Intertemporal Substitution in a Monetary Framework

Evidence from Chile and Mexico

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The Euler approach seems to work better when money is considered. For both Chile and Mexico the estimates of the intertemporal elasticity of substitution are greater than one.
This paper — a product of the Debt and International Finance Division, International Economics Department — is part of a larger effort in PRE to apply new models of international finance to developing economies. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Sheilah King-Watson, room S8-025, extension 31047 (27 pages).

Arrau estimates a monetary Euler system of a utility-maximizing representative consumer from two inflationary Latin American countries: Chile in the late seventies and Mexico in the early eighties.

The results show that money is necessary to get reasonable parameters of the utility function. For both countries, tests of the overidentifying restrictions are satisfactory at usual levels of significance and estimates for the intertemporal elasticity of substitution are greater than one.

The results indicate that velocity sensitivity to the nominal interest rate is lower for Chile than for Mexico, but this difference could be explained by a model of currency substitution.

...More important, a model of currency substitution may be the appropriate way to explain the monetary puzzle observed in Mexico after the stabilization attempt of late 1987.

...Despite the fact that inflation was sharply (and permanently) reduced, velocity did not go down. The model of currency substitution suggests that a good way to hedge against a discrete devaluation would be to increase liquidity in foreign — not domestic — currency.
Intertemporal Substitution in A Monetary Framework: Evidence from Chile and Mexico

by
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1 Introduction

The failure of the Euler equation approach to explain the joint time series of consumption and asset returns has produced three lines of research.\(^1\) The first extension studies the implications of non-separability between non-durable consumption and other commodities. Neither leisure (Mankiw, Rotemberg and Summers, 1985) nor durable consumption (Bernanke, 1985) can make the trick. In both cases the results confirmed the refusal of the data to fit the restrictions of the model. The second line of research interprets the time series of consumption by isolating a group of individuals who would face liquidity constraints and who would follow the "rule-of-thumb" of consuming their income (Hayashi, 1987; Campbell and Mankiw, 1989). The third and more recent line of research questions the utility specification employed by the previous literature, and proposes a non-expected utility specification which allows to disentangle attitude toward risk from intertemporal substitution (Epstein and Zin, 1989; Farmer, 1990; and Weil, 1990).\(^2\)

Although the last two approaches have not been rejected by the data, we propose an alternative route. Following the spirit of the first approach mentioned above, we maintain the hypothesis that the time series of consumption cannot be

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\(^1\)Hansen and Singleton (1982, 1983) generalize the seminal work by Hall (1978), and fail to explain the joint time series of consumption and returns for the U. S. economy. The only exception is when weighted average stock market returns are used, although the theory is valid for any return series.

\(^2\)Applications to the U.S. data are in Epstein and Zin (1987) and Giovannini and Weil (1990). An application to Mexico is in Arrau and van Wijnbergen (1990).
studied separately from the series of money, at least in inflationary countries. We estimate a pure-consumption model and compare the results to a well known monetary optimizing model—a Sidrauski model—for two inflationary countries: Chile in the late seventies and Mexico in the eighties. The monetary version seems to be considerably better. The usual tests confirm previous monetary estimations which suggest that monetary versions of the representative consumer model seem to fit the data better.³

Section 2 describes the model. In this section we propose a more general monetary specification that the one used in previous studies. The specification includes as a particular case the pure consumption model and the fixed-velocity cash-in-advance model. Section 3 discusses the data and presents the results for the pure consumption case and the monetary case. Section 4 shows the implications for the estimation of the important issue of currency substitution. We show that a model of currency substitution could explain the difference in velocity sensitivity to the nominal interest rate (estimate of the intratemporal elasticity of substitution) between the two countries, and the velocity shift observed in Mexico in early 1988. Section 5 concludes.

³See the portfolio model by Poterba and Rotemberg (1987) for the U.S and the monetary estimation by Eckstein and Leiderman (1989) for the Israeli economy. In a recent related paper, Koenig (1990) shows that once money is properly included in Hall-type tests of the Permanent Income Hypothesis, no variables other than the real interest rate and real balances help to predict changes in consumption. Koenig specification is also consistent with the CES specification used in this paper.
2 The Model

The representative consumer maximizes the expected value of a time separable utility function. The consumer chooses the path of \( \{c_s, B_s, M_s\} \) for \( s = t, \ldots, \infty \), to maximize

\[
E_t U = E_t \frac{1}{1 - 1/\gamma} \sum_{s=t}^{\infty} (1 + \delta)^{-(s-t)} u(c_s, m_s)^{(1-1/\gamma)}
\]  \hspace{1cm} (1)

subject to the flow budget constraint

\[
B_t = (1 + i_{t-1}) B_{t-1} + M_{t-1} - M_t + P_t (y_t - c_t)
\]  \hspace{1cm} (2)

where \( E_t \) is the expected value operator, \( c_t \) consumption, \( B_t \) nominal holdings of bonds, \( M_t \) nominal money balances, \( P_t \) consumption deflator and \( y_t \) is labor income. Consumption and income are assumed to be realized at the instant end-of-period, and the subscript for stocks represents end-of-period. Consequently, \( i_t \) is the nominal return on bonds between end-of-period \( t \) and end of period \( (t+1) \). Finally \( m_t \) is real money balances \( (M/P) \).

After some manipulation, and assuming that \( c_t, M_t \) and \( P_t \) belong to the information set as of period \( t \), the first order conditions can be expressed as

\[
E_t \left[ \frac{\partial U}{\partial c_{t+1}} \frac{P_t (1 + i_t)}{P_{t+1}} - 1 \right] = 0 \]  \hspace{1cm} (3)

\[
E_t \left[ \frac{\partial U}{\partial m_{t+1}} \frac{P_t i_t}{P_{t+1}} - 1 \right] = 0 \]  \hspace{1cm} (4)

Unlike previous empirical applications which use the Cobb-Douglas specification,
we specialize the sub-utility \( u(c_t, m_t) \) as the CES

\[
u_t = \left( c_t^{1-1/\rho} + \alpha m_t^{1-1/\rho} \right)^{1-1/\rho}
\]  

The first order conditions (3)-(4) become

\[
E_t \left[ \frac{1}{1 + \delta} \frac{\Omega_{t+1}}{\Omega_t} \left( \frac{c_{t+1}}{c_t} \right)^{-1/\rho} \frac{P_t(1 + i_t)}{P_{t+1}} - 1 \right] = 0
\]

where \( \Omega_t \) is defined as

\[
\Omega_t = \left( c_t^{1-1/\rho} + \alpha m_t^{1-1/\rho} \right)^{(\rho-\gamma)/\gamma(1-\rho)}
\]

In the next section we estimate the system (6)-(7) to recover the time preference parameter \( \delta \), the intertemporal elasticity of substitution \( \gamma \), the intratemporal elasticity of substitution between consumption and liquidity services \( \rho \) and the intensity parameter \( \alpha \). Before that, we show some interesting particular cases which arise from our CES specification:

a) For \( \alpha = 0 \), the term \( \frac{\Omega_{t+1}}{\Omega_t} \left( \frac{c_{t+1}}{c_t} \right)^{-1/\rho} \) becomes \( \left( \frac{c_{t+1}}{c_t} \right)^{-1/\gamma} \), and therefore the Euler equation (6) becomes

\[
E_t \left[ \frac{1}{1 + \delta} \left( \frac{c_{t+1}}{c_t} \right)^{-1/\gamma} \frac{P_t(1 + i_t)}{P_{t+1}} - 1 \right] = 0
\]
which is the one estimated by Hansen and Singleton (1982, 1983).

b) For $\rho = 1$, the specification (2) becomes the Cobb-Douglas case and the system (6)-(7) becomes

$$
E_t \left[ \frac{1}{1 + \delta} \left( \frac{c_{t+1}}{c_t} \right)^{\sigma\beta - 1} \left( \frac{m_{t+1}}{m_t} \right)^{\sigma(1-\beta)} \frac{P_t(1 + i_t)}{P_{t+1}} - 1 \right] = 0 \tag{10}
$$

$$
E_t \left[ \frac{1}{1 + \delta} \left( \frac{c_{t+1}}{c_t} \right)^{\sigma\beta} \left( \frac{m_{t+1}}{m_t} \right)^{\sigma(1-\beta)} \frac{\beta}{(1 - \beta)} \frac{m_t}{c_{t+1}} \frac{P_t i_t}{P_{t+1}} - 1 \right] = 0 \tag{11}
$$

which is the specification used by Poterba and Rotemberg (1987) and Eckstein and Leiderman (1989).

c) Defining $v(c_t, m_t) = \frac{u(c_t, m_t)^{1 - 1/\gamma}}{1 - 1/\gamma}$, we can verify that the sign of the cross-derivative $v_{cm}$ is positive if $\gamma > \rho$, and negative if $\rho > \gamma$, which is an important piece of information to characterize the dynamics of monetary Sidrauski models (Obstfeld, 1985; Calvo, 1986; Arrau, 1990).

d) For $\rho = 0$, the "indifference map" from utility (5) become Leontief-type, which means that money is a fixed proportion of consumption, i.e. velocity is not sensible to the nominal interest rate. This is the same implication which arises from Lucas' (1982) cash-in-advance model. Our model, however, cannot accommodate the richer variable-velocity cash-in-advance models of Svensson (1985) and Lucas and Stokey (1987).

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5Both papers include additional assumptions which imply variations to the above system.
3 Empirical Application

In this section we estimate the pure consumption Euler equation (9) and compare the results to the estimation of the monetary system (6)–(7) for Chile and Mexico.

3.1 Data

The model is estimated with quarterly data from Chile (1975.3-81.4) and from Mexico (1980.4-89.3) which in both cases are the only periods for which we have reliable data on private consumption. The data sources are described in Appendix A. The series of consumption is available only as the total expenditure in both durable and non-durable consumption. For money we use M1 (demand deposits plus currency), for interest rates we use returns of one-month-maturity assets, and for consumption deflator we use the CPI. Consumption and money series are normalized by total population. The data on population is available for the middle of the year. We assigned that figure to the month of June, compute all other months by geometric interpolation between two consecutive June figures, and average the months of the quarter to obtain quarterly figures. Finally the series on money, CPI and interest rates are available on monthly basis. The quarterly data on the former two series are computed by simple average of the months of the quarter (real balances for money), while the monthly interest rates are compounded to obtain the quarter figure. As we take the convention of assuming that consumption takes
place at the end of the quarter, the interest rate $i_t$ in the system (6)-(7) is the composition of monthly interest rates of quarter $t+1$.

3.2 Estimation

To estimate the system we use the Generalized Method of Moments estimator developed by Hansen (1982) and Hansen and Singleton (1982). The procedure, and a description of Hansen's (1982) overidentifying restriction test, is outlined in Appendix B.

To apply GMM, the errors in equations (6)-(7) must be stationary random variables. As it is obvious from (6)-(8), some non-stationary variables, like the level of consumption and money, appear in the equations. Notice that the term $\Omega_t$ in (8) is homogeneous of degree $(\rho - \gamma)/\gamma \rho$. Consequently, we can express the term $\Omega_{t+1}/\Omega_t$ in terms of stationary variables ($c_{t+1}/c_t$ and $m_{t+1}/m_t$) and velocity ($c_t/m_t$) by multiplying the numerator and denominator by $c_t^{(\gamma-\rho)/\gamma \rho}$. Except for velocity and the nominal interest rate ($i_tP_t/P_{t+1}$), all other variables in this transformed version of the model are stationary according to Dickey-Fuller tests (see below). The transformation does not affect the results of the GMM estimation, but it helps us to understand the necessary assumption to apply GMM. Velocity and the nominal interest rate would normally fail to pass stationarity tests in periods of increasing

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6It is easy to see that in both cases the moment equation (Appendix B) would be minimized for the same set of parameters, and it would obtain the same minimum.
or decreasing inflation, and that is the case for our two countries. In Chile, the sample period is one of decreasing inflation, and in Mexico it is one of increasing inflation. In order to apply GMM, and because we lack a theory of cointegration in our nonlinear system, we have unfortunately no choice but to assume that the trend of these variables is deterministic, and that somehow they compensate each other to yield stationary errors. In fact, the trends of the two variables are related, and the comovement of velocity and nominal interest rate is crucial to identify the parameter $\rho$ (this will become clear in our discussion of sections 3.3 and 4).\footnote{If our assumption is not true, we could have non-standard distribution of the overidentifying restriction test, which would question our criterion to select among different models below. We intend to approach this problem by Monte Carlo experiments in the near future.}

Another important issue which often arises in the application of the Euler equation approach to consumption is the issue of seasonality. Seasonal fluctuations seem to be important components in the rate of growth of consumption and money from one quarter to the next. To approach the issue of seasonality, however, it is necessary to have a precise understanding of the sources of seasonal movements (e.g. Miron's (1986) taste shifters) and how they relate to other secular and cyclical components. Singleton (1988) shows that prefiltering, for instance, could be very distorting. Ignoring the issue of seasonality as we do here is consistent with the restrictions of our model if we assume that seasonal components in the variables of the model net out for our functional forms.

Finally, we proceed to describe the instrument set employed in the estimations.
As instruments, we use the vector \((1, c_t/c_{t-1}, m_t/m_{t-1}, P_{t-1}(1 + i_{t-1})/P_t)\) plus a second lag of these variables. Dickey-Fuller tests suggest that our instruments are stationary time series.8

3.3 Results

In order to interpret the results, we need to have an idea of the expression for velocity in our model. Recalling that variables indexed with \(t\) subscripts are nonstochastic as of period \(t\) (except \(i_t\)) we can combine (3)–(4) and define the marginal rate of substitution as \(MRS_t = \frac{\partial U/\partial c_{t+1}}{\partial U/\partial c_t}\) to obtain

\[
\frac{\partial U/\partial m_t}{\partial U/\partial c_t} = \frac{\partial u/\partial m_t}{\partial u/\partial c_t} = \alpha \left( \frac{c_t}{m_t} \right)^{1/\rho} = \frac{E_t \left[ MRS_t \frac{i_t}{P_t} \right]}{E_t \left[ MRS_t \frac{(1 + i_t)^{1/\rho}}{P_t} \right]} \tag{12}
\]

Neglecting uncertainty to concentrate by now only on first moment effects we obtain

\[
velocity = \frac{c_t}{m_t} = \left( \frac{i_t}{(1 + i_t) \alpha} \right)^\rho \tag{13}
\]

which shows that velocity is increasing in the nominal interest rate, and the sensitivity of velocity to the interest rate is increasing in \(\rho\).

In Figure 1 and 2 we plot velocity and nominal interest rate for Mexico. As we can see, the nominal interest rate path (inflation) and velocity are increasing in Mexico up to 1987.4. This is totally consistent with the expression (13) above. In 1988-89, however, we can see that the successful stabilization in Mexico did not

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8For all the instruments we run Dickey and Fuller (1979) tests assuming the model \(z_{t+1} = \mu + \rho z_t + e_t\). All tests rejected nonstationarity at the usual 95% of confidence.
produced an expected reduction in velocity (Figures 1 and 2). As the interest rate is sharply reduced early in 1988, velocity stays very high. This monetary puzzle (lack of reaction of velocity to a sharp stabilization policy), known as the Rachet effect, has not been satisfactorily explained as yet. One tentative explanation, which we provide in the next section, is related to the currency substitution literature. By now, and given that this phenomenon cannot be accommodated with the current version of the model, we exclude the period 1988-89 in the estimation.

Now we turn to the estimation. In Table 1 we report the estimation of the consumption equation (9) (when $\alpha$ is constrained to be zero in equation 6). In other words we estimate the same consumption equation estimated by Hansen and Singleton (1982, 1983). We can see that for Chile $\sigma$ is estimated with low precision and it is out of admissible range. For Mexico the test for overidentifying restrictions is not passed at 95% of confidence. In short, Table 1 summarizes the rejection of the data to fit the pure consumption model.

In Table 2, we report the estimation of the whole system (6)-(7). We summarize as follow.

a) Both countries do pass the test for overidentifying restriction at usual level of significance.

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9 In this paper we estimate $\sigma = 1 - 1/\gamma$ instead of $\gamma$. Hansen and Singleton estimated $\sigma = 1$.

10 The parameter $\sigma$ must be less than one, being one equivalent to an infinite intertemporal elasticity of substitution.
b) The annualized time preference parameter is about 1.6% for Chile and 2.8% for Mexico.

c) The parameter $\sigma$ is estimated with relatively low precision. Taking the point estimates for $\sigma$, the implied intertemporal elasticity $\gamma$ is about 1.6 for Chile and 2.9 for Mexico. In spite of the low precision, we can reject the hypothesis of $\gamma$ being close to zero (say 0.1), which is claimed by Hall (1988) and Caballero (1988) as the appropriate number for the U.S..

d) The estimate of $\alpha$ is significantly different from zero, which means that our inclusion of money into the utility function seems to receive support from the data. Comparing Table 1 and 2 we can conclude that our specification is much better than excluding money.

e) The estimate for $\rho$ is significantly different from zero and one in both cases. Both the Cobb-Douglas specification and the fixed-velocity specification are therefore rejected. The estimate for $\rho$ is about 0.3 for Chile and 0.7 for Mexico. As we show in the next section, however, it could be possible that the estimate for Mexico is biased upward if the issue of currency substitution is important in this country.

f) The combination of the intertemporal elasticity bigger than one and the intratemporal elasticity lower than one suggests that the crucial “cross-derivative” from Sidrauski models would have a positive sign. The result is important to select among different models of the southern cone stabilization experiences. Both
Obstfeld (1985) and Arrau (1990) require a negative cross derivative to explain a current account deficit in response to credible stabilization policy, while Calvo (1986) requires a positive cross derivative in a model with lack of credibility.

4 Currency Substitution, Velocity and the Rachet Effect in Mexico

Although there is not much evidence of strong “dollarization” in Mexico before 1980 (Ortiz, 1983), currency substitution is likely to be an important issue in Mexico in the eighties. During the eighties, Mexico suffered a three digits inflation for the first time, which makes the hypothesis much more appealing. In this section we show that a model of currency substitution can simultaneously explain the higher estimate for Mexico of $\rho$ in the previous section and the apparent lack of response in velocity to the stabilization policy in early 1988, which is clear from Figures 1 and 2 (Rachet effect).

Suppose that the index of liquidity includes both home and foreign currencies (Calvo, 1985). Let the index of liquidity “$I$” be

$$l_t = m_t^{1-a}d_t^a$$

where $m_t$ is home currency as before and $d_t$ is foreign currency in units of domestic consumption ($d_t = \frac{e_tD_t}{P_t}$, where $e_t$ is the nominal exchange rate and $D_t$ is foreign currency denominated in foreign currency units).

Substituting $l_t$ instead of $m_t$ in (1) and (5), augmenting the right hand side of
budget constraint (2) to include $\epsilon_t(D_{t-1} - D_t)$, and reoptimizing, we obtain the Euler equations (3), (4) and

$$E_t \left[ \frac{\partial U/\partial c_{t+1}}{\partial U/\partial d_t} \frac{P_t(i_t - \epsilon_t)}{P_{t+1}} - 1 \right] = 0$$  \hspace{1cm} (15)

where $\epsilon_t$ is the rate of devaluation ($\epsilon_{t+1}/\epsilon_t - 1$). As we can see comparing the Euler equation for the local currency (4) and the Euler Equation for the foreign currency (15), the foreign currency is protected against inflation if inflation and the rate of devaluation are closely correlated.

If we had the information of the stock of foreign currency held by domestic residents, we would be able to recover the correct utility parameters by estimating the three-equation system, including (15). Unfortunately the foreign currency series is not observable. In the rest of the section we explain the consequences of the currency substitution model for the estimation of the previous section and the potential to explain the Rachet effect in Mexico.

Combining (4) and (15) we have

$$\frac{\partial U/\partial d_t}{\partial U/\partial m_t} = \frac{\partial l/\partial d_t}{\partial l/\partial m_t} = \frac{a}{1 - a} \frac{m_t}{d_t} = \frac{E_t \left[ MRS_t \frac{(i_t - \epsilon_t)P_t}{P_{t+1}} \right]}{E_t \left[ MRS_t \frac{i_t}{P_{t+1}} \right]} \hspace{1cm} (16)$$

For the currency substitution model of this section, the expression (12) is still correct if we substitute $m$ by $l$ in the denominator. To obtain velocity (ratio $c/m$), we can combine (12), (14) and (16) (previous substitution of $m$ by $l$ in the first equation)
to obtain

\[
\text{velocity} = \frac{c_t}{m_t} = A \left( \frac{E_t \left[ MRS_t \frac{i_t P_t}{P_{t+1}} \right]}{E_t \left[ MRS_t \frac{(1+i_t) P_t}{P_{t+1}} \right]} \right)^\rho \left( \frac{E_t \left[ MRS_t \frac{i_t P_t}{P_{t+1}} \right]}{E_t \left[ MRS_t \frac{(i_t - \epsilon_t) P_t}{P_{t+1}} \right]} \right)^a
\]  

(17)

where \( A = \frac{a^a}{(1 - a)^a \alpha^\rho} \). Neglecting uncertainty to see the first moment effects, expression (17) becomes

\[
\text{velocity} = \frac{c_t}{m_t} = A \left( \frac{i_t}{1 + i_t} \right)^\rho \left( \frac{i_t}{i_t - \epsilon_t} \right)^a
\]  

(18)

Now we can better interpret the estimation for Mexico in the previous section. If \( a = 0 \) (no currency substitution) we can see from (18) that the parameter \( \rho \) tell us how sensible is velocity to the nominal interest rate, as the consumers substitutes liquidity services by consumption services. According to the estimation of the previous section \( (\rho = 0.75) \), a one percent increase in the nominal interest rate \( i/(1 + i) \) produces a 0.75 percent increase in velocity. However with currency substitution, the above estimate could be more than consumption-liquidity services substitution.

From (18), velocity in terms of the local currency not only responds to the nominal interest rate due to consumption-liquidity services substitution (summarized by \( \rho \)) but also to the “intensity” parameter between the two currencies in the liquidity index (parameter \( a \)). In a period of increasing inflation like Mexico during 1980-87, velocity would grow fast as both effect point in the same direction.\(^{11}\) Consequently a misspecification of the model by failing to include this second effect would result in

\(^{11}\)Notice that the term \( i_t - \epsilon_t \) will generally not increase with inflation as the term is close to the foreign interest rate.
an upward-biased estimation for $\rho$ as the estimated parameter must accommodate the rapid growth in velocity resulting from both type of substitution against money resulting from inflation. Therefore the currency substitution model described here can account for the difference of estimation in $\rho$ for Chile and Mexico.\footnote{The implicit assumption is that currency substitution was not an issue in Chile. But even if it was, and because during 1976-81 inflation is decreasing in Chile, the estimate of $\rho$ would be biased downward in Chile, and the above statement is still valid.}

Next we show the potential of the currency substitution model described in this section to account for the Rachet effect in 1988. What are the conditions to explain a large reduction in inflation and the nominal interest rate without response in velocity?.

From (18) we could already argue that a reduction in $i_t$ is consistent with a fixed velocity as long as $(i_t - \epsilon_t)$ is adjusted correspondingly. Clearly that should imply an increase in the risk premium associated to holding domestic money, moving the consumer to adjust the liquidity index in favor of the foreign money. To formalize this argument and to understand the character of the risk premium mentioned above we require to analyze the dependency of velocity to second moment effects as well.

To make the story simpler, we will rely only on exchange rate uncertainty and we will assume that both the inflation rate $P_{t+1}/P_t$ and the nominal interest rate $i_t$ are nonstochastic as of period $t$. We should mention that the “heterodox” stabilization by the end of 1987 included price freezing as part of the stabilization package,
which make the first assumption less arbitrary. This assumption is not necessary for the argument below but simplifies it considerable. The consequence of this two assumptions is that the real interest rate is nonstochastic, and from (3) we can see that

\[ E_t[MRS_t] = \frac{P_{t+1}}{(1 + i_t)P_t} \]  

(19)

Now combining the above assumptions, (16) and (19), after some manipulation velocity becomes

\[ velocity = \frac{\epsilon_t}{m_t} = A \left( \frac{i_t}{1 + i_t} \right)^{\rho + \alpha} \left[ \frac{i_t - E_t[\epsilon_t]}{1 + i_t} - COV_t \left( MRS_t, \frac{\epsilon_t P_t}{P_{t+1}} \right) \right]^{-\alpha} \]  

(20)

where \( COV_t \) stands for conditional covariance. If the rate of devaluation and the MRS are orthogonal, then we are back into equation (18) and the Rachet effect will only be explained by an increase in the expected rate of devaluation beyond the rate of devaluation before the stabilization. However, there is a good reason to think that the conditional covariance between the rate of devaluation and the MRS actually increases when the stabilization takes place, making the Rachet effect more plausible. Consider the following argument.

When the exchange rate was increasing with inflation before 1988, the term  

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13The package also include preannouncement of the exchange rate at a decreasing rate of devaluation, so we implicitly argue that this latter announcement was less credible than the one on prices.

14This assumption is not supported by survey data from Mexico which suggest that immediately after the stabilisation plan the expectations of devaluation remained at the same value of the rate of devaluation (inflation) before the policy (National Institute of Statistics, INEGI). Therefore the expectations of devaluation neither increased nor decreased.
\( \frac{\epsilon_t P_t}{P_{t+1}} \) was trending upward and the covariance with the MRS presumably was close to zero.\(^{15}\) After the stabilization, however, there is a good reason to expect a large discrete devaluation at some point. Large discrete devaluations are normally contractionary in consumption (on impact), and therefore, the conditional covariance between MRS and the rate of devaluation becomes positive.\(^{16}\)

The Rachet effect should be clear by now. When the nominal interest rate goes down, the consumer does devote more resources to increase liquidity, but most of them go to the foreign currency. The reason is that the foreign currency helps to hedge against the possible reduction in consumption due to a discrete devaluation, and therefore is relatively cheaper to increase liquidity in terms of the foreign currency. In terms of equation (20), the increase in the conditional covariance between the rate of devaluation and the MRS offsets the impact of the nominal interest rate on velocity.

Another implication of the currency substitution explanation for the Rachet effect is that it would be temporary until the exchange rate policy becomes more

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\(^{15}\)Possibly negative. Notice that if consumption growth is isolated from nominal movements in the exchange rate by some form of monetary veil in this gradually inflating period, the MRS covaries negatively with inflation as an increase in inflation increases velocity; and because the Sidrauski cross-derivative is positive (section 3.3), an increase in velocity reduces MRS.

\(^{16}\)As discussed in the previous section, the MRS is a function of the growth of consumption, growth of money and velocity itself. However, we can substitute (8) in (6) to find a relation between the slope of consumption and the MRS for a fixed velocity. If the common growth of consumption and money (implication of fixed velocity) is \( g \), we can show that \( \partial MRS_t / \partial g = -1/\gamma \), which shows the negative relation between the MRS and the consumption (and money) slope, given fixed velocity.
credible.\textsuperscript{17}

5 Concluding Remarks

The paper estimates a system of monetary Euler equations for Chile and Mexico. Somewhat surprisingly, in both cases the monetary estimation is notoriously better than the pure consumption estimation. All the parameter estimates are in admissible ranges and the test for overidentifying restrictions is passed. The point estimate of the intertemporal elasticity of substitution is between 1.5 for Chile and 3 for Mexico. In both cases, the CES specification for the intratemporal utility function between consumption and liquidity services seems to be supported as the intratemporal elasticity of substitution between money and consumption is precisely estimated between zero and one. This result is important as it implies that both the Cobb-Douglas specification and the fixed-velocity specification are rejected.

The results indicate that velocity sensitivity to the nominal interest rate is lower for Chile than for Mexico. This difference, however, could be explained by a model of currency substitution. More important, a model of currency substitution may be the appropriate way to explain the monetary puzzle observed in Mexico after the

\textsuperscript{17}Non credibility in the exchange rate policy is the main argument to explain the huge real interest rate in Mexico after the stabilisation of 1987. This implication also matches the events in Israel after the stabilisation policy of 1986. The Rachet effect also occurred after the stabilisation package took place and velocity did go down with many quarters of lag. For Mexico we have to wait a little longer to confirm this presumption, although some preliminary evidence suggests that this is the case.
stabilization attempt of late 1987. In spite of the fact that inflation was sharply (and permanently) reduced, velocity did not go down. The model of currency substitution suggests that a good way to hedge against a discrete devaluation would be to increase liquidity in foreign currency, not domestic.

Appendix A: Data Sources

This appendix details the data sources used in the paper.


Mexico. Consumption is private consumption, money is M1 (currency plus demand deposits), interest rate is 28-days government bonds (CETES) and the consumption deflator is the CPI index (All data come from “Indicadores económicos de México”, Dirección de Investigaciones Económicas, various numbers). Population data comes from IFS, International Monetary Fund.
Appendix B: Econometric Methodology

The econometric methodology to estimate the system of equations is the Generalized Method of Moments (Hansen, 1982; Hansen and Singleton, 1982). The reader is also referred to Gallant (1987) as the exposition below somewhat differs from Hansen-Singleton’s.

Let us define $q_t = q(\theta, x_t)$ as the 2x1 functional vector in square brackets in the system (6)-(7) in the text (column vector). $\theta$ is the column vector of the 4 parameters to be estimated and $x_t$ is the vector of consumption (indexed at $t$ and $t+1$), real balances (indexed at $t$ and $t+1$), real interest factor (as in equation 6) and nominal interest rate (discounted by the inflation factor as in equation 7).

Let $z_t$ be a column vector of the 7 instruments described in section 3.2 and which are known as of period $t$. Therefore the system (6)-(7) in the text implies the 14 orthogonality conditions

$$E(q_t \otimes z_t) = 0 \quad (B.1)$$

which are the focus of the estimation procedure.

For a sample size $n$, the estimate $\hat{\theta}$ is obtained by minimizing the objective function

$$f(\theta, \Omega) = \left( \sum_{i=1}^{n} q_t \otimes z_t \right)' \Omega^{-1} \left( \sum_{i=1}^{n} q_t \otimes z_t \right) \quad (B.2)$$

where $\Omega$ is an estimate of the variance-covariance matrix of the random variable
\[(q_t \otimes z_t) \text{ equal to} \]
\[
\Omega = \sum_{i=1}^{n} (q(\hat{\theta}, x_i) \otimes z_i)(q(\hat{\theta}, x_i) \otimes z_i)' 
\]  
(B.3)

The estimation proceeds in two steps. The first step estimator \(\hat{\theta}\) is obtained by minimizing with respect to \(\theta\) the expression

\[
f \left( \theta, I \otimes \sum_{i=1}^{n} x'_i z_i \right)
\]  
(B.4)

Finally the variance-covariance matrix of the estimates is

\[
Var(\hat{\theta}) = \left[ \left( \sum_{i=1}^{n} \frac{\partial q_t}{\partial \bar{\theta}'} \otimes z_i \right)' \Omega^{-1} \left( \sum_{i=1}^{n} \frac{\partial q_t}{\partial \bar{\theta}'} \otimes z_i \right) \right] 
\]  
(B.5)

where the derivatives are evaluated at the point estimate.

As shown by Hansen (1982), the minimized objective function \(f(\hat{\theta}, \Omega)\) is distributed asymptotically as a \(\chi^2_{m-k-p}\) where m in the number of equations (2 in our case), p is the number of parameters to be estimated (4 in our case) and k the number of instruments (7 in our case). This is the critical value for the overidentifying restrictions test.
Bibliography


Table 1: Estimation of Consumption Euler Equation

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<thead>
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<tr>
<td>(1/(1 + \delta))</td>
<td>0.966</td>
<td>0.999</td>
</tr>
<tr>
<td></td>
<td>(0.0064)</td>
<td>(0.0085)</td>
</tr>
<tr>
<td>(\sigma = 1 - 1/\gamma)</td>
<td>1.267</td>
<td>-1.558</td>
</tr>
<tr>
<td></td>
<td>(0.158)</td>
<td>(1.167)</td>
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<tr>
<td>(S)</td>
<td>3.95</td>
<td>8.84</td>
</tr>
<tr>
<td></td>
<td>(0.734)</td>
<td>(0.968)</td>
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*Note: Standard errors in parenthesis. "S" is the criterion objective function. Below "S" we report the probability that a \(\chi^2(3)\) random variable is less than "S". In the first and third columns one observation is lost. See text for procedures and Appendix for data sources.*
<table>
<thead>
<tr>
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<th>Chile (1971.3-1981.4)</th>
<th>Mexico (1980.1-1987.4)</th>
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<tr>
<td>$1/(1 + \delta)$</td>
<td>0.996 (0.0121)</td>
<td>0.993 (0.0047)</td>
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<tr>
<td>$\sigma = 1 - 1/\gamma$</td>
<td>0.371 (0.252)</td>
<td>0.652 (0.283)</td>
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<tr>
<td>$\alpha$</td>
<td>0.0019 (0.00063)</td>
<td>0.0319 (0.0037)</td>
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<tr>
<td>$\rho$</td>
<td>0.305 (0.0258)</td>
<td>0.748 (0.059)</td>
</tr>
<tr>
<td>$S$</td>
<td>12.42 (0.742)</td>
<td>14.53 (0.850)</td>
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**Note:** Standard errors in parenthesis. During the estimation $\alpha$ was constrained to lie between zero and one by estimating $\cos^2(\alpha)$. "$S$" is the criterion objective function. Below "$S$" we report the probability that a $\chi^2(10)$ random variable is less than "$S$". In the first and third columns one observation is lost. See text for procedures and Appendix for data sources.

**Table 2:** Estimation of Monetary Euler System
FIGURE 1. Mexico: Velocity, 1980.1-89.2

SOURCE: Appendix.

FIGURE 2. Mexico: Nominal Interest Rate, 1980.1-89.2

SOURCE: Appendix.
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