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**Money Demand in an Open Economy Framework: Argentina
(1932-2002)**

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Abstract

This paper analyzes the demand for money in Argentina using the new open macroeconomic framework provided by the Redux Model. In a set up of this model with nontradable goods the fundamentals of money demand appear to be, not only, domestic product and interest rate, but also, net foreign assets revenues, productivity differential and terms of trade. These five fundamentals allow to estimate the demand for money in macroeconomic unstable economies like Argentina. We find that the transaction-elasticity and the interest-elasticity are similar to those of developed countries, and that the structural volatility of Argentina's money demand may be explained by external shocks transmitted through foreign sector related elasticities.

JEL Classification Numbers: E41, F41, C22

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"[...], the chief substantive issues outstanding are three: first what specific collection of assets corresponds most closely to the theoretical concept of money [...]; second, what the variables are on which the demand for money so defined depends; and third, whether the demand for money is sufficiently stable [...]. These are essentially empirical issues, to which empirical research has yet produced no conclusive answers; and they clearly have an important practical bearing on monetary policy."

Harry G. Johnson, "Monetary Theory and Policy",
American Economic Review, June, 1962, pp.344-45

I. Introduction

After Harry Johnson's survey, hundreds of empirical papers were written all around the world, nonetheless the question on what variables does money demand depend, remains open. Need we only more empirical research? Need we new econometric methodologies? Or need we also to update money demand theory? In our view, developments during the last twenty years in cointegration analysis and equilibrium correction models, Granger and Weiss (1983), Engle and Granger (1987), Johansen (1988), Johansen and Juselius (1990), Phillips and Loretan (1991), Saikkonen (1991), Stock and Watson (1993) constitute a solid methodological background to estimate long-run money demand. But, studies still report conflicting results and the question of money demand fundamentals remains opened. If forty years of applied research cannot produce conclusive answers, then we are in trouble. Consequently, looking forward to solve this puzzle, we will build a suitable theoretical framework, because empirical research cannot substitute the lack of theory. Developments in money demand theory from Fisher (1911), through Pigou (1917) and Keynes (1930), to Friedman (1956) have stated the issue in a closed economy framework.¹ More recent models that derive money demand from individual utility maximization represent a clear advance, as they are built on the firmer foundation of individual choice. The money in the utility function approach of Sidrauski (1967) and Brock (1974) are the earliest examples, but they also assume closed economies. During the last twenty years, despite the developments in intertemporal open-economy macroeconomics, their integration with the money demand analysis has not been achieved.

The purpose of this paper is to find money demand fundamentals in an open-economy and to detect whether a stationary long-run real money demand for Argentina exists. That means we address, forty years later to the second and third issue raised by Johnson (1962).

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¹ See the well known book of Laidler (1993) for a friendly description of these earlier theories.

The demand for money plays an important macroeconomic role, as a critical component in any formulation of monetary policy. Knowing the income elasticity of money demand helps in determining the rate of monetary expansion that is consistent with long-run price level stability. In this sense, money demand is a key element in applied macroeconomic analysis, specially in financial programming used by the IMF. A stable money demand is essential for a Central Bank interested in using monetary aggregates to conduct monetary policy.

In Argentina, the study of the demand for money remains underdeveloped. During the nineties a growing literature based on cointegration techniques, Melnick (1990), Ahumada (1992), Ericsson and Kamin (1994), Choudry (1995), Ahumada and Garegnani (2002), has made an important contribution to the understanding of the money demand, highlighting partial aspects or periods of Argentina's economic history. Cointegration is appealing in that it provides a rigorous time-series framework for applying long-run economic theory. But these new estimation methodologies were implemented in the context of traditional money demand models. The aim of this paper is to improve the theoretical framework and consequently the money demand specification that underlies cointegration estimates, using an intertemporal open-economy macroeconomic model.

Argentina, as an emerging market is characterized by currency crises, great changes in relative prices and currency substitution. In such a country, the traditional strategy of modeling money demand without a well specified micro founded model might work in the medium run but does not fit well to the long run. In fact, regime shifts change the relevant opportunity cost over time and requires, a set of ad-hoc variables: inflation, currency depreciation, maximum inflation rate to date, and dummies.

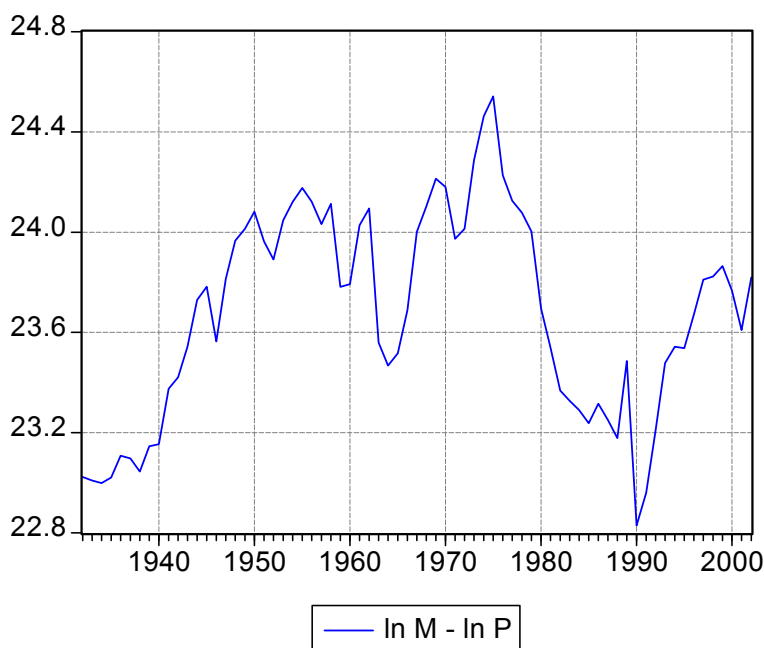
The problem with this modeling strategy rises since estimates of the demand for money can be obtained for short periods of time (the 70s, 80s or 90s), and nothing can be said about the future since there can always be a regime shift. It is the idea of this paper to make these regime shifts endogenous by using an appropriated theoretical model, that is to say, an open economy framework. A glance on the empirical literature about the money demand specification shows that there is not a standard open-economy functional form. What can be found in the literature are open economy variables, like exchange rate depreciation, spread between local and foreign interest, foreign exchange risk, but none of these are fundamentals, they are only proxies of some money demand fundamentals. In this paper we show that in addition to the estimation problems due to low span data widely analyzed in the empirical literature, there is also probably a misspecification problem in the literature, due to missing variables. In real world, countries are open-economies and no just closed economies of the type supposed by traditional money demand estimates.

To tackle this issue we develop a simple theory of money demand in an open economy, considering a new open macroeconomic model that captures one of the main features of the Argentine economy, that is, the great changes over time in the relative price of nontradable goods.

Figure 1 plots the evolution of real holdings of narrow money ($M1/P$) over the last 71 years, expressed in logarithms of real pesos ($P=1$ in 1993). $M1$ includes peso currency and demand deposits. Four periods may be distinguished. The first one is characterized by a real money balances increase until mid 50s. After that, oscillatory movements that finish in the mid 70s with a maximum just after the Oil shock can be seen. Then a declining trend takes place until it reaches a minimum during the hyperinflation of 1990. In this period, real money holdings decline 82% between the maximum and minimum value of the sample.

Finally, we can see an upward trend (160%) during good times of Convertibility. The figure also shows a local maximum in 1989 hyperinflation and a local minimum during the collapse of Convertibility Plan in 2001. Real money drops 28% within 1999-2001.

Figure 1: Real Money



Many questions arise from the view of the figure. Why does real money have such wide movements? Is mismanagement in monetary policy all that counts? Does the instability of money demand play a role? Does real money balances have an equilibrium level?

In the monetary markets, supply and demand interact permanently. Figure 1 shows real money supply, nevertheless, not all shown values are equilibrium values, that is to say, not all are demanded values. The quantity of money demanded is not an observable variable; all that can be measured is the quantity of money supplied. To establish which are equilibrium values, it is necessary to estimate the demand for money.

The paper is organized as follows. Section 2 outlines a small open economy version of the Redux model, and derives the money demand equation. Section 3, moves to the empirical work, describing the data set. The methodology is presented in section 4. Section 5 discusses the econometric results and estimations. Finally, section 6 concludes.

II. Redux Model and Money Demand Equation

The money demand equation will be derived from the extended version of the Obstfeld and Rogoff (1995) model. The country is populated by a continuum of consumer-producers arranged on the unit interval, $[0,1]$. Each household produces a distinct and differentiated nontraded good using only its labor. The nontraded sector is monopolistically competitive, with an elastic labor supply and prices set one period in advance. Production of the homogeneous traded good, in contrast, is viewed as exogenous and the price of traded goods is covered by the law of one price. Households derive utility from consumption, money holdings and leisure. A higher output represents more income which on the one hand pleases the agent but on the other hand the concomitant loss of leisure implies a disutility for her.

We assume that households have identical utility functions, so that we will work with a representative agent (household). People have tastes for all varieties of goods and the household's consumption basket is represented by a constant elasticity of substitution (CES) index that aggregates across the available varieties of nontraded goods and the homogeneous traded good.

The utility function of agent j is

$$U_j = \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma-1} C_s^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \left(\frac{M_s}{P_s} \right)^{1-\varepsilon} - \frac{\kappa}{2} y_{Ns}^2 \right] \quad (1)$$

where $0 < \beta < 1$ is the subjective rate of time discount, $\sigma > 0$ the elasticity of intertemporal substitution, and ε and $\kappa > 0$. The consumption index C aggregates consumption of traded and nontraded goods

$$C = \left[\gamma^{\frac{1}{\theta}} C_T^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_N^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \quad (2)$$

where $\theta > 0$ is the constant elasticity of intra-temporal substitution (i.e. elasticity of substitution between traded and nontraded consumption). The composite nontraded good consumption index C_N is

$$C_N = \left[\int_0^1 c_N(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} \quad (3)$$

The second term in the objective function reflects the utility derived from holding real money balances, for instance to facilitate transactions. The third term $-(\kappa/2)y_{Nt}^2$ captures the disutility of work effort, in this case, with an elasticity from output of 2. If utility from effort ℓ_N is given by $-\Psi\ell_N$ and the production function is $y_N = A_N\ell_N^{1/2}$, then $\kappa = 2\Psi/A_N^2$.

Agent j can invest in an internationally traded asset denominated in units of the tradable good that pays off a real return r , which is given exogenously. The flow budget constraint faced by agent j is given by

$$P_{Tt}F_{t+1} + M_t = P_{Tt}(1+r_t)F_t + M_{t-1} + p_{Nt}(j)y_{Nt}(j) + P_{Tt}y_{Tt} - P_{Tt}C_t - P_{Tt}T_t \quad (4)$$

where $y_{Nt}(j)$ is the individual's output and p_{Nt} is the price of the nontraded good produced by agent j .² Each agent also receives an exogenous endowment y_{Tt} of the traded good every period and the price of traded goods is covered by the law of one price.

The consumption-based price index is given by

$$P = \left[\gamma P_T^{1-\theta} + (1-\gamma)P_N^{1-\theta} \right]^{\frac{1}{1-\theta}} \quad (5)$$

where the price index for nontraded good is

$$P_N = \left[\int_0^1 p_N(j)^{1-\theta} dj \right]^{\frac{1}{1-\theta}}$$

Agent j is the monopolistic producer of the variety j of the nontraded good and faces the demand function

$$y_N^d(j) = \left[\frac{p_N(j)}{P_N} \right]^{-\theta} C_N^A \quad (6)$$

where $C_N^A = \int_0^1 C_N^j dj = C_N$ is aggregate consumption of nontraded goods.

Finally, we assume zero government expenditure so that all seigniorage revenue is returned to the population in the form of lump-sum transfers

² We normalize the foreign currency price of the tradable good to unity, which implies $P_T = E$, and allows to replace the nominal exchange rate E by P_T in the budget constraint.

$$\tau_t = \frac{M_t - M_{t-1}}{P_t} \quad (7)$$

II.1. First-Order Conditions

Use [6] to eliminate $p_N(j)$ from [4], and then maximize lifetime utility [1] subject to the resulting budget constraint, taking the aggregate consumption of nontraded goods C_A^N as given. Define the nominal interest rate by

$$1 + i_t = \frac{P_{Tt+1}}{P_{Tt}}(1 + r_t) \quad (8)$$

The first-order conditions for the maximization problem of the agents are ³

$$\frac{C_{Tt+1}}{C_{Tt}} = [\beta(1 + r_t)]^\sigma \left[\frac{\left(\frac{P_t}{P_{Tt}}\right)}{\left(\frac{P_{t+1}}{P_{Tt+1}}\right)} \right]^{\sigma-\theta} \quad (9)$$

$$\frac{C_{Nt}}{C_{Tt}} = \frac{(1-\gamma)}{\gamma} \left(\frac{P_{Nt}}{P_{Tt}}\right)^{-\theta} \quad (10)$$

$$\frac{M_t}{P_t} = \left[\chi C_t^{\frac{1}{\sigma}} \frac{1 + i_t}{i_t} \right]^{\frac{1}{\epsilon}} \quad (11)$$

$$y_{Nt}^{\frac{\theta+1}{\theta}} = \left(\frac{\theta-1}{\theta\kappa}\right) C_t^{\frac{1}{\sigma}} (C_{Nt}^A)^{\frac{1}{\theta}} \left(\frac{P_{Nt}}{P_t}\right) \quad (12)$$

Equilibrium is characterized by these four relationships in conjunction with the budget constraint [4] and the transversality condition

$$\lim_{T \rightarrow \infty} \prod_{s=t}^{t+T} \left(\frac{1}{1+r} \right) \left(F_{t+T+1} + \frac{M_{t+T}}{P_{t+T}} \right) = 0 \quad (13)$$

First, equation [9] is the Euler condition governing the dynamic evolution of consumption. Consumption depends on the sequence of relative prices (the consumption-based real interest rate effect). If the aggregate price level relative to the price of traded goods, is currently low relative to its future value, this encourages present over future consumption (as the consumption-based real interest rate is lower). However, relative inter-temporal prices also encourages substitution from traded to nontraded goods. The former effect dominates if the inter-temporal elasticity of substitution is larger than the intra-temporal one ($\sigma > \theta$), consequently present tradable consumption is preferred over the future one.

Second, equation [10] links consumption of nontraded and traded goods with relative prices and shows that the elasticity of substitution is parameterized by θ .

Equation [11] represents the money market equilibrium condition that equates the marginal rate of substitution between consumption and real money balances services to $i_t/(1+i_t)$, that

³ They follow from differentiating with respect to F_{t+1} , C_{Nt} , M_t , and y_{Nt}

is, to the consumption opportunity cost of holding real money balances. As usual, real money balances are decaying in the nominal interest rate, but notice that money demand depends on consumption rather than on income, an important distinction in an open economy. We will go deeper in this feature to find out the fundamentals of money demand in open economies. Finally, equation [12] states that the marginal utility of the additional revenue earned from producing an extra unit of good equals the marginal disutility of the needed effort. This relationship represents the equilibrium supply of nontradable goods, the higher the consumption index C , the lower the level of production, as the agent increases leisure in line with consumption of other goods.

II.2. Steady-State Equilibrium

For simplicity, assume $\beta(1+r)=1$, which rules out the desire to borrow and lend in the steady-state. Let us consider the case when all prices are fully flexible and all exogenous variables, including the money stock, are constant. Let us assume that the initial stock of net foreign assets is zero ($F_0 = 0$). Let us normalize the endowment of the traded good so that the relative price of nontraded goods in terms of traded goods is the unity in this steady-state ($P_N/P_T = 1$). This implies that the endowment in steady-state is

$$y_T = C_T = \frac{\gamma}{1-\gamma} y_N \quad (14)$$

In this symmetric equilibrium, $C_{Nt}^A = y_{Nt} = (1-\gamma)C_t$ and the steady-state production and consumption of nontraded goods is given by

$$y_N = C_N = \left[\frac{\theta-1}{\theta \kappa} \right]^{\frac{\sigma}{\sigma+1}} (1-\gamma)^{\frac{1}{\sigma+1}} \quad (15)$$

From this expression, production of the nontraded good will be the larger, the more competitive is the nontraded goods sector (the larger is θ), the less taxing is work effort (the smaller is κ) and the larger is the weight placed on consumption of nontraded goods in the utility function (the larger is $(1-\gamma)$).

The last two equations describe optimal production and consumption of both goods in steady-state. Now the next step is to find out the relationship that rules real money balances. Use [12] to eliminate C_t from [11] and consider the equilibrium condition of the nontradable goods market $C_{Nt}^A = y_{Nt}$, then

$$\frac{M_t}{P_t} = \left[\chi \frac{\theta-1}{\theta \kappa y_{Nt}} \frac{P_{Nt}}{P_t} \frac{1+i_t}{i_t} \right]^{\frac{1}{\epsilon}} \quad (16)$$

Plug the steady-state nontraded goods production [15] into [16]. The initial equilibrium price level P_0 can be found considering the constancy of the price level in steady-state (from the no-bubbles condition) and the initial value for the money stock M_0 .

$$\frac{M_0}{P_0} = \left[\chi \left(\frac{\theta-1}{(1-\gamma)\theta\kappa} \right)^{\frac{1}{\sigma+1}} \frac{1+r}{r} \right]^{\frac{1}{\epsilon}}$$

II.3. Log-linear approximation

Since we know that $\kappa = 2\Psi / A_N^2 = 2\Psi \ell_N / y_N^2$, [16] becomes

$$\frac{M_t}{P_t} = \left[\chi \frac{\theta-1}{2\Psi\theta} y_{Nt} \frac{P_{Nt}}{P_t} \frac{1+i_t}{i_t} \right]^{\frac{1}{\epsilon}} \quad (17)$$

Log-linearly approximating this equation around the steady-state where $y_N = (1-\gamma)y$ gives

$$\hat{M}-\hat{P} = \frac{1}{\varepsilon} \left[\hat{y} - \hat{i} + (\hat{P}_N - \hat{P}) \right]$$

where $\hat{x} = \frac{dx}{x_0}$ denotes the percentage change relative to the benchmark steady-state, and

$$\hat{i} = d \ln \frac{i}{1+i}.$$

Totally differentiating [5] and dividing each side for P in order to approximate around the benchmark steady-state, we have

$$\frac{dP}{P} = \gamma \frac{P_T^{1-\theta} P^\theta}{P} \frac{dP_T}{P_T} + (1-\gamma) \frac{P_N^{1-\theta} P^\theta}{P} \frac{dP_N}{P_N}$$

Knowing that in the benchmark steady-state $P = P_N = P_T$, gives

$$\hat{P} = \gamma \hat{P}_T + (1-\gamma) \hat{P}_N$$

Then

$$\hat{M}-\hat{P} = \frac{1}{\varepsilon} \left[\hat{y} - \hat{i} + \gamma(\hat{P}_N - \hat{P}_T) \right] \quad (18)$$

From Lane and Milesi-Ferretti (2000), we know that in this setup the relative price of nontradable goods is given by⁴

$$\hat{P}_N - \hat{P}_T = \frac{1+\sigma}{\theta(1+\sigma) + \gamma(\sigma-\theta)} \left[r \hat{F} + \hat{A}_T - \frac{2\sigma}{\sigma+1} \hat{A}_N + \hat{P}_T^X - \hat{P}_T^M \right] \quad (19)$$

where $\hat{F} = dF/C_{T0} = dF/\gamma y_0$, \hat{A}_T and \hat{A}_N stand for the impact of productivity surges in tradable and nontradable goods, and $\hat{P}_T^X - \hat{P}_T^M$ the change in terms of trade.

Finally, plugging [19] in [18] allows us to express the variations of real money balances around the benchmark steady-state in terms of supply and demand shocks, interest rates shocks, technology shocks, and terms of trade shocks.

$$\hat{M}-\hat{P} = \frac{1}{\varepsilon} \left[\hat{y} - \hat{i} + \gamma \frac{1+\sigma}{\theta(1+\sigma) + \gamma(\sigma-\theta)} \left(r \hat{F} + \hat{A}_T - \frac{2\sigma}{\sigma+1} \hat{A}_N + \hat{P}_T^X - \hat{P}_T^M \right) \right] \quad (20)$$

II.4. Money Demand Equation

The equation to estimate is similar to individual agent demand [20], but in aggregate form and in levels. This is

$$\ln \frac{M_t}{P_t} = \eta + \beta_2 \ln y_t + \beta_3 \ln \frac{i_t}{1+i_t} + \beta_4 \frac{r F_t}{y_t} + \beta_5 \ln A_{Tt} + \beta_6 \ln A_{Nt} + \beta_7 \ln \frac{P_{Tt}^X}{P_{Tt}^M} + u_t \quad (21)$$

The random disturbance u_t is expected to be stationary. Additionally from [20]

⁴ See appendix 1

$$\beta_2 = -\beta_3 = \frac{1}{\varepsilon} > 0; \quad \beta_4 = \frac{\varphi}{\gamma} > 0; \quad \beta_5 = \beta_7 = \varphi > 0; \quad \beta_6 = -\frac{2\sigma\varphi}{(\sigma+1)} < 0$$

where

$$\varphi = \frac{\gamma(1+\sigma)}{\varepsilon(\theta(1+\sigma) + \gamma(\sigma - \theta))}$$

The assumptions made to build the model require that coefficients in equation (21) must have the following signs. First, a higher level of output requires more real money balances as transactions increase. Therefore the GDP-elasticity of money demand $\beta_2 > 0$. Second, higher nominal interest rate will reduce money demand because consumption opportunity cost of holding real money balances increases, it follows that the elasticity with respect to the opportunity-cost variable $i_t/(1+i_t)$, $\beta_3 < 0$. For simplicity, this will be referred to as the interest elasticity of money demand.⁵ These are the standard determinants of real money balances in a closed economy, but in an open economy we have additional factors. The third effect, a new one, is related to net foreign assets. Higher revenues from net foreign assets lead to an increase in consumption and in money demand (wealth effect), therefore $\beta_4 > 0$. Coefficients $\beta_5 > 0$ and $\beta_6 < 0$ are the monetary consequences of Balassa-Samuelson effect appreciating and depreciating domestic money, and consequently increasing and reducing money demand. Finally, terms of trade improvements would generate a positive wealth effect, reducing labor supply in the nontraded sector and increasing consumption, thus $\beta_7 > 0$. We have shown that in an open economy it is necessary to take in account the opportunity cost of currency depreciation, driven by the relative price of nontradable goods. As pointed by equation [19] the last four determinants we described modify the relative price of nontradables, and hence the real exchange rate. In this sense, they link exchange rate market to money market, and monetary disequilibrium to exchange rate misalignments. For instance, a reduction in revenues from net foreign assets will induce an increase in equilibrium real exchange rate, which in a context of sticky prices causes overvaluation of the domestic currency and excess demand for foreign currency. At the same time, a smaller revenue from net foreign assets implies a reduction in consumption and in money demand by equation [21]. In this case, the excess of supply in money market is the consequence of the initial disequilibrium (overvaluation) in foreign exchange market.

In order to reduce the number of estimated parameters we will consider that $\sigma=1$, then

$$\ln \frac{M_t}{P_t} = \eta + \beta_2 \ln Y_t + \beta_3 \ln \frac{i_t}{1+i_t} + \beta_4 \frac{r F_t}{y_t} + \beta_5 \ln \frac{A_{Tt}}{A_{Nt}} + \beta_7 \ln \frac{P_{Tt}^X}{P_{Tt}^M} + u_t \quad (22)$$

where β_5 represents now the elasticity of money demand derived from Balassa-Samuelson effect, that is the elasticity related with the productivity differential (tradable/nontradable).

Note that the last three determinants of money demand (revenues from net foreign assets, productivity differentials and terms of trade) did not appear in traditional closed-economy analysis.

III. Data set

Figure 2 shows the determinants of Money Demand. For a detailed description of data sources see data appendix.

⁵ The elasticity of money demand with respect to the nominal interest rate is

$$\frac{\partial \frac{M_t}{P_t}}{\partial i_t} \frac{i_t}{\frac{M_t}{P_t}} = \beta_3 \frac{1}{1+i_t}$$

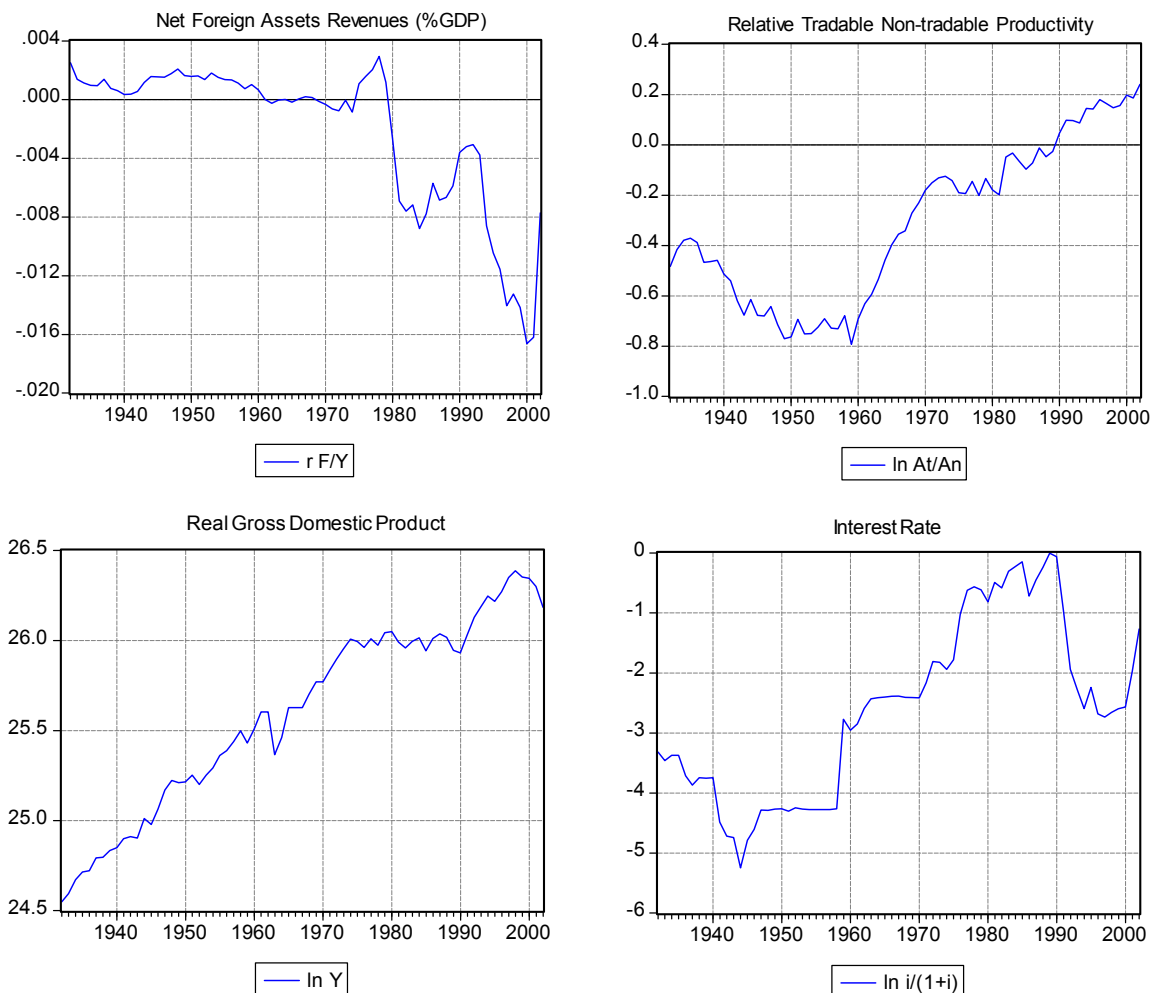
Gross Domestic Product increases until the middle 70s. After that, we can see the so called lost decade of the 80s. At the end of the sample, it can be seen the growth recovery of the 90s with the collapse of Convertibility Plan in 2001.

The figure of nominal interest rates reveals the existence of financial repression after World War II. The financial system reform took place in 1977 in a high inflation context, which means high nominal interest rates. Nominal interest rates reach a maximum during hyperinflation and then decrease to standard levels after 1991 with the Convertibility Plan. Regarding revenues from net foreign assets, we must consider that the two main experiments of exchange rate based stabilization plans (Tablita and Convertibility) led to persistent current account deficits and eroded the net foreign assets position of the country. The revenues from external assets fell in consequence.

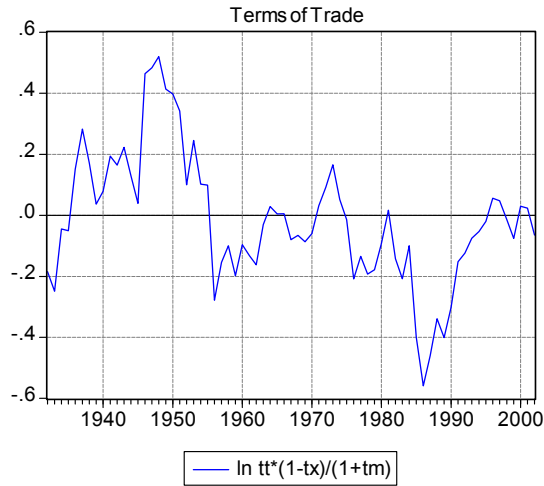
Tradable productivity differential diminishes at the beginning of the sample until 1960, it started growing steady until mid 70s when some oscillatory movements took place. Finally the growth trend started again.

The terms of trade adjusted by commercial policy⁶ show a maximum value in the mid 40s after World War and a minimum in the mid 80s after the debt crisis and during Plan Austral years. In the last decade they recovered and showed values in line with the mean of the sample. We can also see a local maximum during the oil crisis.

Figure 2: Determinants of Money Demand



⁶ we pre multiply the terms of trade by $(1 - \text{tariffs on exports})$ and divide it by $(1 + \text{tariffs on imports})$



IV. Methodology

The employed econometric procedure to estimate money demand is a version of the multivariate cointegrated systems originally developed by Johansen. The main idea behind cointegration is a model specification that includes beliefs about the movements of variables relative to each other in the long run. Thus, if the money demand equation [22] describes a stationary long-run relationship among real money balances, real income, interest rates, net foreign assets revenues, productivity differential and terms of trade, it can be interpreted that the stochastic trend in real money balances is related to the stochastic trends in these variables. In other words, if the variables are cointegrated, they will be constrained to an equilibrium relationship in the long run. While it is possible for deviations from the equilibrium to exist, they are mean reverting. Individually these variables might drift apart in the short run, but in the long run they are constrained. In simple words, two or more non-stationary time series are cointegrated if a linear combination of these variables is stationary (converges to an equilibrium over time). Applications of the cointegration test in the estimation of the money demand function are explicitly analyzed in Johansen and Juselius (1990). Essentially, the method applies the maximum likelihood principle to determine the presence of cointegrating relationships in non-stationary time series. Two different tests are provided to determine the number of cointegrating relationships, the trace test and the maximum eigen-value test. If a nonzero vector (or vectors) is (are) indicated by these tests, a stationary long-run relationship is implied.

Defining the vector

$$y_t = \left(\ln \frac{M_t}{P_t}, \ln Y_t, \ln \frac{i_t}{1+i_t}, \frac{r F_t}{Y_t}, \ln \frac{A_{Tt}}{A_{Nt}}, \ln \frac{P_T^X}{P_T^M} \right)'$$

of dimension 6x1 which contains the six time series to be used in money demand estimation. If the six variables are integrated of order one, $I(1)$, the existence of at least one cointegration vector among these variables allows to represent the model of money demand as follows

$$\Delta y_t = \mu + \alpha \beta' y_{t-1} + \sum_{i=1}^k \pi_i \Delta y_{t-i} + \varepsilon_t \quad (23)$$

where μ is a vector of constants of dimension 6x1, α and β are matrices of dimension 6xr, and r is the number of cointegration vectors; π_i are k matrices of dimension 6x6 with

coefficients. The short-term dynamics are represented by the series in first differences, and the long-term relations by the variables in levels. Following [23], any deviation in the long-term equilibrium ($\beta'y_{t-1} \neq 0$) may influence the short-term dynamics. If real money balances is to return to long-term equilibrium, some of the variables –interest rate, domestic product, net foreign assets revenues, sectoral productivities, terms of trade or real money- should react to the size of the disequilibrium. Adjustment coefficients α_i capture this short-run movements.

Also, if y_t is integrated of order one, the Δy_t process is stationary, y_t is non-stationary, but $\beta'y_{t-1}$ (representing the disequilibrium in money market) is stationary.

V. Estimation and Results

Since cointegration test requires a certain stochastic structure of the time series involved, the first step in the estimation procedure is to determine if the variables should be non-stationary in levels (should contain a unit root). To be able to know the order of integration of the series that make up vector y_t , the Augmented Dickey-Fuller test (ADF) has been used.

V.1. Augmented Dickey-Fuller Test

The null hypothesis in the ADF test is a unit root. Six variables are tested for unit roots: real money balances calculated as M1 divided by the GDP deflator, real GDP, the interest rate variable, revenues from net foreign assets as a percentage of GDP, productivity differentials and terms of trade. Table 1 shows the detailed results.

Considering real money balances, real GDP, interest rate, revenues from net foreign assets and relative tradable-nontradable productivity, the ADF test in levels does not allow to reject the null hypothesis of unit roots, but it can be rejected at 1% in first differences. This means that all these variables are integrated of order one $I(1)$. With terms of trade, the hypothesis of unit roots can be rejected at 1% in levels and in first differences. Then, within the period, terms of trade is a stationary variable.

Table 1: Augmented Dickey-Fuller Test

Variable	Structure	Lags	t-statistics
ln M/P	Level	0	-2.135262
	1 diff	0	-7.57809**
ln Y	Level	0	3.200970
	1 diff	Intercept	1
Ln $i/(1+i)$	Level	0	-0.687532
	1 diff	0	-6.97760**
rF / Y	Level	1	-1.427606
	1 diff	0	-6.38994**
Ln A_T/A_N	Level	0	-0.887844
	1 diff	0	-10.6569**
Ln P_T^X/P_T^M	Level	0	-2.60001**
	1 diff	0	-9.72321**

* denotes significance at 5%

** denotes significance at 1%

V.2. Cointegration Test

One of the most critical aspects of Johansen's approach is to determine the rank of $\alpha\beta'$, since it essentially depends on the model to be clearly specified. The optimum lag structure (represented by the k value) is chosen according to the Schwartz information criterion $k=1$. The Johansen test with two statistics, λ trace and λ max, was used for the analysis of the cointegrating vectors. The statistics were built using the eigenvalues of the matrix $\alpha\beta'$ from [24], following the hypotheses of the number of cointegrating equations. If there is at least one cointegrating vector among the variables, the model by means of [24] can, then, be estimated. Table 2 summarizes the results.

Table 2: Johansen Test

Number of coint. eq.	Eigen- value	λ trace Statistics	Critical Values		Signif	λ max Statistics	Critical Values		Signif
			5%	1%			5%	1%	
None	0.497983	120.2946	94.15	103.18	**	48.92765	39.37	45.10	*
At most 1	0.352947	71.36695	68.52	76.07	*	30.90820	33.46	38.77	
At most 2	0.255645	40.45874	47.21	54.46		20.96184	27.07	32.24	
At most 3	0.178812	19.49690	29.68	35.65		13.98723	20.97	25.52	
At most 4	0.073635	5.509670	15.41	20.04		5.430564	14.07	18.63	

*(**) denotes significance at 5%(1%)

Trace test indicates 2 cointegrating equations at the 5% level and 1 cointegrating equation at the 1% level. Max-eigenvalue test indicates 1 cointegrating equation at both 5% and 1% levels.

The normalized equation is obtained from reduced forms, and may represent money demand, money supply, or some more complicated interaction (Johansen and Juselius 1990). If we consider the 1% level, only one cointegrating vector exists, and the normalized equation appears to be (taking into account the signs of the coefficients) a money demand function.

Table 3: Coefficients of the cointegrating vector β

Variable	Coefficient	t-statistics	Significance
Ln M/P	1.000000		
Ln Y	-0.909921	-7.54201	**
Ln $i/(1+i)$	0.357106	6.04398	**
rF / Y	-90.08256	-6.40233	**
Ln A_T/A_N	-1.028035	-3.72595	**
Ln P_T^X/P_T^M	-0.517970	-2.10597	*
C	0.029689		

*(**) denotes significance at 5%(1%)

Table 3 shows the cointegrating vector, note that all coefficients have the expected signs and that values are significantly different from zero.

Substituting the values of table 3 into equation [22] we obtain the money demand equation

$$\ln\left(\frac{M}{P}\right)_t = -0.03 + 0.91 \ln Y_t - 0.36 \ln\left(\frac{i}{1+i}\right)_t + 90.1 \left(\frac{rF}{Y}\right)_t + 1.03 \ln\left(\frac{A_T}{A_N}\right)_t + 0.52 \ln\left(\frac{P_T^X}{P_T^M}\right)_t + u_t \quad (24)$$

The real GDP, the interest rate, the relative productivities and the terms of trade coefficients are elasticities, and the net foreign assets revenue coefficient is a semi-elasticity. The GDP elasticity of money demand (0.91) is in line with results surveyed by Sriram (2001) who report a mean of 0.98 and a median of 0.89 taking account the long-run income elasticities of 21 country studies.

The interest elasticity of money demand is -0.36, using the same definition of money and a demand function based on consumption and interest rates Chari, Kehoe, and McGrattan (2000) find for the United States a similar value (-0.39).

The semi-elasticity of net foreign assets revenues is very high implying that money demand is vulnerable to external shocks (current account deficit and international interest rates shocks). The relative tradable-nontradable productivity differential elasticity is also high. The terms of trade elasticity of money demand is 0.52. All in all, it seems that foreign sector related elasticities of money demand can explain Argentina's real money balances volatility.

V.3. Restriction over coefficients

The theoretical model implies $\beta_5 = \beta_7$, Table 4 shows the exercise. The test gives a Chi-square(1) value of 1.115157, Probability 0.290964, and we cannot reject that both elasticities are 0.7.

Table 4: Coefficients of the restricted cointeg vector

Variable	Coefficient	t-statistics	Significance
Ln M/P	1.000000		
Ln Y	-0.891844	-8.15915	**
Ln $i/(1+i)$	0.273658	7.96637	**
rF / Y	-79.06536	-7.63059	**
Ln A_T/A_N	-0.696144	-4.27580	**
Ln P_T^X/P_T^M	-0.696144	-4.27580	**
C	-0.527005		

*(**) denotes significance at 5%(1%)

The theoretical model implies $\beta_5 = \beta_7$ but also $\beta_2 = -\beta_3$, that is GDP elasticity and interest elasticity do not differ in absolute value. Nonetheless, the null hypothesis of this joint restriction is rejected (Chi-square(2): 7.118120, Probability: 0.028466).

After we have already analyzed the demand for money in the long-run, we are going to study the short-run dynamics of the relationship by specifying a vector error-correction model.

V.4. Short-run Dynamics

Table 5 shows in detail the estimated adjustment coefficients (elements of vector α in equation 23). Those corresponding to the $\ln(M/P)$, $\ln Y$, $\ln(i/(1+i))$ and $\ln(P_T^X/P_T^M)$ variables are significant. Thus, an excess money supply generates an increase in domestic prices and a reduction in real money supply, a reduction in gross domestic product (because of less work effort), an increase in nominal interest rate (because of expected inflation) and a reduction in terms of trade. That is to say, gross domestic product and interest rate are not exogenous variables. The movement in GDP and in interest rate magnify the imbalance on monetary market, but the reductions in M/P allow to offset gradually the gap.

Table 5: Adjustment coefficients α

Variable	Coefficient	t-statistics	Significance
Ln M/P	-0.366551	-4.52460	**
Ln Y	-0.071199	-2.29739	*
Ln $i/(1+i)$	0.402677	2.15294	*
rF / Y	0.000752	0.91588	
Ln A_T/A_N	0.039644	1.57940	
Ln P^X_T/P^M_T	-0.130647	-2.05933	*

*(**) denotes significance at 5%(1%)

Table 6 shows the results of testing the restriction for $\alpha_k = 0$. It can be inferred from the last row (the test for $\alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_7 = 0$) that in Argentina, the money demand fundamentals are not weakly exogenous. There exists a feedback relationship. Therefore, the use of the single-equation approach applied many times in the literature turns out to be impossible, the only way to estimate money demand is through Johansen methodology, which estimates the joint system.

Table 6: Testing for weak exogeneity

Variable	χ^2	DF	Significance
$\alpha_2 = 0$	5.421867	1	*
$\alpha_3 = 0$	2.893524	1	
$\alpha_4 = 0$	0.661588	1	
$\alpha_5 = 0$	2.034344	1	
$\alpha_7 = 0$	3.919965	1	*
Joint	19.23181	5	**

*(**) denotes significance at 5%(1%)

By analyzing the speed of adjustment (ϕ) towards the equilibrium, we may note that the rate at which the disequilibrium converges can be approximated by:

$$\phi = \beta_1\alpha_1 + \beta_2\alpha_2 + \beta_3\alpha_3 + \beta_4\alpha_4 + \beta_5\alpha_5 + \beta_7\alpha_7 < 0$$

But, $\alpha_4 = \alpha_5 = 0$, then: $\phi = \beta_1\alpha_1 + \beta_2\alpha_2 + \beta_3\alpha_3 + \beta_7\alpha_7$

$$\phi = 1 * (-0.37) - 0.91 * (-0.07) + 0.36 * 0.40 - 0.52 * (-0.13) = -0.149$$

Disequilibrium is reduced every year in 15%.

V.5. Money Demand and Shocks

Figures 3 to 5 show the simulated responses to different shocks with their respective 66% confidence bounds. These bounds were constructed following the bootstrap methodology developed in Hamilton (1994). The impulse response function of figure 3 shows the effects over money demand of a negative shock (-9%) in terms of trade, (similar to the mean of year-to-year change in terms of trade in the sample).

Figure 3

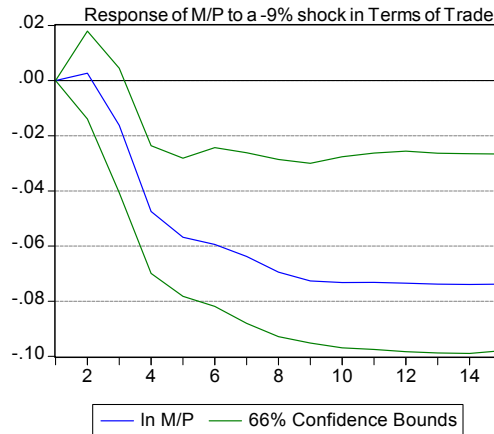
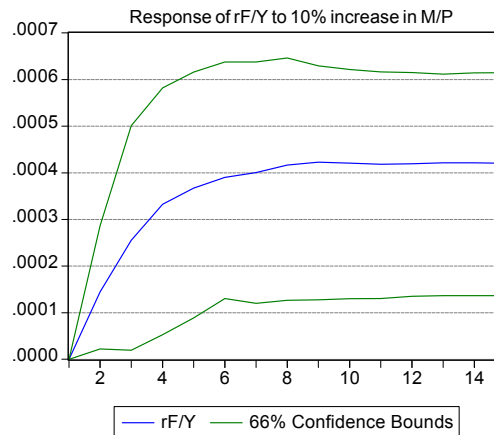


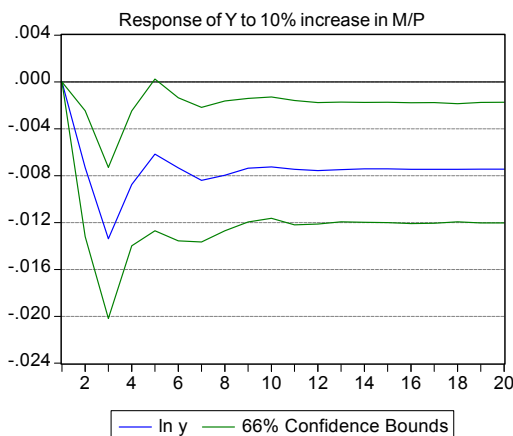
Figure 4 shows how currency substitution works, a 10% expansion in real money by the Central Bank induces an increase in revenues from net foreign assets. Agents avoid inflation tax and capital losses accumulating net foreign assets.

Figure 4



Finally, the impulse response function (Figure 5) shows that an expansive monetary policy which increases the money supply above the equilibrium level produces a negative impact over the domestic product. The optimizing behavior of the household guarantees that the ratio of the marginal utility of money to the marginal utility of consumption equals $i/1+i$. Any additional money holdings generates disutility. To restore equilibrium, the household increases net foreign assets holdings and reduces work effort, therefore GDP declines.

Figure 5



VI. Conclusions

The major advantage of the error-correction-modeling developed in the late 80s and during the 90s is that the economic theory is allowed to specify the long-run equilibrium while the short-run dynamics is defined by the data. But if theory remains in a closed-economy framework, estimations of money demand yield, in general, poor results. Traditional analysis of money demand fundamentals based on income and interest rates are not useful for an emerging market like Argentina where agents substitute foreign assets for domestic money to avoid external and/or domestic shocks. In this paper we develop a theoretical framework to tackle these problems. After specifying an open-economy model that is explicitly based on the optimizing behavior of the households and that captures the main features of the Argentine economy, we obtain a long-run money demand equation. The long-run behavior of the money demand can be explained by domestic product, interest rate, net foreign assets revenues, relative productivity differential and terms of trade. Applying the Johansen cointegration estimation methodology we find a stable relationship for the demand for money. The long-run GDP-elasticity and the interest-elasticity are similar to those of developed countries but in Argentina net foreign assets revenues, productivity differential and terms of trade elasticities cannot be omitted. It seems that net foreign assets revenues, relative tradable productivity and the terms of trade elasticities are the main factors explaining the volatility of money demand. This structural feature of the Argentine economy contributes to the country macroeconomic instability and may difficult the fine tuning of the monetary policy. The finding of a GDP-elasticity below one (0.91) means that in order to achieve price stability, monetary authorities must increase money stock slower than the increase in output. We also find evidence that given a steady-state equilibrium in money market, an expansive monetary policy turns into an accumulation of external assets (revenues from net foreign assets increases) and a reduction in the level of GDP.

In general terms, we think that the theoretical finding of the paper gives a clue to solve many of the money demand estimation puzzles cited in the literature⁷. For example, fixing up the money demand equation probably allows to solve the missing money puzzle of the United States economy of the mid 70s. The sharp deterioration in conventional estimates of money demand in United States after 1974 can presumably be explained by deterioration in terms of trade after the oil shock.

The body of international empirical evidence on money demand estimates indicates, in many cases, the existence of structural breaks, like changes in the intercepts requiring ad hoc rationalizations (e.g. dummy variables). In our view the apparent instability of long-run money demand equations can be explained by permanent terms of trade shocks (including tariffs shocks), government bond yield shocks and sectoral productivity shocks, which were omitted in previous studies. So that, changes in omitted variables over time, would show up as changes in the intercepts.

The three new fundamentals of money demand we have found, also allow to reconsider the rejection of homogeneity with respect to the price level observed in many studies, which is a sign of misspecification and another frequent money demand puzzle. All in all, the paper makes a contribution for abandoning the traditional and limiting closed-economy specification of money demand.

Finally, we hope the use we have made of the Redux Model satisfies the authors instead of falling in the warnings they have pointed at: "Beware of articles that claim to have found the "right" way to model money. The literature is strewn with inflated claims that subsequently prove ill-founded."⁸

⁷ see Goldfeld and Sichel (1990).

⁸ Obstfeld and Rogoff (1996), p.530

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Appendix 1: The Relative Price of Nontradables

In the steady-state the domestic country budget constraint becomes

$$PC = P_T rF + P_N y_N + P_T \bar{y}_T \quad (25)$$

This implies that consumption equals income (output of non-tradable goods plus endowment of tradable goods, plus income from net foreign assets holdings) in steady state. Total consumption is a composite consumption, hence

$$\begin{aligned} P_T C_T + P_N C_N &= P_T rF + P_N y_N + P_T \bar{y}_T \\ P_T C_T &= P_T rF + P_T \bar{y}_T \end{aligned} \quad (26)$$

The benchmark steady state is characterized by $F_0 = 0$, $y_{N0} = C_{N0}$, $y_{T0} = C_{T0}$ and $y_0 = C_0$. The traded good endowment has been normalized so that the price of non-traded goods in terms of traded goods is the unity, $P_N/P_T=1$. As we are in the steady state, the price index results in $P = P_N = P_T$.

Assume also that the endowment is affected by the terms of trade which can be normalized in the benchmark steady-state to one, $P_X/P_M=1$.

Divide each side of [26] for P_T , introduce the terms of trade, and then approximate the resulting equation around the benchmark steady state, we have

$$\hat{C}_T = r\hat{F} + \hat{y}_T + \hat{P}_T^X - \hat{P}_T^M \quad (27)$$

where $\hat{F} \equiv dF/C_{T0} = dF/\gamma y_0$.

Equation [27] shows how variations of the tradable goods consumption are determined by variations of net foreign assets \hat{F} , tradable output \hat{y}_T and the terms of trade $\hat{P}_T^X - \hat{P}_T^M$.

Assuming that changes on tradable goods supply came from productivity shocks \hat{A}_T , [27] becomes

$$\hat{C}_T = r\hat{F} + \hat{A}_T + \hat{P}_T^X - \hat{P}_T^M \quad (28)$$

Log-linearizing, around the steady state defined by [14] and [15], for consumption [10], we obtain

$$\hat{y}_N = \hat{C}_N = \hat{C}_T - \theta \left(\hat{P}_N - \hat{P}_T \right) \quad (29)$$

From the log-linearized version of equation [12] we can deduce

$$\hat{y}_N = \hat{C}_N = \left(\frac{\sigma - \theta}{\sigma + 1} \right) \gamma \left(\hat{P}_N - \hat{P}_T \right) + \left(\frac{2\sigma}{\sigma + 1} \right) \hat{A}_N \quad (30)$$

Equation [30] expresses the percentage changes on the non-tradable supply around its steady state level. \hat{A}_N represents the impact of productivity shocks of non-tradable goods production.

Combine the results obtained in [28], [29] and [30]. The change in the relative price of non-tradable goods is given by

$$\hat{P}_N - \hat{P}_T = \frac{\sigma + 1}{\theta(\sigma + 1) + \gamma(\sigma - \theta)} \left[r\hat{F} + \hat{A}_T - \frac{2\sigma}{\sigma + 1} \hat{A}_N + \hat{P}_T^X - \hat{P}_T^M \right] \quad (31)$$

Appendix 2: Data Sources and Definitions

Real Money

$$\frac{M}{P}$$

- M: 1932-1938, Comité Nacional de Geografía (1941), *Anuario Geográfico Argentino*.
1939-1959, Banco Central de la República Argentina, *Boletín Estadístico*, several issues.
1969-1990, line 34, Money, International Financial Statistics Database, IMF.
1991-2002, line 34 + demand deposits in dollars.
- P: 1932-1962, BCRA (1976), *Cuentas Nacionales de la República Argentina*, Series históricas, Buenos Aires.
1963-2002, line 99, GDP Deflator, International Financial Statistics, IMF.

Gross Domestic Product

- Y: 1932-1962, Banco Central de la República Argentina (1976), *Cuentas Nacionales de la República Argentina*, Series históricas, volumen III, Buenos Aires.
1963-2002, series W213NGDP_R World Economic Outlook Database.

Interest Rate

$$\frac{i}{1+i}$$

- 1932-1935: Tornquist y Cia. (1932-1938) *Business Conditions in Argentina*, Buenos Aires.
1936-1960: Dagnino Pastore (1964), *Ingreso y Dinero, Argentina 1935-60*, Buenos Aires.
1961-1976: deposit rate, Banco Central de la República Argentina, *Boletín Estadístico*.
1977-2002: line 60L, deposit rate, International Financial Statistics Database, IMF.

Net Foreign Assets Revenues

$$r \frac{F}{Y}$$

- 1932-1969, Net Foreign Assets (F) are defined by $F_t = F_{t-1} + CC_t$. Proceeding backwards since 1970 series is obtained using Current Account (CC) from Balboa, Manuel (1972), *Desarrollo Económico*, "Evolución del Balance de Pagos de la República Argentina 1913-1950"
- 1970-1990, Same methodology since 1991 using Current Account corrected by Rodríguez (1986) to take in account the accumulation of net foreign assets by domestic residents. Rodríguez Carlos (1986), "La Deuda Externa Argentina," *Económica*, XXXII, N°2, La Plata, julio-diciembre.
- 1991-2003, line 79AADZF – line 79LADZF, International Financial Statistics Database, IMF.

To express the net foreign assets in constant values, a tradable USA price index (calculated as current tradable GDP divided by constant tradable GDP) is used.

- r we use a real interest rate deduced from 10-year U.S. Government Bond Yield.
1932-1953: series IGUSA10D, 10-year US Bond Yield, www.globalfindata.com
1954-2002: line 61, Government Bond Yield, International Financial Statistics Database.

Relative Tradable Productivity

$$\frac{A_T}{A_N}$$

The tradable and non-tradable productivities were obtained as the ratio of the sectoral product to its sectoral employment. Taking into account the International Standard Industrial Classification (ISIC) the tradable sector is represented by goods produced in:

- C. Mining and quarrying
- D. Manufacturing

The sectors that produce non-tradable goods are:

- E. Electricity, Gas and Water
- F. Construction
- G. Wholesale and retail trade
- H. Hotels and restaurants
- I. Transport, storage, and communication
- J. Finance intermediation,
- K. Real state and business services
- L. Public Administration and Defense
- M. Education
- N. Health and social services
- O. Other social and personal services and community
- P. Private households with employed persons

Y_T, Y_N : 1932-1969: Banco Central de la República Argentina (1976), *Cuentas Nacionales de la República Argentina*, Series históricas, Buenos Aires.
 1970-1979: Banco Central de la República Argentina (1980). *Cuentas Nacionales a precios de 1970*.
 1980-1992: Ministerio de Economía y Obras y Servicios Públicos (1996), *Cuentas Nacionales, Oferta y Demanda Globales 1980-1995*, Buenos Aires.
 1993-2002: Ministerio de Economía (2004), *Informe Económico N°50*, Buenos Aires. (available at www.mecon.gov.ar)

L_T, L_N : 1932-1939: CEPAL (1958), *El Desarrollo económico de la Argentina*, Santiago de Chile.
 1940-1980: Llach Juan and Sánchez Carlos (1984), "Los determinantes del salario en la Argentina", Estudios, Córdoba.
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Terms of Trade after commercial policy

$$\frac{P_T^X(1-t_x)}{P_T^M(1+t_m)}$$

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