# FIGHTING INFLATION IN ARGENTINA: THE CRISIS OF 1982:
## A SD version of a small monetary model, Cagan's fashion.

**Juan C. Rego**
**Fellow**
**Nat. Council of Science & Tech. Research**
**Pedro Goyena 2561**
**(1640) Martinez**
**Buenos Aires**
**Argentina**

## Abstract

Periodically, at different times of its history, the Argentine economy has been dominated by a vicious circle, well known among developing countries. The Central Bank pays interest on money and such interest is financed through emission of more money thus, causing inflation. In one of these periods: the corresponding to February 1981-July 1982, the accumulated inflation increased to 250 per cent. In 1982, the government decided to reduce the interest rate abruptly, in order to achieve a quick reduction of the inflation rate. However, the year 1982 witnessed the failure of the application of this financial reform. Although the growth rate of liquid assets declined, the inflation rate for July 1982 duplicated the previous month rate. This article reformulates a small economic model, in the Cagan tradition, due to Rodriguez (1986). It was conceived to explain the historic dynamics of the financial indicators, after the reform. Hopefully, the readability of the model should improve, when compared with the original version. And, instead of attributing the dynamics globally to the complex behavior of the system, the paper identifies the causes of this dynamics throughout the causal structure that produced it.

## I. Introduction

In the first place, the article presents the System Dynamics model. Secondly, the simulation runs, proposed by Rodriguez, are reproduced in order to guarantee a right SD translation of the original model. Finally, a causal tracing is carried out, taking advantage of what Vensim software offers for an effective causal assignment. Thus, the action of successive links, throughout the causal network, becomes more evident.

## II. The System Dynamics model

Regular practice in System Dynamics requires to start with the identification of the control's mechanism of the system. Therefore, it would be reasonable to assume the presence of a negative or balancing loop. Its function would be to maintain the stock of real money at the level demanded by people. Figure 1 shows this structure.

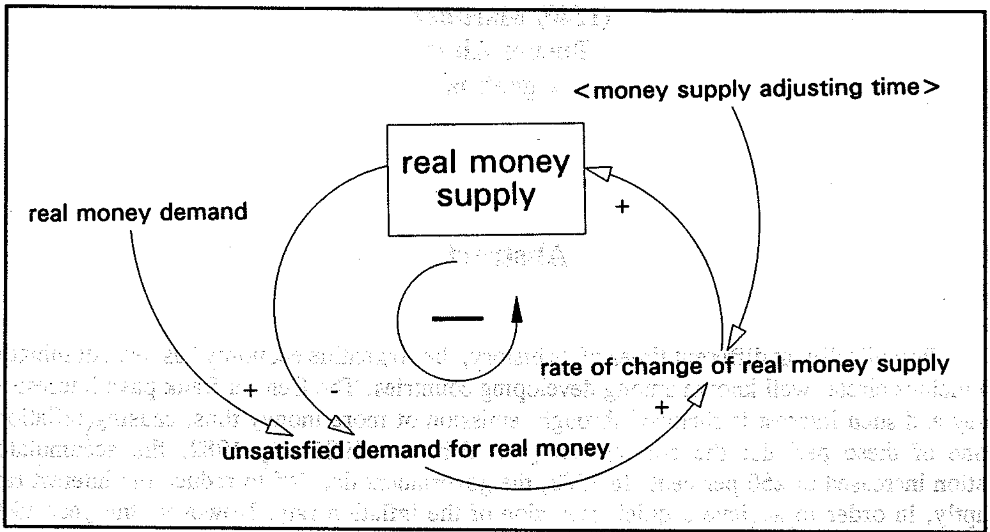


**Figure 1: Real Money Supply's Control Loop.**

The loop appearing in figure 1 is the starting point for the definition of the System Dynamics model. Out of figure 1 immediately emerges the convenience of the definition of a stock that accumulates the real monetary balances. Given a nominal money supply *M*, and the price level *P*, the real money m refers to the ratio $m=M/P$. The equation 1 illustrates the state equation that accumulates the mentioned stock. Its initial value represents an economy with a monetization level about 15 percent.

$$m=\frac{M}{P}=0.15+\int_0^T \dot{m}\, dt \tag{1}$$

The rate of change of real money stock is proportional to the difference between real money demand and supply. The latter were previously defined, in equation 1. The adjustment time of the stock, $T_m$, reflects the speed of the correction. This simple rule establishes the first differential equation of the system, represented in equation 2. In Systems Dynamics terminology such a decision rule represents the regulating valve for incoming flow to the stock.

$$\dot{m} = \frac{dm}{dt} = \frac{\{m^d - m\}}{T_m} = \frac{\{m^d - m\}}{2.5\ (month)} \qquad (2)$$

Before advancing onto the inflationary effects of monetary expansion, related with equation 2, let us recall some elementary accounting of inflation. Taking logarithms to both sides of the equality $m=M/P$, results $ln(m)=ln(M)-ln(P)$. Then, derivatives are taken to both sides of the new equality and after the introduction of nominal monetary expansion $\mu$ and rate of inflation $\pi$ concepts, the following accounting identity applies:

$$\left\{\frac{1}{m}\frac{dm}{dt}\right\} = \left\{\frac{1}{M}\frac{dM}{dt}\right\} - \left\{\frac{1}{P}\frac{dP}{dt}\right\} = \left\{\frac{\frac{dM}{dt}}{M}\right\} - \left\{\frac{\frac{dP}{dt}}{P}\right\} = \mu - \pi \qquad (3)$$

or simply, real monetary expansion is what remains of nominal monetary expansion $\mu$, after discounting inflation $\pi$:

$$\frac{\dot{m}}{m} = \mu - \pi \qquad (4)$$

Nominal money emission has a dual objective. Traditionally, it is issued to finance the normal deficit of the government, $(d*M)$. This deficit is expressed as a percentage $d$ of the nominal money stock $M$. In Argentina 1982's case, money was also issued to finance the interest $(i*M)$ that was paid on nominal money stock M. In equation 5, $i$ stands for the nominal interest rate, supported by the Central Bank. The emission should finance both items:

$$\frac{dM}{dt} = iM + dM = \{i + d\}M \qquad (5)$$

Solving the nominal monetary expansion $\mu$, in terms of deficit $d$ and nominal rate of interest $i$, equation 6 follows:

$$\frac{\dot{M}}{M} = \mu = \{i + d\} \qquad (6)$$

Factoring out current inflation $\pi$ from equation 4 and taking into account equation 6, the following equation 7 results:

$$\pi = \mu - \left\{\frac{\dot{m}}{m}\right\} = \left\{i + d\right\} - \left\{\frac{\dot{m}}{m}\right\} \qquad (7)$$

The current rate of inflation does not influence people directly. Its delayed version does. To model this effect, an expected rate of inflation $\pi^*$ is defined, as a first order delay, related to what econometricians know as transformation of Koyck. The rate of change of expected inflation (equation 8) is proportional to the difference between the current rate of inflation $\pi$ and the expected rate of inflation $\pi^*$. Correction's speed depends on the time $T_\pi$ that the economic agents require to learn from perception mistakes. Equation 8 is the second differential equation of the system.

$$\dot{\pi}^* = \frac{d(\pi^*)}{dt} = \frac{(\pi - \pi *)}{T_\pi} == \frac{(\pi - \pi *)}{5\ (month)} \qquad (8)$$

Next state variable (equation 9) accumulates the expected inflation. Its initial value is about 17 percent, monthly:

$$\pi^* = 0.17 + \int_0^T \dot{\pi}^* \, dt \qquad (9)$$

The desired degree of real monetary balances depends on the inflation level of economy. A variation of a Cagan function is used for the determination of real money demand $m^d$. As the holding of monetary balances is remunerated by the Central Bank, the money demand can be formulated as a positive function of the opportunity cost of money. This cost is appraised by the difference between the nominal interest rate $i$ that is paid on money and the expected inflation rate, $\pi$ *.

$$m^d = qe^{br} = qe^{b(i-\pi^*)} = 0.2\ e^{4(i-\pi^*)} \qquad (10)$$

The causal structure of the complete model is exhibited in figure 2. There the negative loop already shown in figure 1 appears. This takes charge of keeping the real money stock, at the levels demanded by the public. But figure 2 also displays the consequences of the money stock's alterations. They are extended, though delayed, through two other loops. One of them is positive and the other is negative. Although different, they share most of the causal chain which follows the outline of figure 2. Furthermore, there are two accumulations or stocks of the system, corresponding to the integrations shown in equations 1 and 9. However, they have very different functions within the system. While the delayed inflation passively follows the current inflation, the real money stock is a controlled variable, regarding a goal of the system. Such controlling effect is evident in figure 4 below. Towards the end of the simulation run, money supply comes back to 15 percent, its initial value.

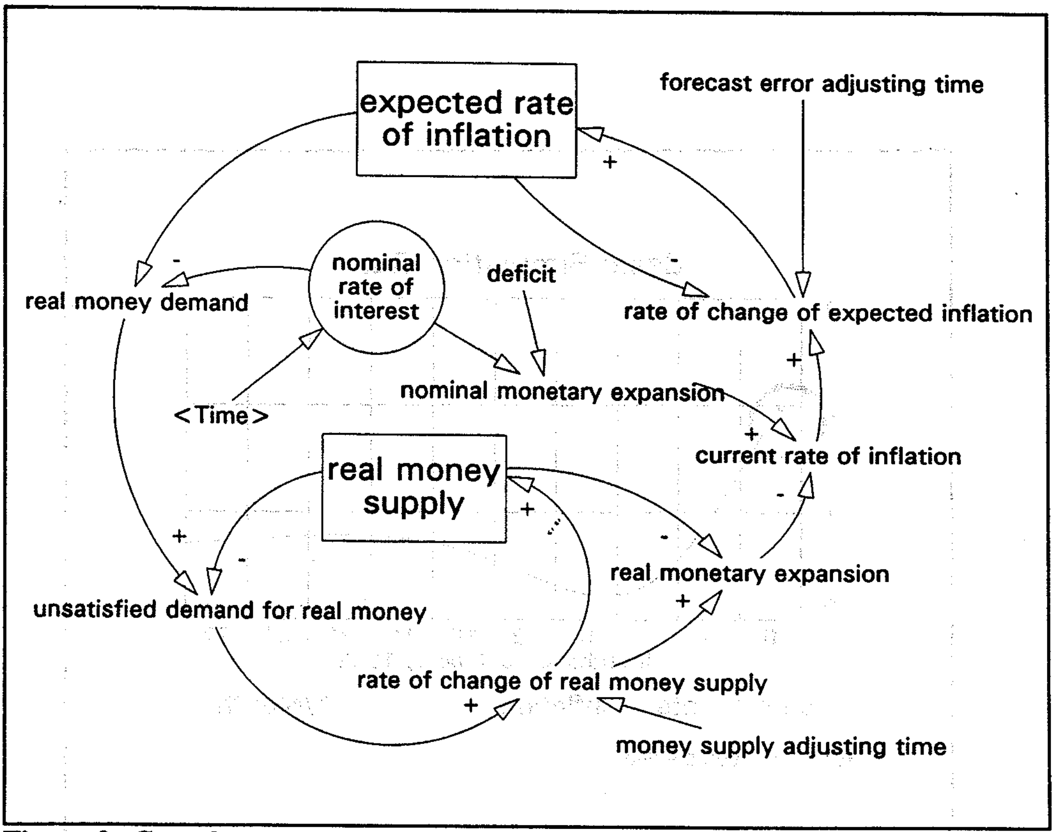


**Figure 2: Causal structure of the complete model.**

## III. Simulation of the Model.

The simulation experiment disturbed the initial equilibrium, around 17 percent of inflation rate, by reducing the exogenous rate of nominal interest rate to zero. Such a level of inflation rate was consistent with a monetization level of about 15 percent. Figure 3 shows the response of the system to the fall of the nominal interest rate. The dynamics exhibit a counter-intuitive behavior. Inflation rate jumps up, reaching at once 20 percent. It takes a complete month to fall back to the initial 17 percent level. After suffering strong oscillations, inflation becomes stationary, almost 20 months later, at a lower 7 percent level. But this time was too long and the government had not the required political strength to achieve the goals of the financial reform. This fact caused a crisis which abruptly ended the reform. Although there are numerical differences, the simulation shown in figure 3 observes a similar dynamics to the one observed in the original experiments carried out by Rodriguez (1986, figure 1). However, neither the overshooting is so high, nor the fall so low. It should be noted that in Rodriguez's paper the inflation was estimated by the increase in the logarithm of the index price. Such a formulation was only an approximation to the real inflation rate.

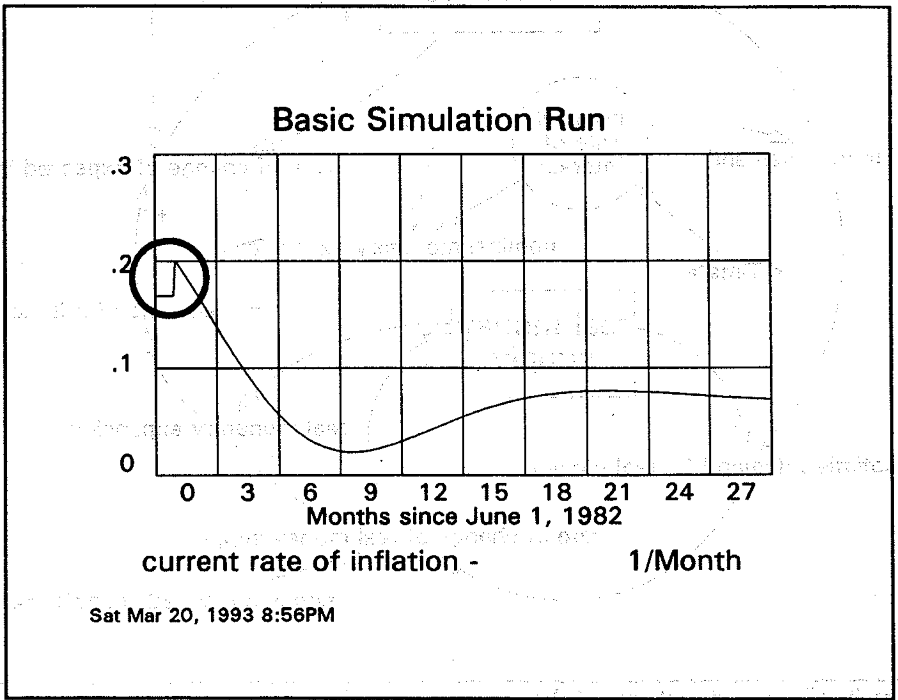

**Figure 3: Inflation's overshooting.**

## IV. Causal Tracing.

Then, the consequences of the exogenous shock throughout the causal network are tracked, using the facilities that the Vensim program offers (Eberlain 1990). The exogenous nominal interest rate acts directly on the rate of nominal monetary expansion (See figure 2). It is an obvious leverage point of the system. But the nominal interest rate also acts on the opportunity cost of money. Of the two possible set points for the tracking of the causality, we chose the one more detached from the variable that presents the undesirable symptoms: the opportunity cost of money. Then, we follow the consequences of the shock trough to inflation rate.

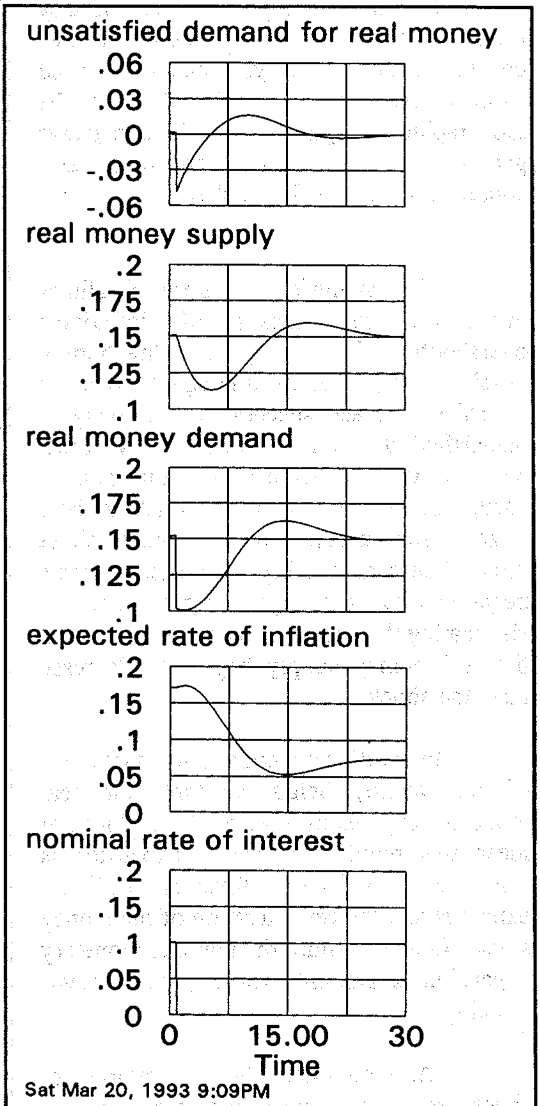


**Figure 4: Variables affecting real money demand.**

Figure 4 represents a set of graphics, produced by Vensim, one on top of another. They represent the dynamics of the variable to explain and its immediate causes. These graphics share the horizontal time axis. Initially in equilibrium, the opportunity cost of money is minus 7 per cent, since money holding earns 10 percent, in an inflationary context around 17 percent. This causes minimal levels of real money demand, about 15 percent.

Of the two causes that affect the opportunity cost of money, the effect of the shock dominates initially. Expected inflation grows slowly, from 17 per cent to 17.7 percent, monthly. The opportunity cost of money collapses below minus 17 percent, reproducing the fall of the nominal interest rate.

Due to the drop of the opportunity cost of money, the demand for money also falls, from 15 percent to 10 percent. It recovers itself slowly, by means of the parsimonious increase of the expected inflation. The latter is a delayed variable. The demand of money, that is, a flow variable, reacts quicker to the exogenous shock than the stock of real money, due to its inertia. Thanks to these differences in speed, unsatisfied demand also follows the dynamics of the previously established demand.

Shrinking supply of real money follows naturally to a contracting money demand, but more gently, as can be expected from an inertial state variable. Therefore the top graphic of figure 4 exhibits a negative gap between money demand and supply as a consequence of the financial reform.

The analysis of figure 5 allows uncovering the causes of inflation's overshooting. Starting again at the bottom graphic of figure 5, we find again the above described fall and successive recovering of unsatisfied demand for real money. Such negative gap determines that the rate of change of real money stock, which initially is zero, should take negative values, about minus 2 percent monthly. The reason for this negative rate of change being the need of eliminating the excess of money supply. And the real money supply begins to decrease after the shock.

In equilibrium conditions, with stock of real money being constant, the real monetary expansion is zero. But it does not mean that nominal monetary expansion is also zero. Inflation finances ordinary expenses and the remuneration of the money stock. In equilibrium, the nominal monetary expansion $\mu$ amounts roughly 17 percent, monthly.

As mentioned, the anti-inflationary shock produces a contraction of real money supply. The level of government expenses is reduced to cover just the deficit, about 7 percent. This reduction in the expenses is not big enough to compensate the contraction of the real money expansion. The savings because of the reform, which amount to approximately 10 percent, are neutralized by the extra 12-13 percent generated by the squeezing of the real monetary expansion. Then, the level of inflation required to support such expenses grows suddenly to the region of 20-21% monthly.

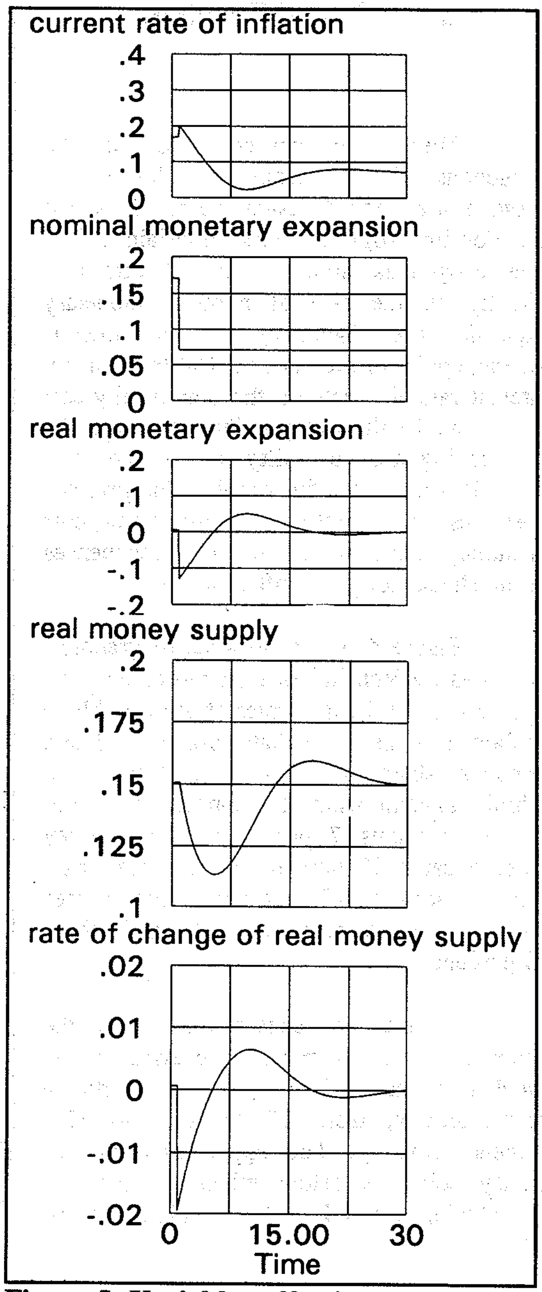


**Figure 5: Variables affecting current rate of inflation.**

## V. Summary.

The purpose of this exercise was to translate a small economic model in homelike terms to SD practitioners, while trying to preserve the original mathematical structure. There were positive and negative loops operating. Negative or balancing loops were responsible of the control of real monetary supply. Time allowed, this could have been achieved, but there was impatience for results. Why the failure of this reform? These negative loops, combined with a positive or reinforcing loop, produced an unexpected amplification of the inflation (counter-intuitive overshooting). The fall of the nominal interest rate and the consequent collapse of the speed of nominal monetary expansion did not compensate the contraction of demand by real monetary balances. And the inflation rate over-reacted. The present reformulation replicates the results of simulations done with the original model and the causal structure of the system has the flavor of an authentic Systems Dynamics model. The "invisible hand" operating on the monetary market found its cybernetic equivalent, in valves and flow terms. A cybernetic model is ruled by its objectives. It is equivalent to what economists call endogenously determined models. In this case, the Cagan's function, in its character of behavioral equation, implicitly contains the target pursued by the system. As it was seen, in figure 4, the system, after the shock, comes back to the initial levels of monetization. The system targets are inserted in the form of Cagan's function. Another form would turn the system to another level of monetization.

## Bibliography

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