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Hyperinflation with Currency Substitution: Introducing an Indexed Currency

SEVERAL COUNTRIES HAVE EXPERIENCED monetary systems in which two currencies issued by the same government serve as legal tender at the same time. The best-known cases are those of the Soviet Union between November 1922 and March 1924 and Hungary immediately after World War II. In the Soviet Union, depreciating Soviet rubles circulated side by side with the stable chervonets. In Hungary, the tax pengö, an indexed currency, was used as a means of payment together with the regular pengö. But the experience with indexed currencies belongs not only to history. Between August 1990 and April 1991, the new córdoba circulated together with the gold córdoba in Nicaragua. In January 1992, the Ukraine began issuing coupons that circulated along with Soviet rubles.[1]

Similarly, during the 1980s, Latin America experienced the phenomenon of "dollarization" by which U.S. dollars become used for transactions purposes. The process of dollarization is similar to that of introducing an indexed currency, as it also provides an alternative means of transacting. A difference between the establishment of indexed currencies and dollarization still remains in that the process of dollarization entails the need to run current account surpluses in order to "purchase" the stock of monetary balances.

Usually, in the dual currencies experiences, one of the two currencies maintains a stable purchasing power, while the other depreciates very quickly. The conventional

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1. Other examples are the issues of private money during the German hyperinflation, which seems to have amounted to about six times the official money supply (Keller 1958), and the issue of provincial currency in Argentina in the 1980s.

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wisdom is that it is the introduction of a stable currency that accelerates the rate of depreciation of the original one.[2] The argument is that by introducing a second currency the demand for the old money decreases. The ensuing excess supply increases inflation.

This paper challenges this interpretation on both theoretical and empirical grounds. First, we develop a theoretical model in which the inflation rate is a bubble on the price level. The basic framework follows previous work by Sidrauski (1967) on models of money in the utility function and Obstfeld and Rogoff (1983) for its extension to hyperinflations. We show that if an alternative monetary asset is introduced, the rate at which inflation accelerates declines. Although initially the rate of inflation may increase or decrease, depending upon how strong a decline in monetary balances is induced by the currency substitution process, the rate of inflation along the hyperinflation path will eventually be smaller than without currency substitution.

We then test the prediction of the model for two historical episodes. First, we consider the case of the introduction of an indexed currency in the Soviet Union in the 1920s. Second, we discuss the case of dollarization in the Argentine hyperinflations of 1989 and 1990. Both experiences are shown to be consistent with the model.

The paper is organized as follows. Section 1 describes the basic Obstfeld-Rogoff framework. Section 2 derives the appropriate properties of a utility function that includes two monies in its argument. Section 3 presents a model with two fiat currencies. Section 4 discusses the empirical testing of the model. Finally, section 5 contains some policy and welfare implications.

1. THE BASIC FRAMEWORK

Consider the Sidrauski (1967) model with no capital; the problem is

$$\text{Max } V = \int_0^\infty u(c_t, m_t)e^{-\delta t}dt \ , \tag{1}$$

subject to

$$c_t + \frac{dm_t}{dt} = y - \pi_t m_t + x_t \ , \tag{2}$$

where c_t is the agent's consumption in period t, m_t is his holding of real monetary balances, y is the agent's fixed endowment, π_t is the inflation rate, and x_t is government transfers. The first-order conditions for this problem are

2. To see this approach applied to the Hungarian experience, see Bomberger and Makinen (1980 and 1983), Kaldor (1946a and 1946b), and Nogaro (1948). See also Siklos (1989) and for a recent study introducing weekly data Siklos (1991).

$$u_c(c, m) = \lambda \,, \tag{3}$$

$$\frac{d\lambda/dt}{\lambda} = \delta + \pi - u_m(c, m)/\lambda \,, \tag{4}$$

$$\lim_{t \to \infty} \lambda e^{-\delta t} m_t = 0 \,, \tag{5}$$

where we have dropped the time subscripts for convenience. Furthermore, we have

$$\dot{m}/m = \sigma - \pi \tag{6}$$

and

$$x = \sigma m \,, \tag{7}$$

where σ is the rate of growth of the nominal stock of money.

Substitute equations (6) and (7) into (2) to obtain the equilibrium level of consumption, $c_t = y$. If we assume that the utility function is separable in consumption and real money balances, the fact that $c_t = y$ (where y is constant) implies that the marginal utility of consumption must be constant, or that $\dot{\lambda} = 0$. We can therefore normalize c such that $\lambda = u_c = 1$. Equation (4) then becomes

$$u_m(m) = \delta + \pi \,. \tag{8}$$

So, substituting (6) into (8) gives

$$\dot{m} = (\delta + \sigma)m - u_m(m)m \,. \tag{9}$$

Equation (9) is a differential equation in m. As the derivative with respect to m near the steady state $(-u_{mm}m)$ is positive, the equation is unstable. This ties down the price level by determining a unique steady-state level of real money balances. But the steady state is not the unique equilibrium. Obstfeld and Rogoff (1983) have shown that in this model, while hyperdeflations can be ruled out (because they violate the transversality condition), the same is not true of hyperinflations. As long as

$$\lim_{m \to 0} m u_m(m) = 0, \tag{10}$$

a rational hyperinflation may take place even with constant nominal money growth.

Figure 1 shows the dynamics of equation (9). The full line corresponds to the case in which condition (10) is satisfied. A is the steady state. At A, $u_m = \delta + \sigma = \delta + \pi$, which is the traditional money demand function obtained in these models. The hyperdeflationary solutions are located to the right of the steady state and generate an unbounded growth of real monetary balances.

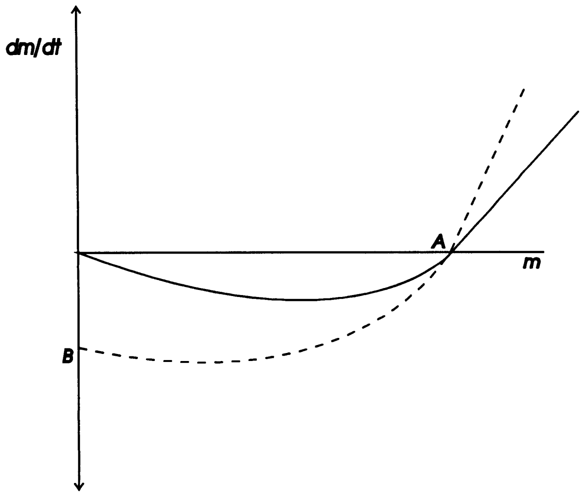

FIG. 1. Monetary Dynamics in the Obstfeld-Rogoff Model

The solutions to the left of the steady state generate a fall in real money and therefore correspond to hyperinflationary paths. Given that for these paths, $\dot{m} = 0$ when $m = 0$, the origin is an alternative steady state and corresponds to a nonmonetary equilibrium.

Alternatively, we have

$$\lim_{m \to 0} m u_m(m) > 0, \tag{11}$$

This case is represented by the dashed line in Figure 1. A is still a steady state, and the hyperinflationary paths are still to the left of A. But now, on the hyperinflationary solution path the economy eventually reaches point B, at which point money holdings become negative ($\dot{m} < 0$). These paths are infeasible, and therefore can be ruled out.

It is interesting to note that the assumption that eliminates hyperinflations implies that money has to be essential, in the sense that its marginal utility must increase faster than the rate at which money balances converge to zero. In particular $u_m \to \infty$ is a necessary condition to rule out hyperinflations. This condition is likely to be false when alternative currencies are available, making it more difficult to rule out hyperinflations in those settings.

2. THE PROPERTIES OF THE UTILITY FUNCTION

To extend the previous setup to one in which currency substitution occurs, it is important to characterize the proper utility function to be used. This is particularly important because we know that the results depend critically on the assumptions on the cross-partial derivatives between the two monetary assets. Liviatan (1981), for example, showed that using traditional utility functions with positive cross-partials, that is, in which $u_{m_1m_2} > 0$, generated counter-intuitive responses of money demand to changes in the inflation rate.[3]

The consensus in the literature is that the appropriate utility function should be characterized by negative cross partials (that is, $u_{m_1m_2} < 0$). In this paper, we derive such a utility function explicitly from a Baumol-Tobin-Barro transactions model.

The Baumol-Tobin-Barro setup starts by postulating a model in which individuals require monetary holdings to purchase a constant flow of consumption, c. If agents run short of currency, they must incur a cost in order to obtain additional monetary balances. These costs are usually associated with the costs of going to the bank or the costs associated with converting illiquid assets into currency. Holding currency, in turn, entails a loss in terms of foregone interest. To reduce the amount of money held, individuals have to increase the number of conversions from indexed assets to currency.

In our model we add to the above setup the option of committing a certain amount of assets to be held as foreign or indexed currency. This renders the interest rate and the liquidity services at the same time but entails a cost associated with transacting through this more sophisticated transactions mechanism. For simplicity we will assume that the agent commits to use a certain amount of indexed currency (m_2) each time he obtains domestic currency (m_1) and that the costs associated with using this indexed currency are quadratic in m_2.[4] The agent minimizes transactions costs, L, equal to

$$L = m_1 i + N(k_1 + k_2 m_2^2) \ , \tag{12}$$

where N is the number of conversions or trips to the bank and k_1 and k_2 are constants that determine the real cost of both kind of transactions. i is the nominal interest rate. Total liquidity costs are equal to the foregone interest on domestic currency holdings plus transactions costs that equal the cost of "going to the bank" plus the cost of operating through sophisticated financial instruments. Minimization of (12) with respect to N and m_2 gives the demand functions for both currencies. Average domestic monetary holding will equal

$$m_1 = \frac{c - Nm_2}{2N} ; \tag{13}$$

3. Possible solutions were suggested by Calvo (1985) and Engel (1989).

4. The setup could be thought as one in which agents obtain both domestic and indexed (foreign) currency at the bank and where there is a fee on currency conversions or where transacting in the indexed currency is more costly. This could arise, for example, due to indivisibilities or illegality constraints (Sturzenegger 1991). The assumption of a quadratic cost is imposed only for simplicity as the argument holds for any convex cost function.

or equivalently,

$$N = \frac{c}{2m_1 + m_2} . \tag{14}$$

Feenstra (1986) showed that if we define c^* as "gross consumption," that is, as including "net consumption" (c) and transactions costs, there is an equivalence between the problem (1)–(2) defined over c^* and an analogous intertemporal maximization problem in which the agent maximizes a utility function that depends only on c, subject to a budget constraint containing liquidity or transaction costs. Our objective is to characterize the corresponding utility function that makes two problems analogous.

From the definition of c^*, we have that

$$c^* = c + N(k_1 + k_2 m_2^2) . \tag{15}$$

The appropriate money in the utility function must satisfy $V(c^*, m_1, m_2) = u(c)$, where $u(c)$ is the original utility function of the liquidity cost problem. Substituting for N from (14), we obtain

$$V(c^*, m_1, m_2) = u\left(\frac{c^*}{1 + \frac{k_1}{2m_1 + m_2} + \frac{k_2 m_2^2}{2m_1 + m_2}}\right) . \tag{16}$$

In particular, if $u(c) = \log(c)$, then the utility function takes the form

$$V(c^*, m_1, m_2) = \log(c^*) - \log\left[1 + \frac{k_1}{2m_1 + m_2} + \frac{k_2 m_2^2}{2m_1 + m_2}\right], \tag{17}$$

that is, the utility function is *separable* in both consumption and liquidity services.

For V to be well defined, we require that $V_i > 0$ and that $V_{ii} < 0$, where $i = \{c, m_1, m_2\}$. The two conditions are obviously satisfied for c^* and m_1, as can be seen by simple differentiation of (17). For m_2, we obtain

$$\frac{\partial V}{\partial m_2} = \frac{1}{2m_1 + m_2} - \frac{1 + 2k_2 m_2}{2m_1 + m_2 + k_1 + k_2 m_2^2} > 0 , \tag{18}$$

which will be positive for k_2 small enough. Equation (18) states that the marginal benefit from holding indexed currency, which is given by the savings of transactions costs, must exceed the marginal costs incurred by using more of this currency.[5]

The cross-partial derivative equals

5. The second-order derivatives are again negative for c^* and m_1 and for m_2 for small enough k_2.

$$-\frac{\partial V}{\partial m_1 \partial m_2} = \frac{1}{(2m_1 + m_2)^2} - \frac{1 + 2k_2 m_2}{(2m_1 + m_2 + k_1 + k_2 m_2^2)^2}. \tag{19}$$

It is easy to show that if (18) is satisfied, the right-hand side of (19) will also be positive. To see this, multiply (18) by $(2m_1 + m_2 + k_1 + k_2 m_2^2)^{-1}$ and notice that the resulting expression is positive and smaller than the right-hand side of (19). This proves that under the necessary conditions for (17) to be a well-defined utility function, the cross-partials between currencies have to be negative.

In what follows, we work with a utility function that satisfies the properties shown for (17), that is, separability in both consumption and liquidity services and negative cross-partials for both monies.

3. THE TWO FIAT CURRENCY MODEL

Let the representative agent model solve the problem (where again we drop time subscripts when no confusion arises)

$$\text{Max } V = \int_0^\infty [u(c) + l(m_1, m_2)]e^{-\delta t} dt \tag{20}$$

subject to

$$\dot{m}_1 + \dot{m}_2 + \pi_1 m_1 + \pi_2 m_2 + c = y + x_1 + x_2 \ , \tag{21}$$

where the utility function satisfies the properties outlined in section 2.

The agent can accumulate both kinds of monies or consume. His income is a fixed endowment, y, plus government transfers in both monies. The first-order conditions for this problem are

$$u_c = \lambda \ , \tag{22}$$

$$u_{m_1} - \lambda \pi_1 - \mu = 0 \ , \tag{23}$$

$$u_{m_2} - \lambda \pi_2 - \mu = 0 \ , \tag{24}$$

$$-\dot{\lambda} + \delta \lambda = \mu \ , \tag{25}$$

and

$$(m_1 + m_2)\lambda e^{-\delta t} = 0 \ . \tag{26}$$

Also, from the definition of real monetary balances we have that

$$\dot{m}_1 / m_1 = \sigma_1 - \pi_1 \tag{27}$$

and

$$\dot{m}_2/m_2 = \sigma_2 - \pi_2 \; . \tag{28}$$

Substituting (27) and (28) into the budget constraint (and using conditions analogous to (7) for government transfers in each currency) gives $y = c$ as before. We again normalize in such a way that $\lambda = 1$. Substituting (23) and (24) into (27) and (28) gives two differential equations in both real money balances:

$$\dot{m}_1 = (\sigma_1 + \delta - u_{m_1})m_1 \tag{29}$$

and

$$\dot{m}_2 = (\sigma_2 + \delta - u_{m_2})m_2 \; . \tag{30}$$

Equations (29) and (30) describe the evolution of a dynamic system in two variables.[6] Notice that in the steady state, $\sigma_1 = \pi_1$ and $\sigma_2 = \pi_2$ and that therefore the relative money holdings will be a function of the relative nominal interest rates quoted in each currency. Linearizing this system around the steady state generates a dynamic system with two positive eigenvalues.[7]

The system is completely unstable with the unique convergent path being the steady state. In addition if conditions analogous to (10) are satisfied, the economy presents a multiplicity of equilibria, described by the hyperinflation paths converging on the single currency equilibria.

The phase diagram for the linearized system is given in Figure 2.[8] Points A and C represent the one-currency equilibria. Along the branch denoted I, m_1 suffers a hyperinflation. Along II, it is m_2 that asymptotically disappears. As both real monetary balances are jump-variables, the economy can move to any point along these paths and still satisfy the dynamic equations that describe the evolution of the monetary equilibrium.

It is interesting to examine the comparative statics of this model under the assumption that we remain at the steady state without hyperinflation. Suppose a new currency, say m_2 is introduced. This moves the equilibrium from point A to point B. Because the cross-marginal utilities are negative, the introduction of m_2 induces a decrease in the equilibrium holdings of m_1. This is achieved by a jump in the price level of the original currency.

Suppose now that the rate of money growth for m_1 increases. This shifts the $\dot{m}_1 = 0$ locus downward to $\dot{m}_1' = 0$. The final equilibrium entails lower real holdings

6. The slopes of $\dot{m}_1 = 0$ and $\dot{m}_2 = 0$ are given by $-u_{m_1m_2}/u_{m_1m_1}$ and $-u_{m_2m_2}/u_{m_1m_2}$. The concavity of u allows us to determine that the equation for $\dot{m}_2 = 0$ has a higher slope in absolute value.

7. The trace equals $-(m_1u_{m_1m_1} + m_2u_{m_2m_2}) > 0$ indicating the presence of at least one positive root. Furthermore the determinant has the sign of $u_{m_1m_1}\, u_{m_2m_2} - u^2_{m_1m_2}$ which by concavity is assumed to be positive. This indicates that both roots have the same sign, that is, positive.

8. Condition (10) for each currency insures that the curves intersect the corresponding axis.

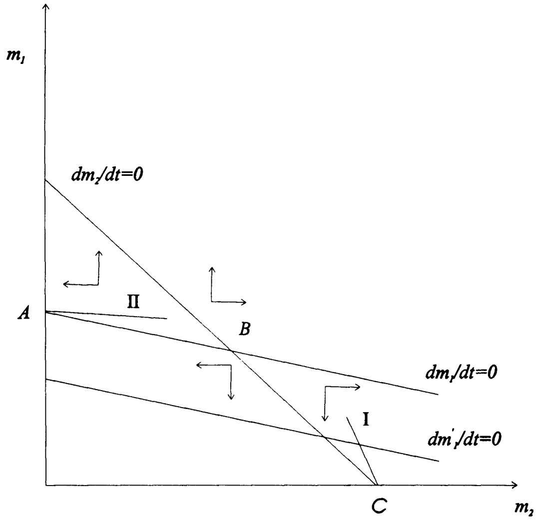

FIG. 2. Monetary Dynamics in the Two Fiat Currency Model

of m_1 and greater holdings of m_2, that is, a price-level jump in terms of the "worsened" currency and a fall of the price level measured in terms of the "new" or more stable one. The relative price-level shift implies lower real holdings of the original money in steady state. Therefore, the steady-state implications of the model are the expected ones and to some extent work as a Gresham's Law in reverse: across steady states, good money displaces bad.

Assume now that while one currency is evolving through a hyperinflationary path, another currency "backed" by the government is introduced.[9] Furthermore, suppose it is m_2 that is backed. We now examine how the introduction of this second currency affects the dynamic process for the initial one. The original currency m_1 will evolve according to

$$\frac{\dot{m}_1}{m_1} = \sigma_1 - \pi_1 = \sigma + \delta - u_{m_1}(m_1, m_2). \tag{31}$$

For the hyperinflationary paths we are considering, (31) is negative, as we are to the left of the steady state and real money holdings approach zero. The rate of the depreciation of real money balances is given by the expression $\sigma + \delta - u_{m_1}(m_1, m_2)$. The effect on the rate of decline of monetary balances, and therefore on inflation, will be given by the net effect on the marginal utility of money. There are two effects at work. On one hand the increase in holdings of m_2 will push the marginal

9. In this context, "backing" means forcing condition (11) to hold in the monetary equilibrium.

utility downward. On the other hand, the fall in the holdings of m_1 will have the opposite effect. We discuss the net effect with the help of Figure 3.

Figure 3 integrates Figures 1 and 2. The outer locus $\dot{m}_1(m_2 = 0) = 0$ is constructed for the case in which $m_2 = 0$ and corresponds to that in Figure 1. Now, consider a point along the hyperinflationary path for currency m_1 once m_2 has been introduced, say, point C. The inner curve for $\dot{m}$ is constructed for the corresponding value of m_2. To know if the inflation rate of the original currency increases or decreases, we need to identify the change in $\dot{m}/m$ upon moving to the new equilibrium point. Along the single currency hyperinflationary solution, money balances for m_1 are bounded below by $\underline{m_1}$, the amount of real money balances corresponding to the new equilibrium, and above by $\bar{m}$, the maximum possible holding of money balances before the introduction of the alternative currency. It can now be seen from Figure 3 that if the initial monetary balances were above m^*, then $\dot{m}/m$ (the slope of the line that starting at the origin goes through a particular point in the $\dot{m}_1 = 0$ curve) increases in absolute value as the economy jumps to point C; therefore from (31) the inflation rate increases as well. Conversely, if initial money balances are below m^*, the rate of inflation falls.

Even though the initial effect on the level of the inflation rate is ambiguous, if the new currency is a substitute for original currency in the sense of section 2, then the rates of inflation required to sustain the hyperinflation path will be lower than before. For the same holdings of domestic currency, currency substitution lowers the marginal utility of money thereby reducing the rate of inflation from (31). In addition, the rate of growth of inflation falls as, along the hyperinflation path (I) de-

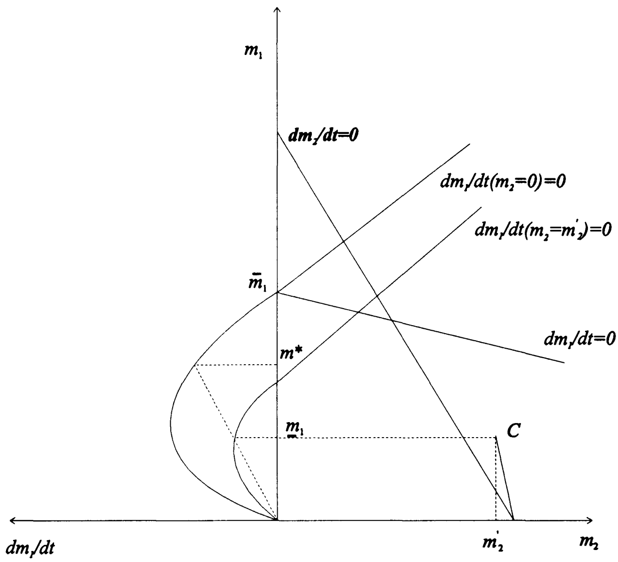

FIG. 3. Effects of a Second Currency on Monetary Dynamics

scribed in Figure 2, the holdings of the indexed currency increase. This reduces the marginal utility of domestic money as compared with an equivalent change in monetary holdings without the possibility of substituting away.

A fall in the rate of increase of the inflation rate due to the introduction of a more "stable" currency and a reduction in the inflation rates experienced during the hyperinflation goes against the conventional wisdom regarding the effects of currency substitution. But, the intuition for this seemingly puzzling result is rather straightforward. Along the hyperinflationary path, people are willing to reduce monetary balances because they expect the inflation rate to increase in the future. If money is "essential" in the sense that its marginal utility is very high, then the inflation rate required to induce people to substitute out of this currency must be very large. If money loses this "essentiality" property—because a very close substitute develops or becomes available—then the inflation rate required to sustain a path with declining real monetary balances falls.

4. EMPIRICAL TESTING

The hypothesis that hyperinflation is a bubble on the price level has been empirically tested by Flood and Garber (1980), Flood, Garber, and Scott (1984), and Casella (1989). The latter two papers were unable to reject the existence of a bubble on the price level.

In this paper we follow Flood and Garber (1980) and test for bubbles for two historical episodes. First, we consider the introduction of the chervonets, an indexed currency, in November 1922 in the Soviet Union. We then consider the two Argentine hyperinflations of May–August 1989 and of December–March 1990. The Argentine experiences present an ideal case study because an intense process of financial adaptation took place in the short time span between the two hyperinflations.

The model discussed in this paper generates three predictions. First, that both monies are substitutes and therefore that the demand for the original currency falls upon introduction of an alternative. Second, that bubbles are important in explaining the hyperinflationary process. Third, that the value of the bubble grows at a smaller rate in the presence of an alternative currency making the bubble eventually smaller. The first prediction of the model derives from the negative cross-partial derivative result obtained in section 2. We tested this by observing whether money demand falls when the new currency is introduced or financial adaptation takes place. The other hypotheses were tested by estimating the value of the bubbles before and after an alternative currency becomes available and testing whether they are statistically significant.

To estimate the value of the bubble, we used a variation of the empirical model developed by Flood and Garber (1980). Their model is a discrete time, partial equilibrium version of the theoretical model considered in this paper which allows for changes in the rate of monetary growth; since the rate of money growth is not constant in the real world, it must be accounted for in the econometric testing.

Specifically, the model consists of a Cagan money demand function of the form

$$m_t - p_t = \gamma + \alpha E_{t-1}(\pi_t) + \epsilon_t \ , \tag{32}$$

where m_t and p_t are the logs of nominal money balances and the price level. As usual, E_{t-1} denotes the expectation conditional on the information available at the beginning of the period. Finally, ϵ_t is a random shock. The money demand semielasticity, α, is negative.

The rational expectations solution of (32) for the inflation rate is

$$E_{t-1}(\pi_t) = A_0 \phi^t - \frac{\phi^{-1}}{\alpha} \sum_{i=0}^{\infty} E_{t-1}(\sigma_{t+i}) \phi^{-i} \ , \tag{33}$$

where $\phi = \dfrac{\alpha - 1}{\alpha} > 1$ and A_0 is an arbitrary constant. The term $A_0\phi^t$ corresponds to the bubble and describes the solution considered in this paper. The second term in (33) represents the fundamentals driving the rate of inflation. The model predicts that with currency substitution, ϕ will be smaller and the bubble will grow at a lower rate. A fall in ϕ takes place upon an increase in the absolute value of α. Both predictions of the model are therefore tied to the behavior of α.

The empirical implementation of the model involved the following steps. First, we tested for the order of integration of the relevant variables: the rate of inflation and the real stock of money. We then computed a money demand function that allows for a change in monetary holdings and a change in the inflation semielasticity at the moment of the introduction of an indexed currency. We follow Taylor (1991) in emphasizing that (32) is a cointegration relation, but instead of relying on OLS we use the Johansen MLE procedure to test the hypothesis of cointegration and to estimate the corresponding cointegrating vector.

Once a consistent estimate of the semielasticity of money demand was obtained, we computed ϕ and estimated the inflation prediction equation (33). As the variables are first-order integrated processes the estimators of this equation are consistent only if there exists a cointegrating vector relating them; but even if this is the case the limiting distribution of the coefficients of the cointegrating vector are nonstandard and skewed to the left (Stock 1987). In order to obtain the consistent estimators of the standard errors, which we need to test the hypothesis that bubbles are a significant component of inflation, we computed Stock and Watson (SW) regressions (Stock and Watson 1989). The SW procedure entails running GLS on the cointegrating equation and adding the backward and forward lags of all the residuals of any cointegrating relationship present between the regressors. Alternatively, OLS on the SW regression with Newey-West corrected standard errors (Newey and West 1987) also give asymptotically correct standard errors. As nominal money growth is an I(1) process, the cointegrating vectors that have to be added to equation (33) are the differences of nominal money growth. This procedure enables us to test the significance of the bubble term and to estimate the value of A_0. Finally, we compute the corresponding bubble for each hyperinflation. Cointegration tests for the SW regressions were implemented through augmented Dickey-Fuller tests (ADF).

Estimation of (32) was carried out by substituting the actual inflation rate for its expected value. This would in general introduce an errors-in-variables problem. In this case, due to the integratedness of the equation, the error term is asymptotically irrelevant (see Engle and Granger 1987).

The Soviet Hyperinflation

The history of Soviet inflation begins with the restriction of convertibility shortly after the beginning of World War I. During the years until 1921, an important fraction of government spending was financed by money issue, even though shortly after the revolution, regulations issued by the People's Commissariat of Finance restricted the circulation of currency in an attempt to construct a money-free economy. As the economy reverted to barter, economic activity collapsed, and real money holdings declined sharply. After 1921, a strong turn in economic policies took place under the "New Economic Policy" program. The NEP accomplished a wide liberalization of the monetary and financial markets. Inflation nevertheless continued unabated. The Soviet government increasingly became convinced of the need to establish a stable currency. Finally, the issue of the chervonet was agreed upon. The state bank was responsible for the issue, but it was required to secure up to no less than one-quarter of the sum issued by precious metals and stable foreign currency. Even though it was not a convertible currency, the value of the chervonet remained stable during 1923, while the Soviet ruble continued to depreciate at an ever increasing rate.

Initially, chervontsi were regarded with distrust but afterward quickly began to replace old Soviet rubles. Finally, in March 1924 the old Soviet ruble was liquidated by being exchanged at fixed parity with the chervonets. When the Soviet rubles were withdrawn from circulation (on March 10, 1924) each new ruble was exchanged for $50,000,000 prerevolutionary rubles.

We first tested for the order of integration of the money demand variables: the stock of real monetary balances and the inflation rate.[10] The ADF_6[11] statistics for real monetary balances and inflation equal -1.16 and -0.27, respectively, which when compared with the critical value of -2.89, does not allow rejection of the hypothesis of first-order integratedness.[12]

Table 1 shows the statistics for the cointegration tests and the corresponding cointegrating vector estimated with the Johansen MLE procedure, where m_t denotes real holdings of Soviet rubles, and π_t is the inflation rate. The dummy D_t takes a

10. Monthly observations for the price level, stock of nominal money and stock of chervontsi was obtained from Cagan (1956), Katzenellenbaum (1925), and Yurovsky (1925).

11. The subscript in the *ADF* coefficient indicates the number of lags used in the computation of the statistic.

12. See Fuller (1976, Table 8.5.2. second panel) for one hundred observations.

TABLE 1

JOHANSEN'S MLE, RUSSIA (VARIABLES: m, π, $D\pi$, $Cher$)

Null	Altern.	Statistic	95% Crit. Val.
$r = 0$	$r = 1$	156.18	28.14
$r \leq 1$	$r = 2$	24.86	22.00
$r \leq 2$	$r = 3$	6.73	15.67
$r \leq 3$	$r = 4$	1.95	9.24
Cointegrating Vector:			
$m_t = 4.11 - .567\pi_t - 1.89D\pi_t + .06Cher_t$			

value of one for periods after January 1923. While chervontsi were officially introduced in late November 1922, they only started to circulate in significant quantities in January 1923. The variable $Cher_t$ measures the real stock of chervontsi in circulation.[13]

As can be seen from the table the test strongly supports the presence of at least one cointegrating vector. The elasticity of money demand—the critical parameter to determine the effects on the bubble—falls, being equal to $-.57$ before the introduction of the indexed currency and -2.46 after the reform.[14]

The consistent estimates of the semielasticities obtained from the cointegrating vector allowed us to compute the value of ϕ. For the pre-chervonet period, $\phi = 2.76$; after the introduction of the chervonets, $\phi = 1.41$. The bubble term grows slower under the indexed currency system than before. In this sense, we obtain that the rate of inflation required to sustain the bubble falls after an indexed currency is incorporated.

We next proceeded to test for the relevance of the bubble, by estimating the appropriate inflation prediction equation (33). Following Flood and Garber (1980), we ran the corresponding SW regression for

$$\pi_t = \delta + \beta_1\sigma_{t-1} \ldots + \beta_k\sigma_{t-k} + A_0\phi^t + A_1\phi^{t*} + u_t \ , \qquad (34)$$

which is appropriate as long as an AR(k) model is sufficient to describe the σ process. The two bubbles have the time variables normalized for comparison. We tested for a bubble (A_0) between August 1922 and November 1922, that is, prior to the introduction of the chervonets, and for a second bubble (A_1) between January 1923 until the redemption of the Soviet rubles in April 1924. The SW regression for (34) gave coefficients equal to 0.0023 for the first bubble and 0.0047 for the second.[15] The corresponding t-statistics are 1.55 and 2.10, respectively.[16] An $ADF_3 = -5.06$

13. The cointegration tests were computed for the period 21:7–24:2. As was described before, this is the period which corresponds to the NEP.

14. The alternative cointegrating vector was disregarded as it implied a positive inflation semielasticity for at least one of the two subperiods.

15. We added to the regression the differences in the rate of money growth for which we could not reject the null of integratedness ($ADF_3 = 1.15$). To construct the SW regression we added current and two forward lags and set $k = 6$.

16. The Newey-West standard errors allowed for six significant covariances, with a dampening factor of .33 in the corresponding window.

accepts the null of cointegration for this SW regression if compared with the Engle and Granger (1987) 5 percent critical value of -3.17.

From this, we conclude that there was no bubble prior to the introduction of the chervonet but that one developed shortly thereafter. Computation of the bubble indicates that it was responsible for about 80 percent of the inflation rate toward the end of the hyperinflation.[17]

The model accounts both for the decline in monetary balances after the introduction of the indexed currency and for the importance of bubbles in accounting for the hyperinflationary process. Unfortunately, a comparison between the two bubbles is not possible for this case as prior to the introduction of the chervonet, there was no bubble; the inflationary process was basically driven by fundamentals.

The Argentine Hyperinflations

Argentina has a long history of inflationary financing. During the 1980s the rate of inflation increased substantially, reaching hyperinflationary levels during the period May–August of 1989. During the hyperinflation, extensive financial adaptation took place, and the degree of dollarization increased substantially. (See Sturzenegger 1991 and Dornbusch, Sturzenegger, and Wolf 1990.) A stabilization program implemented in August 1989 stabilized the economy until December. After mid-December, inflation increased once again and remained high until March.

The two Argentine hyperinflations were the conclusion of decades of excessive reliance on seigniorage to finance government spending. What makes these experiences extremely relevant for the model at hand is the deepening of the financial adaptation process during the first hyperinflation. The second hyperinflation therefore took place with more alternative monetary assets already in place and therefore allows us to test the predictions of the model.

At an informal level, one could argue in favor of the model by noticing that inflation reached 200 percent during the first hyperinflation but only 100 percent during the second, while in both cases, the reduction in real monetary holdings was equivalent.[18] This suggests that the rate of inflation required to reduce monetary holdings decreased substantially in the short time span between the two hyperinflations.

More formally, we first tested for the integratedness of real money and the inflation rate.[19] The ADF_6 statistics for real monetary balances and inflation equal 0.44 and -1.14, which when compared with the critical value of -2.89 do not allow rejection of the hypothesis of integratedness.[20]

Table 2 shows the statistics for the cointegration tests and the corresponding

17. The methodology allows us to test for bubbles for any arbitrary period. If alternative dates are tried for the time span of the bubble, similar results obtain.

18. The trough in the level of real money holdings attained a value of 4.93 for the first hyperinflation and of 4.90 for the second. This level corresponds to a decline of 18 percent from the previous peak for the first hyperinflation and a fall of 15 percent from the previous peak for the second hyperinflation.

19. The data was obtained from *Indicadores de Coyuntura,* FIEL, Bs. As., several issues. The sample includes monthly observations for the period 85:8–90:3.

20. See Fuller (1976, Table 8.5.2. second panel) for one hundred observations.

TABLE 2

JOHANSEN'S MLE, ARGENTINA (VARIABLES: m, π, $D\pi$)

Null	Altern.	Statistic	95% Crit. Val.
$r = 0$	$r = 1$	101.52	22.00
$r \leq 1$	$r = 2$	30.87	15.67
$r \leq 2$	$r = 3$	1.35	9.24
Cointegrating Vector:			
$m_t = 6.46 - 7.00\pi_t - 3.81D\pi_t$			

(money demand) cointegrating vector estimated with the Johansen MLE procedure.[21] In this case m_t denotes real holdings of Argentine australs, and π_t is the inflation rate. The dummy D_t takes a value of one for periods after July 1989, that is, after the end of the first hyperinflation.

The first hypothesis we wanted to test was whether there was a decline in monetary balances after the first hyperinflation. Notice that the semielasticity of money demand equals -7.00 before the introduction of the indexed currency and -10.81 after the reform.

The consistent estimates of the semielasticities allowed to compute the value of ϕ. Before the first hyperinflation, $\phi = 1.14$; after, $\phi = 1.09$. Again, the rate of growth of inflation is smaller under currency substitution.

We estimated (34) the inflation prediction equation, using the same methodology as described in the section on Soviet hyperinflation. We allowed for bubbles between March and July 1989 and between November 1989 and March 1990. Both bubbles appear strongly significant with coefficients (SW adjusted t-statistics) of .44 (4.28) and .53 (13.32) for the first and second hyperinflation, respectively. From the t-statistics we conclude that bubbles are statistically significant components of an explanation of Argentine hyperinflations. An $ADF_3 = -3.55$ supports the null hypothesis of cointegration for this SW regression when compared to -3.17, the 5 percent critical value in Engle and Granger (1987).

Table 3 shows the bubble for the two Argentine hyperinflations. The second bubble is larger initially but grows more slowly because the rate of inflation required to induce people to hold less money is reduced by the process of financial adaptation or dollarization. The second bubble reaches a smaller value than the corresponding one for the first hyperinflation, this is fully consistent with the predictions of the model.

5. CONCLUSIONS

This paper studied the implications of introducing an "indexed" or "backed" currency on the monetary equilibrium of an economy with fiat currency. To analyze this issue, we constructed a model with a utility function with two currencies. We showed that such a utility function will exhibit a negative cross-partial derivative between the two monies. Contrary to the conventional wisdom, we found that along

21. See footnote 14.

TABLE 3

Bubbles in the Argentine Hyperinflations

Period	t_0	$t_0 + 1$	$t_0 + 2$	$t_0 + 3$	$t_0 + 4$
Bubble No. 1	50%	57%	65%	74%	84%
Bubble No. 2	58%	63%	69%	75%	82%

Bubble1: $t_0 = 89:3$, Bubble2: $t_0 = 89:11$, inflation per month.

a rational expectations hyperinflationary solution in which both monetary assets are substitutes, the introduction of a backed currency reduces the rate of depreciation of the original money.

For the nonhyperinflation solution, the introduction of an indexed currency induces a process of currency substitution across steady states. Upon introduction of the second currency, a price level jump takes place for the original one, reducing its real value. This substitution effect has been stressed in the previous literature. What this paper shows is that it is incorrect to infer from this that the equilibrium rate of inflation of the original currency should increase in a hyperinflation. In our model, on the contrary, by lowering the marginal utility of the existing currency, the indexed currency reduces the inflation rate required to sustain a path with declining real monetary holdings of the original currency. In the model, with fixed money growth, this will result in a smaller rate of inflation.

If the original currency is experiencing a hyperinflation at the time the new currency is introduced, the shift to the backed currency occurs gradually, and in the long run, the whole system shifts to the better currency. In this model, we obtain a Gresham's Law in reverse: *good money displaces bad.*

The model was then tested empirically for the experiences of Soviet Union during the early 1920s and for Argentina during the late 1980s. The evidence shows an increase in the semielasticity of model demand consistent with the implications of the model. We showed that the bubble grows at a smaller rate when two currencies exist, validating the model's implication that the rate of inflation required to sustain the hyperinflationary equilibrium is smaller under the presence of an alternative currency.

The effects on welfare can be analyzed from the first-order conditions for the agent's maximization problem. The utility of the representative agent is maximized at the point at which the marginal utilities of both currencies equal zero, that is, where $\sigma_1 = \sigma_2 = -\delta$ (at the Friedman rule solution). A hyperinflation equilibrium is extremely costly in terms of welfare because it increases the nominal interest rate, thereby inducing people to save on cash holdings. The introduction of the indexed currency, presumably with a lower σ, improves upon the hyperinflationary equilibrium with one currency by providing an alternate currency that more closely satisfies the Friedman rule. This is not only because it provides a channel by which people can substitute their demand to a currency with a lower "relative price" but also because the rate of inflation of the original currency may actually decrease as well. Contrary to the results of some researchers who have cautioned about the risks of financial adaptation because of its exacerbating inflationary effects [see, for example, De Gregorio (1991) and Dornbusch and Reynoso (1989)], the results of this study wholly support the introduction of an indexed currency.

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