign creditors are not willing to finance this greater shock. Since foreign debts are of instantaneous maturity, this triggers a default, a haircut on the foreign debt, the government assumption of certain inter-household debts (which in Argentina were intermediated by the banking system), and a devaluation.

Immediately before the second shock, household wealth and government and national debts are:

$$(108) \qquad a_{T'\_} = \int_{T'}^{T} (1/\rho_+)[\kappa/\lambda_0 + t - y]e^{-r(s-T')}\, ds + \int_{T}^{\infty} [\kappa/\lambda_0 + t_+ - y]e^{-r(s-T')}\, ds =$$

$$= (1/\rho_+)\{[\kappa/\lambda_0 + t](1 - e^{-r(T-T')})/r - Y_0(T',T)\} + \{[\kappa/\lambda_0 + t_+]e^{-r(T-T')}/r - Y_0(T,\infty)\}$$

$$(108b)\ h_{T'\_} = (1/\rho_+)\{[\kappa''/\lambda_0+t](1-e^{-r(T-T')})/r - G_0(T',T)\} + \{[\kappa''/\lambda_0 + t_+]e^{-r(T-T')}/r - G_0(T,\infty)\}.$$

(108c) $d_{T'\_} = (1/\rho_+)\{\ Y_{X0}(T',T)\ -\ [g_M+(\theta\kappa'/\lambda_0)](1 - e^{-r(T-T')})/r\ \}+$

$$+\ \{Y_{X0}(T,\infty) - [g_M+(\theta\kappa'/\lambda_0)]e^{-r(T-T')}/r\ \},$$

where Y_0, Y_{X0} , and G_0 denote the present value of the paths of y, y_X, g after the initial shock.

The second shock has effects on financial wealth and debts. Immediately after the shock, household financial wealth increases due to the haircut on its foreign debt, $q_H\, d_{H,T'\_}$, and the government assumption of inter-household debts, Δ:

$$a_{T'} = a_{T'\_} + q_H\, d_{H,T'\_} + \Delta.$$

Also, the new household consumption plan must adjust to the novelty of a stronger dollar in (T,∞) and an immediate increase of lump sum taxes to t_{++}. Hence, λ must increase to a level λ_+ that reduces consumption sufficiently:

$$a_{T'} = (1/\rho_+)\{\ [\kappa/\lambda_+ + t_{++}]/r - Y_1(T',\infty)\ \}$$

where Y_1 denotes the present value of the future path of y after the second shock.

Using (108) in the last two expressions gives:

(109) $(1/\rho_+)\{\ [\kappa/\lambda_0 + t](1 - e^{-r(T-T')})/r - Y_0(T',T)\ \} + \{\ [\ \kappa/\lambda_0 + t_+]e^{-r(T-T')}/r\ - Y_0(T,\infty)\ \} +$

$$+\ q_H\, d_{H,T'\_} + \Delta\ =\ (1/\rho_+)\{\ [\kappa/\lambda_+ + t_{++}]/r - Y_1(T',\infty)\ \}.$$

Similarly, we have

(109b) $(1/\rho_+)\{\ [\kappa'/\lambda_0 + t](1 - e^{-r(T-T')})/r - G_0(T,T')\ \} + \{\ [\ \kappa'/\lambda_0 + t_+]e^{-r(T-T')}/r\ - G_0(T',\infty)\ \}$

$$-\ q_G\, d_{G,T'\_} + \Delta\ =\ (1/\rho_+)\{\ [\kappa'/\lambda_+ + t_{++}]/r - G_1(T',\infty)\ \} = h^{\bullet}_+$$

(109c) $(1/\rho_+)\{Y_{X0}(T',T) - [g_M+(\theta\kappa'/\lambda_0)](1-e^{-r(T-T')})/r\ \} + \{Y_{X0}(T,\infty) - [g_M+(\theta\kappa'/\lambda_0)]e^{-r(T-T')}/r\}$

$$-\ \ q_H\, d_{H,T'\_} - q_G\, d_{G,T'\_} = (1/\rho_+)\{Y_{X1}(T',\infty) - [g_M+(\theta\kappa'/\lambda_+)]/r\ \} =$$

$$=\ \ h^{\bullet}_+ + (1/\rho_+)\{\ Y_1(T',\infty) - [\kappa/\lambda_+ + t_{++}]/r\ \}.$$

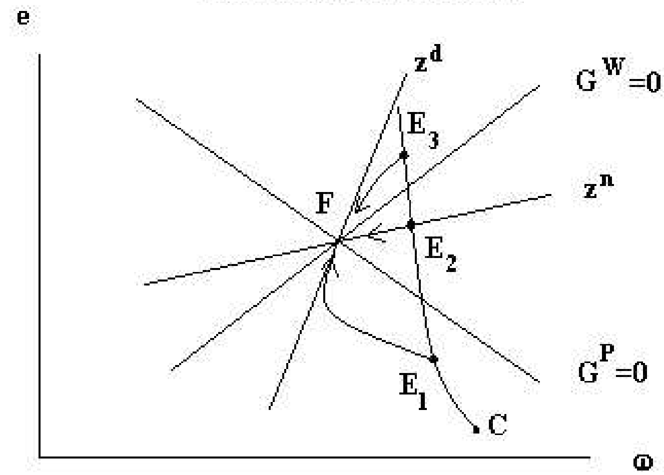
Here, T, T' and ρ_+ are exogenous and jointly measure the size of the strong dollar shock and its allocation to the shock that was expected to be temporary (in (0,T)) and the unexpected permanent part (in (T,∞)) that is revealed in t=T'. The haircuts q_H, q_G and the private debts assumed by the government Δ can mostly be considered exogenous, along with the initial planned fiscal reform (t_+-t decided in t=0 for (T, ∞)). But clearly they can't all be exogenous. They must be in accordance with the inter-temporal accounting given by (109), (109b) and (109c). Looking at (109c) it is apparent that, given the second shock and the magnitude of the devaluation (which determines the paths of e and ω, and hence of y_X), the bigger the haircuts in foreign debts are, the smaller is the necessary trade surplus and hence the necessary adjustment in consumption (measured by λ_+/λ_0). Similarly, (109b) shows that the bigger the haircut on the government foreign debt is, and the smaller the government assumption of inter-household debts is, the smaller is the increase in taxes that is necessary to guarantee fiscal solvency. Note that our assumption on t_{++} implies that the post-restructuring public debt is the new steady state level. Finally, (109) shows that the larger the haircut on private foreign debt and the government assumption of private debts are, and the smaller the tax hike is, the smaller is the necessary contraction in consumption.

II.10. The mechanics of the devaluation

The sudden stop in debt finance triggers a massive run on the currency. We assume that the Central Bank does not try to stifle it because, given the limited magnitude of its international reserves and its lack of foreign sources of finance, it would only lose reserves, severely deepen the recession through the monetary contraction and eventually have to devalue anyway. A change of monetary regime towards a more flexible exchange rate policy would be a distinct possibility but to avoid having to model it we prefer to assume that the pegged regime is maintained. The devaluation is the means by which the government can achieve a quick change in relative prices that increases exportable output, diminishes imports and shifts consumption towards domestic goods, shortening the time necessary to reach the steady state and lowering the output, employment and welfare losses.

As long as it is sufficiently large to take e to a neighborhood of the new steady state, the size of the devaluation is a policy decision. The devaluation increases e and makes ω fall. And the bigger the devaluation is, the larger these effects are. On the e-ω plane, the devaluation shifts ω and e along the curve given by $(W/P_N)_0=\omega e^{\theta}$, where $(W/P_N)_0$ is the product wage in the domestic sector at the time of devaluation (which cannot jump because both W and P_N are predetermined variables). The size of the devaluation determines the path that ω and e subsequently follow towards the final steady state. Figure 6 shows three alternative paths, determined by three possible devaluations. A small devaluation (that, for example, takes the economy from A to E_1) generates a relatively small impact on e (and ω) and takes place within the wage and price deflation quadrant.[15] A medium-sized devaluation, say to E_2, generates a greater increase in e (and fall in ω) and implies that the path to the steady state is along the wage deflation/price inflation quadrant. A sufficiently large devaluation (to E_3) would make the real wage fall (and e rise) so much that the path to the steady state is along the wage and price inflation quadrant.

Figure 6
Alternative devaluations



Let us briefly consider how the Central Bank achieves its desired devaluation. Since we assume that the rate of currency depreciation after the devaluation will be unaltered (at $\overline{\delta}$), the nominal interest rate i does not change. Then for monetary equilibrium it is necessary that the devaluation maintain $\rho m/c=h(i)$ unaltered. Using (47), (60) and (65) gives the stock of currency necessary to maintain monetary equilibrium:

(110) $\quad M_+ = \kappa_4(e^{\sigma\theta+1-\theta}/\lambda)^{1/\sigma}P_N \qquad (\kappa_4 \equiv h(i)\kappa_2^{1/\sigma})$.

[15] Remember that we are assuming that the characteristic roots are real, so that the paths do not spiral towards the steady state.

The increase in λ is determined by the private sector's accommodation to the second shock to maintain inter-temporal solvency, whereas the increase in e is presumably decided jointly by the Central Bank and the government. Expression (100) gives the resulting equilibrium level of currency M_+. Then the Central Bank must generate a one time monetary expansion if it wants to increase $e^{\sigma\theta+1-\theta}$ more than the private sector is increasing λ. This can be accomplished by a discrete one time purchase of foreign exchange, by a non-backed issuance of currency (say, to finance government expenditures), or by any combination of the two.

Let us consider the first alternative. Define the backing (of currency by international reserves) coefficient as $f \equiv ER/M$. We have assumed that before the devaluation $f_0 = 1$, as was the case in Argentina. Call M_0, E_0 , and R_0 (M_+, E_+, and R_+) the values of M, E, and R before (after) the devaluation. If the purchase of foreign exchange is done at the post-devaluation exchange rate we have:

(111) $M_+ = M_0 + E_+(R_+ - R_0)$.

Also, (100) implies

(112) $M_+/M_0 = (E_+/E_0)^{\theta+(1-\theta)/\sigma}/(\lambda_+/\lambda_0)^{1/\sigma}$.

Recalling that $M_0 = E_0R_0$, the last two expressions give the necessary rate of increase of international reserves:

(113) $R_+/R_0 - 1 = \{ [(E_+/E_0)^{\theta+(1-\theta)/\sigma} /(\lambda_+/\lambda_0)^{1/\sigma}] -1 \}/(E_+/E_0)$.

A monetary expansion geared exclusively by a purchase of foreign exchange generates a higher than 100% backing, since (101) implies:

$$f_+ = E_+R_+/M_+ = 1 + (\Delta E/E_0)/\{1 + (\Delta R/R_0)(1+\Delta E/E_0) \} > 1 = f_0.$$

Hence, if the Central Bank is to continue with the policy of 100% backing, it must issue non-backed currency. If instead of (101) we have:

(101') $M_+ = M_0 + E_+(R_+ - R_0) + \Delta_N M$,

where $\Delta_N M$ denotes the non-backed issue of currency, we obtain:

$$f_+ = 1 + [(\Delta E)R_0 - \Delta_N M]/M_+.$$

Hence, the non-backed issuance must be equal to the capital gains on the Central Bank's international reserves $(\Delta E)R_0$ in order to stick to the full backing policy. For our purposes, we can assume that this seigniorage revenue is used to partially finance the government assumption of inter-household debts, and that this gain has already been netted out of Δ.

III. Conclusions

For a small open economy with highly dollarized debts but with little trade with the dollar area it is extremely hazardous to peg its currency to the dollar (or fully dollarize its economy by eliminating its currency altogether). If the dollar appreciates during a considerable period of time, recession and unemployment may make the peg unsustainable. This is particularly so in a world with capital markets in which sudden stops in finance take place, forcing a change of policies, and where long and pronounced phases of dollar appreciations occur recurrently. When the peg is particularly hard, as was the case with Argentina's Convertibility, the regime may endure longer, thus accumulating greater imbalances (as well as debts) that turn what could be a timely exchange rate correction into a catastrophe. This paper makes a case for the interpretation that sticking to Convertibility could have been caused by wrong expectations with respect to the duration of a strong U.S. dollar shock that proved to be much more persistent than expected. For this, it uses a perfect foresight model where expectations with respect to the temporariness of the shock are held with certainty, but a second shock reveals the fact that the shock is permanent and also triggers a sudden stop which forces a default, a haircut on foreign debts, a devaluation, a fiscal reform, and a severe contraction of the real wage.

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Figure A1
Real Broad Dollar Index

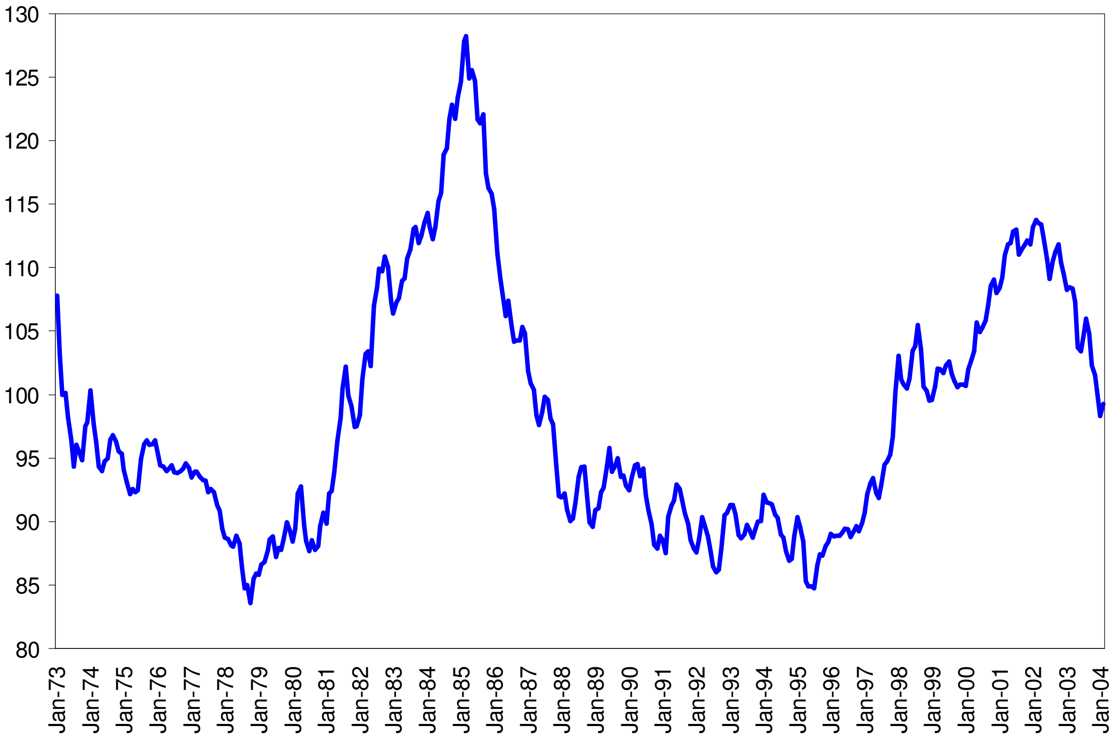

Figure A2
Real Broad Dollar Index (inverted) and Net Private Capital Flows to Emerging Market Countries (rho=0.75)

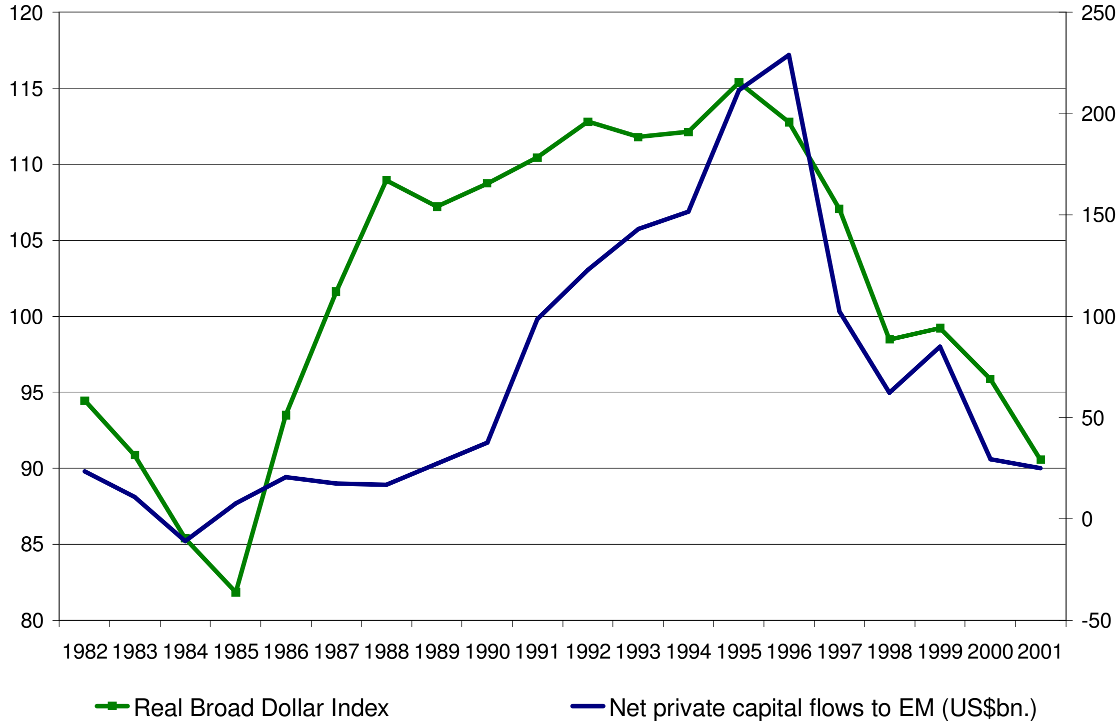

Figure A3
Unemployment and hourly under-employment

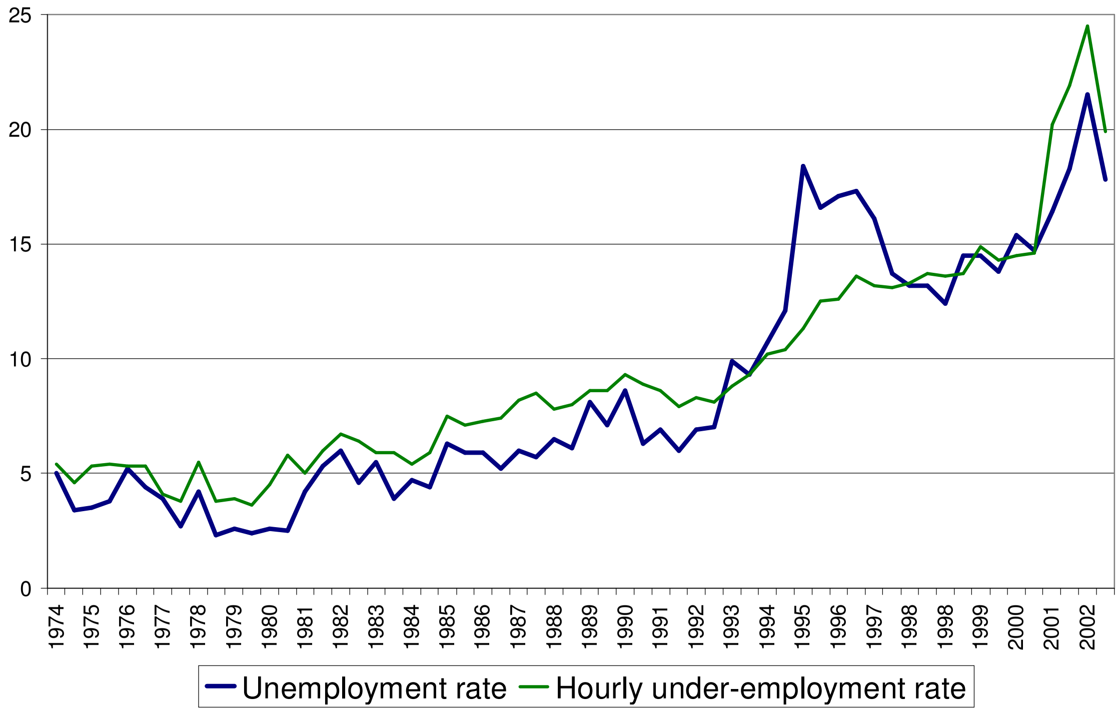

Figure A4
Manufacturing Real Wage and MRER (U.S.A., Europe, Brazil)
MA(4) Average 1975-2002 = 100

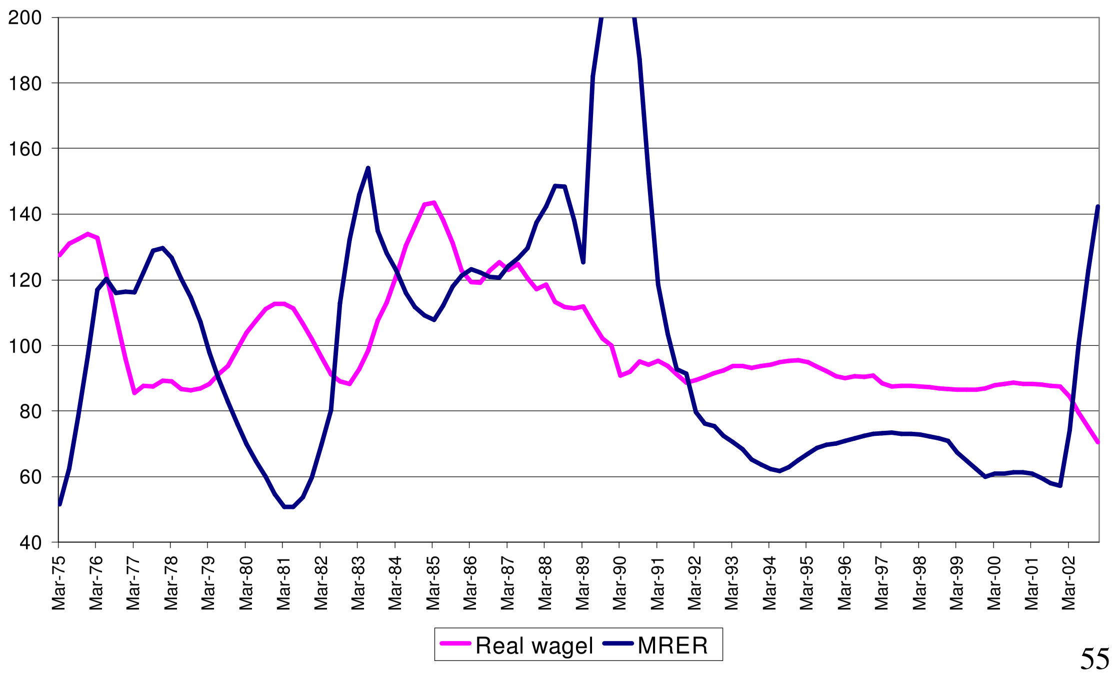

Figure A5
U.S. Real Broad Dollar Index (inverted) and Argentine MRER (USA, Euro, Brazil)

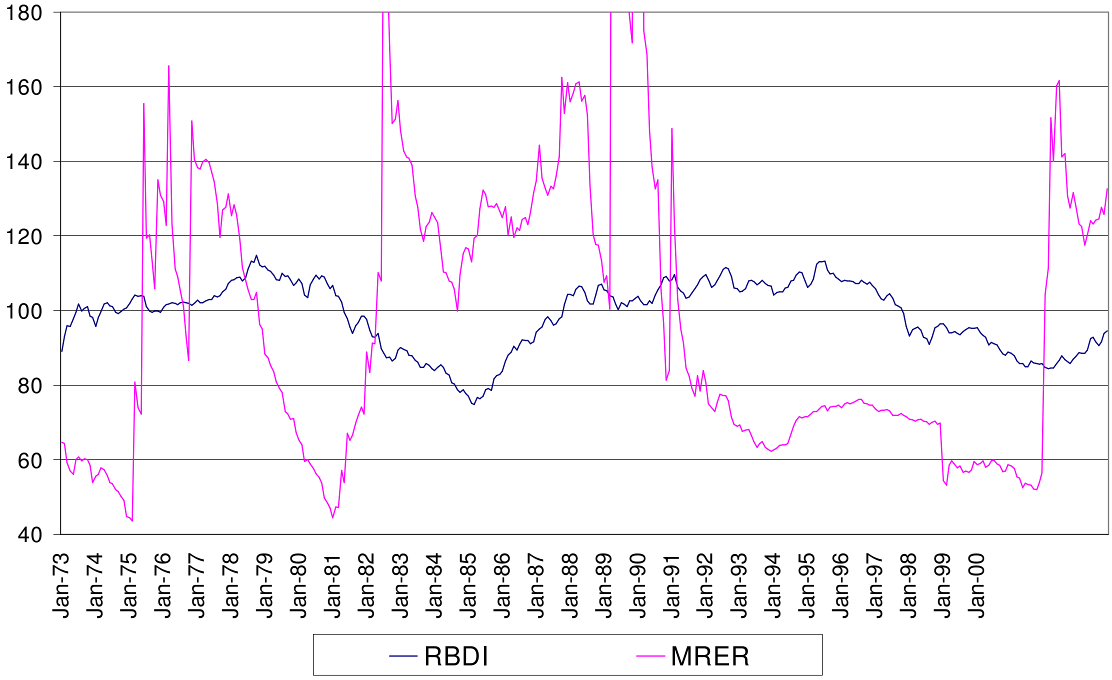

Figure A6
Argentina's MRER and Real Manufacturing Wages
1975-2002

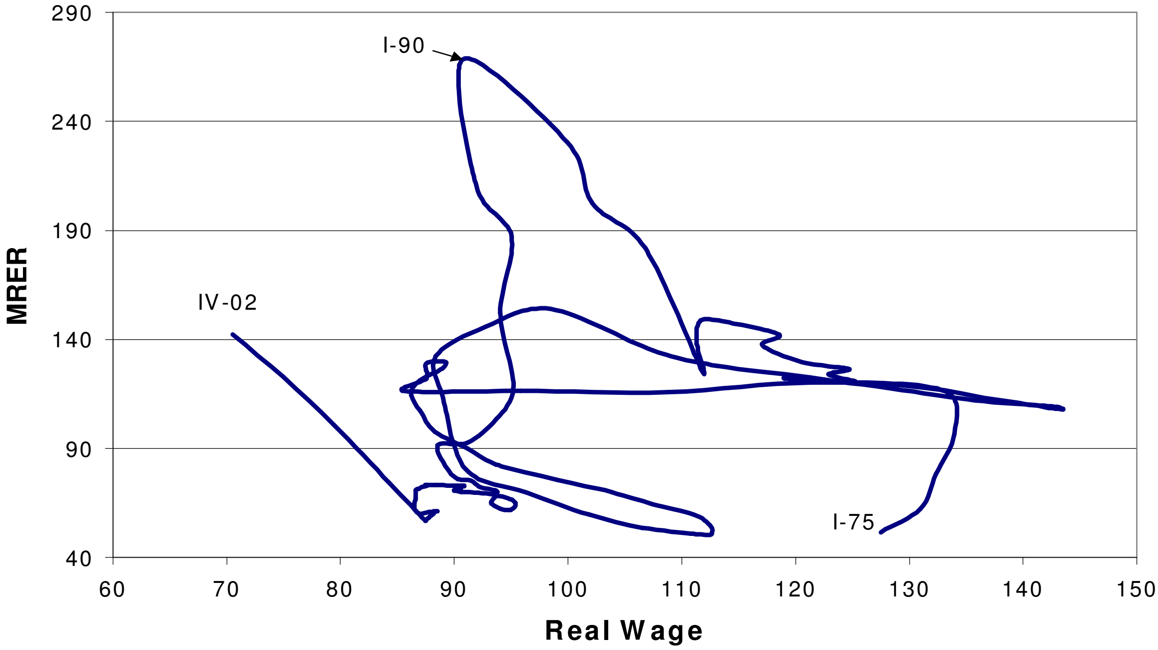

Figure A7
Argentina's MRER and Real Manufacturing Wages
The Tablita episode and after 1977-1983

Figure A8
Argentina's MRER and Manufacturing Real Wages
1991-2002