Did Pesification Rescue Argentina?*

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The Argentinian authorities laid down a *pesification* of all financial claims in February 2002 in such a confusing and chaotic manner that no much good was expected to come of it. Yet the real GDP has increased by 25% since the first quarter of 2002 and is currently superior by 2% to its average during the nineties. This paper challenges the interpretation that considers the *pesification* as a determinant of this amazingly fast recovery. To do so it sets out a simple dynamic model with perfect foresight including *pesification* of debt, floating and self-finance and offers numerical simulations that provide a story in line with the Argentinian stylised facts since 2001.

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When Argentina imploded in December 2001, the amplitude of the collapse was such that it seriously challenged the issue of hard peg exit. Indeed after ten years of bimonetarism under a Currency Board regime, 70% of banking account, credit and liabilities were denominated in dollars. The balance of paiement crisis caused a 200% devaluation that was to imply serious balance sheet effects. It can partly explain why the authorities since 1998 had been so relunctant to devaluate and leave the hard peg regime. The pesification of all financial claims had been supported by some authors (see among others Hausman and Velasco 2002, Krugman 2001) but raised serious issues about contract compliance and was not te be painless. At the end of the day, the Argentinian authorities laid it down in February 2002 in such a confusing and chaotic manner that no much good was expected to come of it.

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Yet the economic recovery has been fast : the GDP has increased by 25% in real terms since the first quarter 2002 and current GDP is superior by 2% to its average during the nineties. This paper challenges the interpretation that considers the *pesification* as a determinant of this amazingly fast recovery.

The balance-sheet litterature that focuses on the effects of credit markets imperfections on growth (Bernanke et Getler 1989, Bernanke, Blinder et Gilchrist 1996) has laid the foundations for a better understanding of the economic crisis in the emerging countries. Indeed the wealth-constrained investment is at the root of the third generation litterature of balance of paiement crisis that combined it with dollarised liabilities features and provided insightful explanations for recent crisis. Krugman (1999) pioneered the formalisation of balance sheet effects : in a country with a large debt denominated in foreign currency and submitted to wealth-constrained investment, a loss of confidence by foreign investors can be self-justifying, because capital flight leads to a plunge in the currency, and the balance-sheet effects of this plunge lead to a collapse in domestic investment. Recently Cespedes, Chang and Velasco (2004) provided a dynamic general equilibrium model combining dollarised liabilities and financial constraint which allows analysis using the familiar IS-BP schedule.

As sketched by Hausman and Velasco (2002), Argentina was hit by an adverse shock due to a loss of appetite of international investors for emerging countries after the Russian and Brazilian crisis in 1998 and 1999. Its ratio of investment expenditures to debt equal to 2 made Argentina *financially vulnerable* according to the estimates of Cespedes, Chang and Velasco (2004) [1]. The Currency Board amplified the contractionary effects preventing the country to adjust. The subsequent recession has led to a balance of paiement crisis in 2001 that caused a 200% devaluation. With 70% of liabilities denominated in dollars before the crisis, the devaluation made the economy bankrupt : new lending vanished because of exploding ratio of debt to export and a part of the old debt was not being serviced. The logic of the pesification was clear: it eliminated the detrimental effects of devaluation in a context of large dollar debt and the devaluation had the traditional expansionary effects via an improvement of the current account. Yet Argentina turned out to be fully isolated from the international credit markets and was facing two major challenges: first one was to stabilize the nominal exchange rate in order to stop agents portfolio transfers from peso to dollar and prevent inflation dynamics. Second challenge consisted in finding back a growth path without access to external finance. This article only tackles the second challenge that deals with real dynamics: once the nominal exchange rate had been stabilised can the *pesification* explain the rapid recovery observed since the second quarter 2002? Can a theoretical

[1] They estimate at 1.2 the ratio for vulnerability and 6 for robustness (Cespedes, Chang and Velasco 2004)

framework including *pesification* of debt, floating and self-finance provide a story in line with the Argentinian stylised facts since 2001?

This paper offers a simple dynamic model with perfect foresight to explore the issue. A single good is produced by competitive firms using labor and capital, and is exported and sold to domestic agents. Labor is supplied by workers and capital by entrepreneurs. These agents consume and in the case of entrepreneurs invest. Entrepreneurs must service an old debt inherited from the past denominated in the domestic currency and they finance investment with their own net worth (consumers do not save and there is no access to the international credit market). This framework eliminates the presence of balance sheet effects in the case of a devaluation since liabilities are denominated in pesos and entrepreneurs do not borrow to invest. Moreover the devaluation shifts demand toward domestic demand which is a component of entrepreneurs net worth. Still, pesification needs not make devaluation expansionary: the impact of an increase in the nominal exchange rate, depends on its pass-through on the prices, which crucially depends on the parameters of the model. A numerical exploration provides the parameter values that make devaluation expansionary. These parameters fit the Argentinian features which is the main contribution of this work: the Argentinian growth recovery might originate from the *pesification* measure.

The next section sets out the model. Section 3 provides its resolution for numerical simulation that is presented in section 4. Parametrization which is a key for the conclusion of this work is detailed in section 4. Section 5 concludes.

1 Model

I study an infinite-horizon small and open home economy. A single good is produced by competitive firms using labor and capital, and is exported and sold to domestic agents. Labor is supplied by workers and capital by entrepreneurs. These agents consume and in the case of entrepreneurs invest. Capital is only self-financed i.e. entrepeneurs finance investment with their own net worth.

1.1 Domestic Production

Time is discrete and indexed by t=0,1,2... and the assumption of perfect competition holds in the sense that firms take all prices, P_t, as given. Firms have a Cobb-Douglas production function:

$$Y_t = K_t^{\alpha} L_t^{1-\alpha}, 0 < \alpha < 1 \tag{1}$$

where Y_t denotes output, K_t capital input L_t labor input and A is a positive constant. In every period, the representative firm maximise profits :

$$Y_t - R_t Y_t - W_t L_t$$

subject to his production function. The input demand conditions yield the following familiar input prices:

$$\begin{aligned} R_t K_t &= \alpha P_t Y_t \\ W_t L_t &= (1-\alpha) P_t Y_t \end{aligned} \tag{2}$$

where R denotes the rental rate of capital and Wt the aggregate wage.

1.2 Workers

The utility of the repesentative worker is the following:

$$u(C, L) = \frac{C_t^{1-\chi}}{1-\chi} - \frac{\varepsilon - 1}{\varepsilon v} L_t^v$$

where $v > 1$ and $\chi > 0$ respectively denote the elasticity of labor supply and the coefficient of relative aversion.

Consumption is composed of domestic goods C_{it}^H and imported goods C_{it}^F in γ and and $(1-\gamma)$ proportion:

$$C_{it} = \kappa \left(C_{it}^H\right)^{\gamma} \left(C_{it}^F\right)^{1-\gamma} \tag{3}$$

where $\kappa = \left[\gamma^{\gamma}(1-\gamma)^{1-\gamma}\right]$. The Law of One Price holds for the imported good so that the peso price of a unit of imports is equal to the nominal exchange rate of S_t pesos per dollar. Workers do not save and their wage is their only source of income which implies the following budget constraint:

$$W_t L_t = P_t C_t^H + S_t C_t^F$$

$$W_t L_t = Q_t C_t \tag{4}$$

with P and Q respectively denote the domestic goods price and the consumption price level. The worker maximises (3) subject to (4) which yields:

$$\frac{1-\gamma}{\gamma} \frac{C_t^H}{C_t^F} = \frac{S_t}{P_t}$$

and

$$Q_t = P_t^{\gamma} S_t^{1-\gamma} \tag{5}$$

The first order condition of optimality yields the following labor supply which depends on the real wage :

$$L_t = \frac{\varepsilon}{\varepsilon - 1} \left(\frac{W_t}{Q_t} \right)^{1-\chi-\nu} \tag{6}$$

The labor supply is a function of the real wage and the slope classically depends on the relative weight of substitution and income effects. If the substitution effect is greater than the income effect ($1 - \chi - \nu > 0$) the labor supply curve is upward slopping.

1.3 Entrepreneurs

At the end of any period t, entrepreneurs have net worth $P_t N_t$ expressed in pesos. Entrepreneurs invest in capital for next period and capital is composed of imported and domestic goods in the same proportion as described above by (3). It implies that the price of the capital in $t+1$ is also Q_t as given by (5). The entrepreneurs' budget constraint is:

$$P_t N_t = Q_t K_{t+1} \tag{7}$$

where K_{t+1} the investment in $t+1$ capital. The capital competely depreciates each period which implies that $I_t = K_{t+1}$.

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$$P_t N_t = Q_t K_{t+1} \tag{8}$$

Net worth is the portion δ of the yield of capital, $R_t K_t$ minus debt service $S_t D_t$. Entrepreneurs pay back the past loans and do not have access to the international credit market so the amount of the debt service is exogenous and fixed :

$$P_t N_t = \delta \left\{ R_t K_t - \bar{D} \right\} \tag{9}$$

$$P_t N_t = \delta \left\{ \alpha P_t Y_t - \bar{D} \right\} \tag{10}$$

1.4 Home goods market clearing

Since workers and entrepreneurs consume home goods in the same fraction γ of their final expenditures, with X_t the value of home exports in dollars, the market clearing for home goods condition yields the last relationship:

$$P_t Y_t = \gamma Q_t (K_{t+1} + C_t) + S_t X_t \tag{11}$$

I make the same asumption as in Krugman (1999) and Cespedes, Chang and Velasco (2004) regarding exports considering that the value of home exports in dollars is exogenous. It can be justified by positing that the foreign elasticity of substitution in consumption is one but that foreigners expenditure share in domestic goods is negligible (due to the asumption of a small open economy). Intuitively a devaluation improves the current account that increases P_tY_t which is a component of the net worth of entrepreneurs (see (10)). Arguably the pesification of financial claim eliminates the balance-sheet effects due to the increase in the debt by the amount of the devaluation and that could result in a reduction of net worth.

Still the pesification needs not make devaluation expansionary. Indeed an increase in the nominal exchange rate, S, in t raises P_tY_t but according to (1) Y_t depends partly on K_t which is already set in t .Then the impact of a nominal exchange rate shock on output in t depends on how much is absorbed by an increase in P_t and how much it increases the labor supply, L_t. According to(2), an increase in P_tY_t improves the remuneration of labor, W_tL_t but L_t depends on the real wage, once again on the relative increase of P_t to W_t. At the end of the day the impact of an increase of the nominal exchange rate on output in t, depends on its effect on P_t, which crucially depends on the parameters of the model. It is the reason why a numerical exploration is required.

2 Resolution

2.1 Equilibrium Dynamics system

Rational expectations equilibria yield a complete system where the state variable is K_t whose evolution caracterizes its full dynamics. The dynamics of the system after a shock on the nominal exchange rate can be analysed in the usual way. By assumption the service of the debt and exports value in dollars is fixed and exogenous. Then the exogenous variables are : $\bar{D}$, X_t and S_t.

2.2 Steady states

Absence of time subscrits denotes steady state.

$$
\begin{aligned}
Y &= K^{\alpha}L^{1-\alpha} && (12)\\
Q &= S^{1-\gamma}P^{\gamma} && (13)\\
W &= (1-\alpha)\frac{PY}{L} && (14)\\
L &= \frac{\varepsilon}{\varepsilon-1}\left(\frac{W}{Q}\right)^{1-\chi-\nu} && (15)\\
PN &= QK && (16)\\
PN &= \delta\left(\alpha PY-\bar{D}\right) && (17)\\
PY\left[1-\gamma(1-\alpha)\right] &= \gamma QK+SX && (18)
\end{aligned}
$$

(12) is the steady state version of the production function (1), (13) corresponds to (5), (15) to (6), (16) to (8), (17) to (10) and (18) to (11).

2.3 The linearised system

The equations that characterize equilibrium can be log-linearised around their steady state value. The resulting system is the following:

$$
\begin{aligned}
y_t &= \alpha k_t+(1-\alpha)l_t && (19)\\
q_t-p_t &= (1-\gamma)(s_t-p_t) && (20)\\
l_t &= (1-\chi-\nu)(w_t-q_t) && (21)\\
w_t-p_t &= y_t-l_t && (22)\\
p_t+n_t &= q_t+k_{t+1} && (23)\\
PN(p_t+n_t) &= \delta\left[\alpha PY\left(p_t+y_t\right)-Dd_t\right] && (24)\\
y_t &= \lambda(k_{t+1}+q_t-p_t)+(1-\lambda)(s_t-p_t+x_t) && (25)
\end{aligned}
$$

with $\lambda=\frac{\gamma QK}{PY(1-\gamma(1-a))}$

2.4 Convergence under perfect foresight

At time t, k_t is given. To solve the system I assume that $s_t=0$. It means that once the nominal exchange rate shock has occured, the monetary policy manages to stabilize it at its new level. Moreover, since the dollar value of exports, X_t, is exogenous, I assume that $x_t=0$ in the absence of a specific export shock. With theses simplifications, the system

(19)-(25) can be reduced to a system of one first-order equation in the unknown k_t whose solution caracterizes the full dynamic of the system:

$$k_{t+1} = \beta k_t$$

(The appendix presents the exact expression of β as well as caracterizes dynamics of all variables of the system in the neighborhood of steady states). In the following the value of the parameters is choosen so that $\beta < 1$.

3 Some numerical explorations

In this section I parametrize the model and simulate it numerically. After having precised the value of the parameters, I provide the results of comparative dynamics in response to a permanent increase in the nominal exchange rate and then I analyze the transitional dynamics of the shock.

3.1 Parametrization

I set the parameters in ranges in line with the Argentinian datas and run sensitivity analysis to different values in theses ranges to select the values that provide simulated dynamics that fit best the Argentinian real dynamics.

The capital share in the production of the home good, α, is assumed to be between 0.3-0.35, as in the standard estimates. The home good share in the production of capital and in the consumption index, γ, is set between 0.6-0.7, to reflect the share of capital in total production (in the nineties the imported good represented around 40% of capital investment)[2]. Empirical evidence usually provide labor supply elasticity closed or lower than 1 (King and Rebello 1999)[3].The capitalists' saving rate, δ is set between 0.92-0.94 as in Cespedes, Change and Velasco (2004). Once I specify the parameter which governs the labor supply elasticity, $1 - \chi - \nu$, I choose $\frac{\varepsilon}{\varepsilon - 1}$ to match the steady state fraction of time spent working L. It depends on the employment rate which is low in the emerging countries and specifically in Argentina (35% during the second half of the nineties) and is estimated

[2]For the sake of simplicity, the model assumes that the home good share in the production of capital and in the consumption index, γ is the same while in reality these fractions are significantly different (40% and 15% respectively). I set γ to equal the share of imported goods in the production of capital because its price is the most relevant since the dynamics of the model lay down in the dynamics of capital.

[3]In the basic RBC model the labor supply elasticity is 4. Yet King and Rebello (1999) highlight that empirical evidence on variation in hours worked is very different from the elasticity built in RBC model and usually provide lower than unity elasticity (Pencavel 1986).

at 17.5% of the available time. Last I set the debt service in line with the ratio observed in 2001: it represented half of the export value in dollars: $\left(\frac{D}{X} = \frac{1}{2}\right)$.

α	γ	$1-\chi-\nu$	δ	L	X	D
$0.3-0.35$	$0.6-0.7$	$0-1$	$0.8-0.95$	0.175	1	0.5

Table 1: Calibration

3.2 Permanent shock to the nominal exchange rate

3.2.1 Comparative statics

This section provides the response of the economy to a permanent 200% increase in the nominal exchange rate such as Argentina experienced in 2001. Table 2 provides the comparative statics before and after the shock and table 3 the parameters associated with these results.

	Y/P	W/P	P	L	Q
Simulations	33%	96%	68%	14%	112%
Argentinian Datas	25%	5%	50%	10%	120%

Table 2: Comparative statics for a 200% nominal exchange rate increase and Argentinian real dynamics between 2002-Q1 and 2004-Q4

α	γ	$1-\chi-\nu$	δ	L	X	D
0.3	0.6	0.3	0.92	0.175	1	0.5

Table 3: Calibration

Before examining the results, note that the value of the parameters fit the Argentinian features and are in line with the values choosen in Cespedes, Chang and Velasco (2004). The value of the labor supply elasticity is positive and close to zero and reflects the relative stability of the employment rate.

Despite its simplicity due to its deterministic feature, the model provides dynamics consistent with the trends observed in Argentina since the pesification. Since the share of imported goods, γ, has been set to reflect the share of imported goods in the investment function, the aggregate domestic price level Q is compared to the production price index (which is composed of 40% imported goods in Argentina) and the home good price level P to the consumption price index (which is only composed of 15% imported goods).

The model predicts 33% real GDP growth, 60% home good price increase and 112% aggregate domestic price level, while the Argentinian GDP has grown by 30%, the consumption and production price indexes respectively by 50% and 120%. Moreover since the elasticity of the labor supply is low, the model predicts a soft increase in the employment

rate which has been true. Analitically it is due to the positive shock on exports which combined with the pesification on financial claims increases the net worth of entrepreneurs. The value of the parameters imply an increase in P_t that does not entirely absorb the subsequent improvement of the current account and allows its repartition to the nominal variables, L_t and Y_t.

Last but not least, the model fails to reproduce the evolution of the real wage which has been almost stable despite the growth recovery since 2002. According to the model, this should reduce the simulated increase in employment and output but the trends should remain similar. This result provides a complementary evidence of the failures of Argntinian labor market institutions to redistribute growth on wages.

3.2.2 Transitional dynamics

Transitional dynamics are computed under the assumption that $s_t = 0$. It means that once the nominal exchange rate shock has occured, the monetary policy manages to stabilize it at its new level. This asumption is made to distinguish in the analysis of the Argentinian stabilization monetary from the real side. In addition I asume that there is no shock on exports hence $x_t = 0$. The rest of the variables adjust according to a law of motion depending on the state variable of the system K_t.

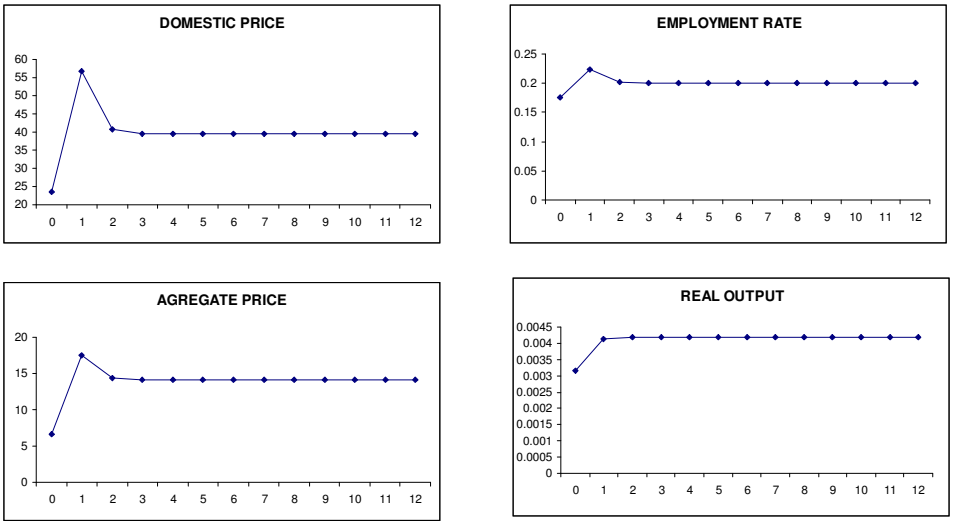

Figure 1: Impulse Responses to a Nominal Exchange Rate Shock

The model predicts an over adjustement of both home good and aggregate prices and a linear increase of the real output.

4 Conclusion

Contrary to Mexico in 1995, Argentina has not been externally rescued by a massive financial support after the devaluation, but had to face the crisis with internal means. This paper challenged the interpretation that considers the *pesification* as a determinant of the amazingly fast Argentinian recovery after the balance of paiement crisis in December 2001. To do so, it offered a simple dynamic model with perfect foresight including *pesification* of debt, floating and self-finance and a numerical simulation of the model to provide the parameter values that make devaluation expansionary. Despite its simplcity the simulated model provides a story in line with the Argentinian outcomes. Argentinian growth recovery might originate from the *pesification* measure. An interesting result of the simulation is that the model can reproduce the real evolutions except for the real wages. If the theoretical framework is to be correct then it gives complementary evidence of the failures of Argentinian labor market institutions to redistribute growth on wages.

This model should largely be sophisticated by substituting deterministic by stochastic dynamics to take into account the agents expectations that were crucial during the crisis.

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5 Appendix

Transitional dynamics

To solve for the transitional dynamics, the log-linearised system is reduced to a system where all log-deviations depend on the log-deviation of K_t from its steady state, k_t.

$$k_{t+1} = \beta k_t$$

with $\beta = \frac{\alpha Z[(1-\gamma\lambda)-PN(1-\gamma)-\alpha PY]}{A[B-\lambda Z(PN(1-\gamma-\alpha PY+1-\gamma\lambda)-U\lambda Z]}$

$A = 1-(1-\alpha)(1-\chi-\nu)$

$B = \left[\frac{1}{X}(1-\alpha)(1-\chi-\nu)(1-\gamma)+(1-\lambda\gamma)\right]$

$Z = \alpha PY$

$$\begin{aligned}
p_t &= k_t \frac{1}{U}\left(\lambda\beta - \frac{\alpha}{X}\right) \\
q_t &= k_t \gamma \frac{1}{U}\left(\lambda\beta - \frac{\alpha}{X}\right) \\
y_t &= k_t \left[\lambda\beta + \frac{1}{U}(1-\lambda\gamma)\left(\lambda\beta - \frac{\alpha}{X}\right)\right] \\
l_t &= k_t(1+1-\chi-\nu)\left[(\lambda\beta + \frac{1}{U}\left(\lambda\beta - \frac{\alpha}{X}\right)[(1-\lambda\gamma)+(1-\gamma)]\right] \\
w_t &= k_t \frac{1}{1-\alpha}\left[\lambda\beta + \frac{1}{U}(1-\lambda\gamma)\left(\lambda\beta - \frac{\alpha}{X}\right) - \alpha\right]
\end{aligned}$$