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DOLLARIZATION IN ARGENTINA

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ABSTRACT

Argentina became highly "dollarized" during its hyperinflations of 1989 and early 1990. Although inflation has returned to very low rates, a high degree of dollarization has persisted during the early 1990s, counter to what the currency substitution hypothesis predicts. This paper provides new evidence that explains the continued dollarization of the Argentine economy.

First, we develop a new measure of dollar currency circulating in foreign countries. This measure improves our ability to analyze dollarization and currency substitution by distinguishing between dollar currency holdings and dollar deposits, and thereby represents an important advance over previous studies that focused on dollar deposit holdings only. Empirically, these components of dollar assets for Argentina have responded differently to recent macroeconomic shocks.

Second, cointegration analysis of peso money demand in Argentina finds a negative "ratchet effect" from inflation on the demand for pesos. The reduction in peso money demand attributable to the ratchet effect is similar in magnitude to the estimated stock of all dollar assets held domestically by Argentine residents, consistent with the hypothesis of irreversible dollarization.

Key words and phrases: Argentina, broad money, dynamic specification, cointegration, conditional models, currency substitution, dollarization, error correction, exogeneity, hyperinflation, irreversibility, money demand, parameter constancy, ratchet effect.

Dollarization in Argentina

Steven B. Kamin and Neil R. Ericsson[1]

1 Introduction

Increased use of foreign currency in many countries has led to a substantial literature on "currency substitution". Heavy usage of foreign currency generally has occurred in countries with high and variable inflation rates and where the rate of currency depreciation has been high and variable as well. In such economies, the opportunity cost of holding domestic currency is high, leading residents to use foreign currency for savings and even transactions. Drawing on portfolio models of asset demand, the currency substitution literature has focused on how the extent of currency substitution depends on the opportunity costs of holding domestic and foreign currencies. Various studies have documented the (predicted) positive association between exchange rate depreciation and the extent of "dollarization", as the phenomenon has been known, particularly in Latin America.[2]

In the last few years, various Latin American countries, including Argentina, Bolivia, and Peru, have experienced a reduction in inflation and exchange rate depreciation from previous record levels. However, the extent of dollarization has, if anything, apparently increased in these countries subsequent to the reduction in inflation. To explain these trends, which appear to contradict the predictions of the basic currency substitution model, various observers have pointed to the possibility of irreversibilities in the dollarization process.[3] Because it is costly to switch currencies in transactions, once dollarization occurs in response to an increase in inflation, private agents may not necessarily return to using domestic currency once inflation subsides. This view may explain the persistence of dollarization in countries like Argentina and Bolivia, as well as the secular declines in their demand for local currency. However, the role of irreversibilities in currency substitution has yet to be submitted to convincing empirical tests.

[1]The authors are staff economists in the Division of International Finance. The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting those of the Board of Governors of the Federal Reserve System or other members of its staff. All numerical results were obtained using PcGive Version 7.00 and PcFiml Version 7.00 γ02; cf. Doornik and Hendry (1992, 1993). We are grateful to Amy Moore and John Irons for excellent research assistance; to Jurgen Doornik and David Hendry for providing us with a pre-release version of PcFiml; and to Hildegart Ahumada, Julia Campos, Josh Feinman, Joe Gagnon, Dale Henderson, David Hendry, David Howard, Robert Kaiman, Andrew Levin, Deb Lindner, Jaime Marquez, Michael Melvin, John Mullin, Bettina Peiers, Patrice Robitaille, Charlie Siegman, John Welch, Tim Wilson, and members of the IF Workshop for helpful comments and suggestions.

[2]See Ortiz (1983), Ramirez-Rojas (1985), Marquez (1987), Melvin (1988), Agénor and Khan (1992), Clements and Schwartz (1992), and Rojas-Suarez (1992).

[3]See Sturzenegger (1992) and Guidotti and Rodriguez (1992).

This paper attempts to shed further light on the dollarization process by focusing on the recent experience of Argentina. A key contribution of this paper is the development of a new measure of dollar currency in circulation in Argentina, based on recorded flows of U.S. currency between Argentina and the United States. This new measure indicates that Argentine residents are holding considerably greater quantities of dollar currency than is generally believed. Additionally, in recent years, these dollar currency holdings have behaved very differently from dollar deposits in Argentine banks. Data on dollar deposits in domestic banks have formed the basis for almost all previous studies of currency substitution, since generally they are the only measures of currency substitution available. These data could be misleading indicators of short-run trends in dollarization.

A second contribution of this paper is to test a model of irreversibility in the dollarization process. Because there are not sufficient data available on the extent of dollar holdings, we focus on the flip side of the demand for dollars: the demand for domestic currency assets. Using an error correction model of peso money demand in Argentina, we find strong statistical evidence that higher inflation exerts a negative effect on the demand for pesos that is not fully reversed, once inflation subsides. The reduction in peso money demand attributable to the ratchet effect is broadly comparable in magnitude to the estimated stock of total dollar assets (both currency and deposits) held domestically by Argentine residents. This suggests that secular reductions in the demand for pesos reflect substitution into dollars rather than mere economizing on peso balances (or other forms of financial innovation).

This paper is organized as follows. Section 2 summarizes the recent evolution of macroeconomic events in Argentina, providing a backdrop for the remaining sections. Section 3 describes the recent behavior of dollar currency holdings, while Section 4 addresses possible explanations for these trends. Section 5 estimates an error correction model for peso money demand, which is used to test the "irreversibility hypothesis". Section 6 addresses the differences between the behavior of dollar currency and dollar deposit holdings, and Section 7 concludes. The Appendix documents data sources.

For expositional convenience, we adopt two conventions. First, "domestic" means Argentine. Second, Sections 2–4 refer to Argentine currency as the austral or the peso, as the historical context dictates, whereas the remaining sections refer to pesos exclusively because model estimation uses data converted into pesos (the current Argentine currency).

2 Recent Macroeconomic Developments

Since the early 1980s, the rate of inflation (and associated rate of exchange rate depreciation) has preoccupied policymakers and private citizens alike in Argentina. As indicated in Figure 1, the acceleration of prices during the early 1980s was sharply reversed in mid-1985 with the implementation of the Plan Austral, which combined wage, price, and exchange rate freezes with some fiscal adjustment.However, while the

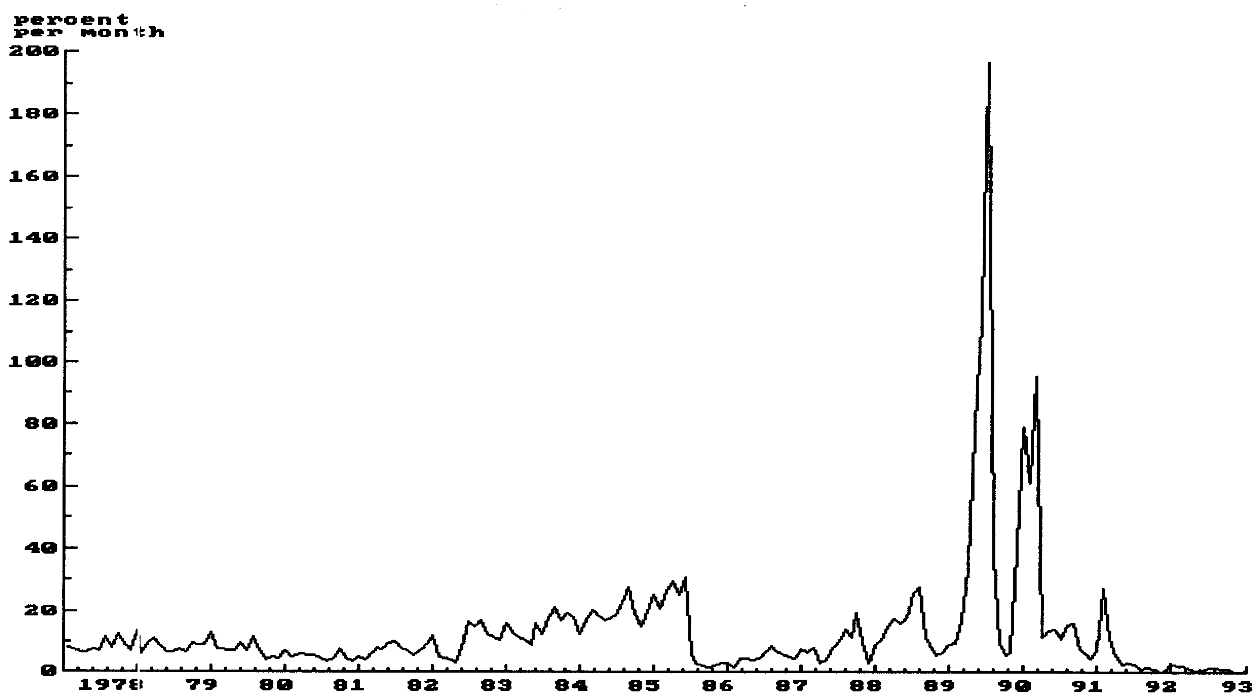

Figure 1. Consumer price inflation in Argentina ($\Delta P_t/P_{t-1}$).*

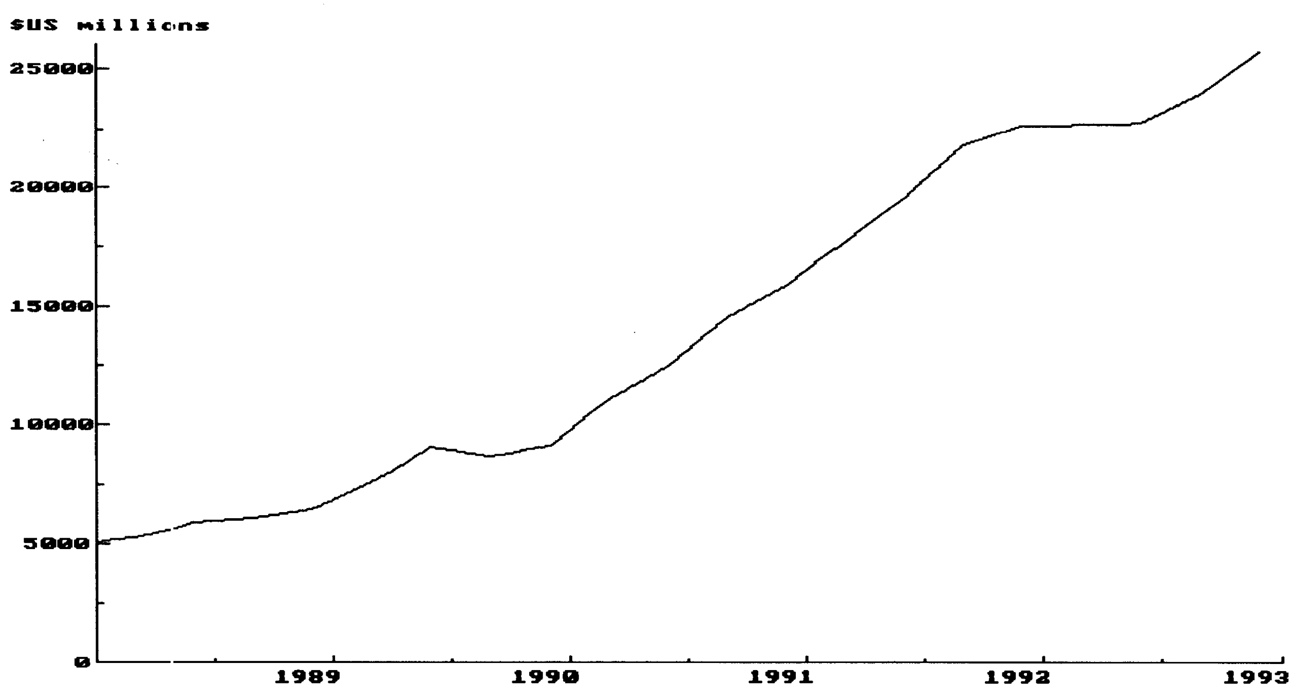

Figure 2. Cumulated net shipments of U.S. currency to Argentina (C).

*Large tick marks on the graphs indicate beginnings of years.

fiscal deficit declined from roughly 12 percent of GDP in 1984 to 5 percent in 1986, this was not sufficient to eliminate inflationary pressures, which resumed in earnest by 1987.

A second major disinflation program, the Plan Primavera ("Spring Plan"), was initiated in August 1988. The linchpin of the program was an agreement with private sector leaders to limit the growth of public prices, private prices, and the official exchange rate to 4 percent per month. Like the Austral Plan before it, the Plan Primavera initially was successful in reducing inflation. However, because the inflation rate did not decline to the rate of official exchange rate depreciation, the real exchange rate appreciated substantially. Additionally, the fiscal situation deteriorated, since the higher interest rates needed to support the exchange rate raised the costs of servicing the government's domestic debt. At the beginning of February 1989, faced with a run on the austral and the depletion of its international reserves, the Central Bank floated the exchange rate for financial transactions. Shortly thereafter, the financial exchange rate depreciated sharply, money demand fell off, and inflation rapidly increased, peaking at 198 percent per month in July 1989.

Following President Menem's inauguration in that same month, the authorities announced a stabilization program broadly similar to the Plan Austral: a freeze on public prices, private prices, and the official exchange rate, coupled with long-range plans to reduce the fiscal deficit. Initially, inflation fell dramatically, but by October, the pace of fiscal reforms slowed while continued inflation appreciated the real exchange rate. Expectations of a corrective devaluation caused the parallel market premium to re-emerge, leading to a marked decline in the Central Bank's international reserves. By December 1989, the Central Bank was forced to float the commercial exchange rate, which quickly depreciated and spurred additional price inflation.

In January 1990, the authorities attempted to restrain inflation by freezing most domestic austral-denominated bank time deposits and converting them to 10-year dollar denominated bonds known as Bonex; the value of these bonds immediately dropped to less than 30 percent of face value. The Plan Bonex, as this action was known, had little immediate effect upon inflation, but did succeed in further reducing the Argentine public's already shaky faith in their financial system. By March 1990, when inflation reached 95.5 percent (monthly basis), M3, which includes currency and all austral-denominated bank deposits, reached a record low of 3.1 percent of GDP.

Subsequently, inflation declined to single-digit levels by October 1990 due to a reduction in monetary emission made possible by concerted efforts to achieve fiscal adjustment. The fiscal deficit declined from over 20 percent of GDP in 1989 to about 3 percent in 1990 and 2 percent in 1991. A new surge of inflation in early 1991, as a result of a corrective depreciation of the floating exchange rate, prompted the government to implement the "Convertibility Program" in March 1991. This program fixed the exchange rate against the dollar and required that the Central Bank hold international reserves equivalent to the monetary base. Since then, the monthly inflation rate has fallen to about 1 percent per month. Nominal interest rates followed suit, indicative of the public's confidence in the stabilization program, at least in the short run. For further analytical and empirical discussion of the Argentine economy, see Howard (1987), Kiguel (1991), the World Bank (1990), Helkie and Howard (1991), Kamin (1991), Manzetti (1991), and Beckerman (1992).

3 The Evolution of Argentine Holdings of U.S. Currency

This section proposes a new measure of dollarization based on CMIR data and considers measurement errors that may be associated with it.

3.1 A New Measure of Dollarization

Almost all studies of dollarization in developing countries rely upon data on dollar deposits in the domestic banking system to indicate the extent of dollarization.[4] While these studies may cite considerable anecdotal evidence concerning the widespread use of dollar currency in particular countries, generally no data are available that quantify the amount of U.S. currency in circulation.

Our study augments data on dollar deposits with estimates of the stock of U.S. currency circulating in Argentina, based upon recorded flows of U.S. currency between Argentina and the United States. The data are aggregated from the Currency and Monetary Instrument Reports (CMIRs) collected by the U.S. Treasury Department, which must be filled out by any individual or entity transporting $10,000 or more into or out of the United States.[5] Estimates of currency flows from this source are available on a quarterly basis since 1988. These data, listed in Table A2 of the Appendix, indicate net flows of U.S. currency to Argentina of $1.4 billion in 1988 and $2.7 billion in 1989, rising to $6.7 billion in 1990 and $6.8 billion in 1991.

To estimate the stock of U.S. currency circulating in Argentina, net currency flows to Argentina were cumulated over time; the evolution of this estimated stock is shown in Figure 2. Based on highly indirect means, local observers place the quantity of U.S. currency circulating in Argentina in the mid-1980s at about $5 billion, and so this figure is used as the end-1987 starting point for the calculation. U.S. currency inflows during 1988–1992 totaled $20.8 billion, implying total U.S. currency of about $26 billion outstanding in Argentina at the end of 1992, or roughly 11 percent of Argentina's GDP.

[4]See Savastano (1992) for a recent discussion of measured dollar deposits in Latin America and their shortcomings as measures of dollarization. See also Giovannini and Turtelboom (1992).

[5]Gruben and Lawler (1983) also use currency flows to examine dollarization. They use data collected by the Federal Reserve Bank of Dallas on U.S. currency flows between Texas banks and banks in northern Mexico, and they find that those flows are influenced by expectations of the (Mexican) peso's devaluation. Because the of the partial nature of the Dallas survey, these data are not suitable for constructing a reliable estimate of the total stock of dollars held in Mexico. Additionally, the proximity of Mexico to the United States may result in substantial unreported currency flows between those two countries.

By comparison, holdings of dollar deposits in the domestic banking system totaled only \$11.0 billion in December 1992. The dollar value of peso M3, which includes currency and all bank deposits, amounted to only \$20.1 billion. Hence, based on our estimates of net currency flows, dollar currency constituted the single most important monetary aggregate in Argentina at the end of 1992, amounting to almost as much as all dollar deposits and all peso money put together.

3.2 Measurement Issues

The massive increase in Argentine U.S. currency holdings indicated by our data may be difficult to believe. One way to rationalize the large increase in estimated dollar holdings is to contend that the stock of dollars held in Argentina has not actually grown. Instead, it could be that most of the recent increases in dollar inflows to Argentina have been offset by increased, unrecorded outflows. One potential source of such outflows would be Argentine travel abroad, including purchases of goods that are not readily available or that are more expensive domestically. However, these activities are estimated to account for only about \$1 billion annually, well under net inflows of roughly \$6 billion for each of 1990 and 1991. Additionally, it is not clear why these activities would have accelerated so much in those years.

Large flows of currency are often believed to be associated with international drug smuggling and money laundering. This possibility would most likely be linked to illicit unrecorded flows of dollars to a foreign country, combined with legal recorded flows of dollars back to the United States. However, Argentina is experiencing net *inflows* of dollars, which suggests that these activities are not the explanation.

A final possibility is that movements of dollars to Argentina are reflowing outward to third countries on an unrecorded basis. There is anecdotal evidence that U.S. currency has been shipped from Argentina on to Brazil, the Cayman Islands, and the Middle East. However, it is difficult to measure these flows, and they are unlikely to be large enough to explain the actual shipments to Argentina in the past three years.

While our estimated Argentine dollar holdings may appear large, they are in line with currency demand in other countries. Table 1 compares Argentine per capita holdings of currency (both local currency and dollars) to holdings of local currency alone in other countries. Table 1 also compares the ratio of currency to GDP across countries. Argentine per capita holdings of local currency alone are low relative to other countries. By contrast, total Argentine holdings of currency, including dollars, are not markedly out of line with international standards.

Scaled by GDP, Argentina's holdings of currency (both pesos and dollars) appear excessive by international standards. However, as discussed below, U.S. currency holdings served in part to substitute for holdings of peso-denominated bank deposits. Argentine holdings of currency and bank deposits in both domestic currency and dollars accounted for about 24 percent of GDP at the end of 1992, well below international standards.

Table 1.
An International Comparison of Currency Holdings in 1990

Country	Currency per capita ($US thousands)	Currency/GDP (percent)
Canada	0.65	2.99
France	0.89	3.99
Germany	1.68	6.60
Italy	1.06	5.31
Japan	2.25	8.76
Switzerland	3.62	10.07
United Kingdom	0.55	2.97
United States	1.00	4.53
Brazil	0.04	3.06
Chile	0.06	3.37
Mexico	0.10	3.60
Korea	0.23	4.13
Taiwan	0.64	8.40
Argentina		
(dollars and pesos)	0.70	18.44
(pesos only)	0.13	3.28

Notes:

1. The data are from *International Financial Statistics*, International Monetary Fund, April 1992 (most countries), *International Financial Statistics*, October 1993 (for Argentina and Mexico, due to reporting delays), and *Financial Statistics*, Central Bank of China, October 1992 (for Taiwan). Dollar holdings for Argentina ($C+D$) are calculated as described in the text.

2. Currency, the exchange rate, population, and GDP for all countries correspond to IFS line numbers 14a, ae, 99z, and 99b. Thus, holdings of "currency per capita" are of domestic currency only, converted to U.S. dollars at the official exchange rate.

3. The figures for the United States may overstate actual currency holdings by U.S. residents because a substantial fraction of U.S. currency appears to be held overseas.

Our estimated Argentine dollar holdings also appear plausible in light of the amount of U.S. currency estimated to be held overseas. From surveys on the use of transaction accounts and cash in the United States, Avery, Elliehausen, Kennickell, and Spindt (1987) estimate that in the mid-1980s only 11 percent of the stock of currency and coin in circulation outside banks was held by U.S. residents for transactions purposes. They estimate that domestic currency holdings by businesses and juveniles and for illegal activities probably increases the share of domestically held currency in circulation to about 20 percent. By implication, approximately 80 percent of U.S. currency could be circulating outside the United States. In December 1992, that amounted to about $230 billion, which is in line with Porter's (1993) estimate by a different method. Thus, Argentine residents appear to hold about one-tenth of all U.S. currency held outside the United States, which is not inconceivable, given Argentina's highly unstable financial situation in the late 1980s.

4 The Hypothesis of Currency Substitution

This section discusses the hypothesis of currency substitution in the Argentine context. For detailed examinations of currency substitution in Argentina, see Fasano-Filho (1986a, 1986b) and Canto and Nickelsburg (1987) *inter alia.*

4.1 The Shift from Domestic to Dollar Assets

If no corresponding outflows of dollars can be confirmed, the increased dollar inflows most likely are attributable to an increase in the demand for this currency by residents of Argentina. This view is consistent with considerable anecdotal evidence. Reputedly, transactions in real estate and almost all big-ticket items are conducted in U.S. currency. Increasingly, dollars are being accepted for smaller everyday transactions as well. Many Argentines acknowledge holding considerable sums of U.S. currency, although (to our knowledge) no survey of these holdings exists.

Increases in U.S. currency holdings may reflect either an increased demand for monetary assets, or a substitution out of domestic and into foreign assets at a given level of total monetary holdings. Figure 3 is consistent with the latter hypothesis. It follows the evolution of three different monetary aggregates over the last 15 years, evaluated in real pesos. M1 includes peso currency and demand deposits, M3 (denoted M here and below) adds all remaining peso bank deposits, and the aggregate labelled "all assets" includes both estimated U.S. currency holdings and the small but growing stock of dollar-denominated bank deposits.[6]

[6]Monthly observations on the stock of U.S. currency in circulation were constructed in order to preserve comparability with data on M1 and M3, which show considerable month-to-month variation. It was assumed that net currency flows were distributed evenly over each quarter, so that monthly flows were equal to one third of their respective quarterly flows. Monthly stocks were then estimated based upon the cumulated monthly flows.

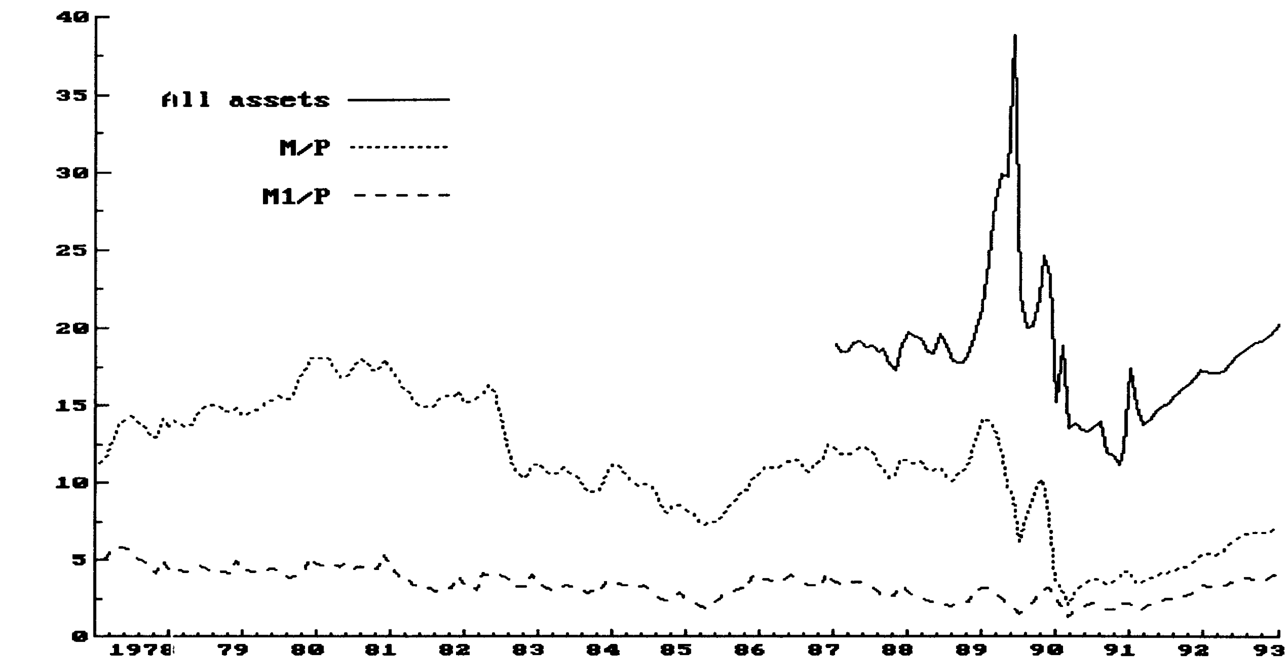

Figure 3. Real holdings of narrow money ($M1/P$), broad money (M/P), and all assets ($[M/P] + [A \cdot E/P]$).

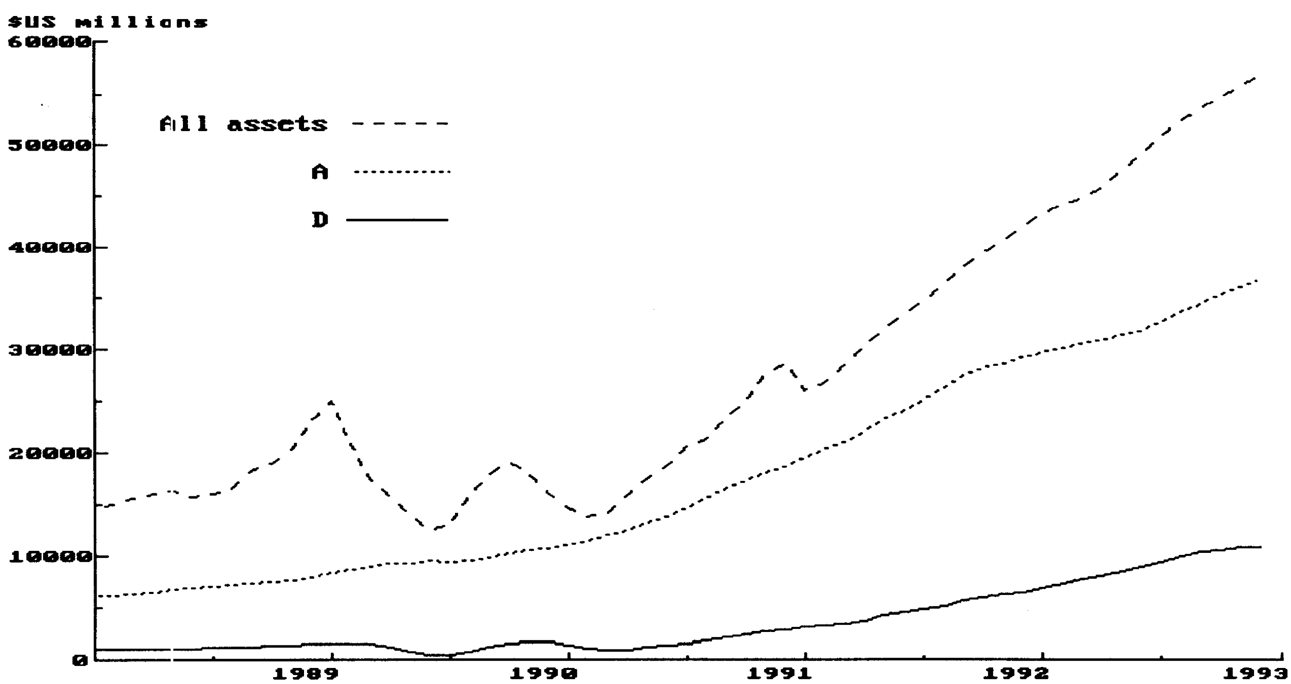

Figure 4. Dollar deposits (D), dollar deposits plus dollar currency holdings (A), and all assets ($A + [M/E]$), as valued in dollars.

Figure 3 shows that a substantial shift out of local-currency assets and into dollars took place in 1990 and 1991. The overall quantity of financial asset holdings in Argentina declined by much less than local currency assets, and by 1993 had fully recovered to its pre-hyperinflation levels.[7] It also suggests that imports of U.S. currency served primarily to replace austral-denominated bank deposits rather than local currency per se. While there has been a secular decline in the ratio of M1 to GDP in the past 15 years, only M3 displays a marked drop in 1989 and 1990, coinciding with the rapid build-up of U.S. dollar holdings.

Figure 4 plots the evolution of dollar-denominated deposits in Argentine banks, and compares them to holdings of U.S. currency and domestic M3 (converted into dollars at the free-market exchange rate). Initially, these dollar-denominated deposits were not popular, as they were subject to a 100 percent reserve requirement at the Central Bank and were considered vulnerable to confiscation in the event of balance-of-payments difficulties. In August 1989, a new type of dollar deposit was authorized that carried a low reserve requirement, to be held at an overseas bank. Since April 1990, these have shown very strong growth, and as of December 1992 totaled about $11 billion, almost as much as peso-denominated bank deposits. This trend suggests that dollar currency inflows are part of a more general surge in the demand for dollar assets. However, as discussed in Section 6, the surge in dollar deposits started somewhat later than the increase in currency inflows, reflecting important differences in the behavior of the two assets.

4.2 Currency Substitution and Capital Flight

Increased dollar holdings appear to be financed by drawdowns in accounts held abroad (flight capital) and continued diversions of dollar receipts from the foreign exchange market. Estimates of the stock of flight capital at the end of 1989 range from $30 billion to $50 billion. Since then, it is believed that billions of dollars have returned to Argentina for investment in the stock market, real estate, and other opportunities. Some of these capital inflows have been exchanged for local currency assets, as reflected in the over $5 billion increase in Central Bank international reserves since 1989. However, it is probable that these inflows also have financed the accumulation of dollar-denominated assets within Argentina.

In this context, it is important to distinguish between "capital flight" and "currency substitution". During the 1980s, macroeconomic and political uncertainty motivated a shift into dollar-denominated money at home (currency substitution) and placements of substantial assets abroad (capital flight). In 1990 and 1991, the perceived reduction in economic and political risks motivated flows of flight capital back

[7]The spike in total assets is due to the substantial real depreciation of the austral in mid-1989. Similarly, that variable's subsequent lower level arises primarily from the strong real appreciation of the exchange rate. As indicated in Figure 4, when the dollar (not peso) value of total assets is measured, it actually rises considerably in 1990 and 1991.

to Argentina, even while currency substitution into dollars occurred.[8] One implication of this phenomenon is that conventional estimates of capital flight, which measure the discrepancy between official balance-of-payments inflows and the change in international reserve holdings, may be misleading.

4.3 Problems with the Conventional Currency-Substitution View

While Figures 3 and 4 make a prima facie case for currency substitution as an explanation for the large dollar inflows to Argentina, the timing of recent macroeconomic events is at odds with the traditional model of currency substitution. In that model, agents vary their relative holdings of domestic and foreign money, based upon current and/or prospective rates of return to holding those currencies. Hence, high rates of exchange rate depreciation, which generally are associated with high rates of inflation, should increase holdings of (e.g.) dollars relative to domestic currency. Conversely, reductions in inflation and in the rate of exchange rate depreciation should reverse dollarization and increase relative holdings of domestic currency, albeit possibly at a lag.

If the conventional currency substitution model applied, Argentine holdings of dollars would have reached their highest points in mid-1989 and early 1990, periods of hyperinflation and extremely rapid exchange rate depreciation. (See Figure 5a.) Since then, dollar holdings would have fallen off dramatically, consistent with a decline in the inflation rate to 19 percent for the 12 months ending in July 1992, the lowest rate since the early 1970s. Additionally, the nominal exchange rate has remained virtually unchanged since January 1991. The actual movement of dollar holdings very much contradicts these predictions. Figures 5b and 5a compare the path of the share of dollar holdings in total financial assets to movements in inflation and exchange rate depreciation. It underscores that this share was much higher in 1991 and 1992 than in 1988, in spite of the stabilization of the macroeconomy.

The recent surge in dollar inflows cannot be explained by concerns that the current stabilization program will break down. First, the share of dollars in total money holdings was almost as high in 1991, when inflation rates were falling substantially, as they were in 1989, when fears of an uncontrolled hyperinflation had much more basis. Second, interest rates on domestic currency deposits currently are below 1 percent (monthly basis), their lowest level in decades. This suggests that there is considerable confidence in the stabilization program, and that dollarization does not reflect fears of a future hyperinflation.

Finally, dollarization in Argentina did not reflect the effect of the Convertibility Plan announced by the government in March 1991. This program legalized all contracts denominated in dollars and fixed the exchange rate to the dollar. Doing

[8] As one Buenos Aires banker put it, the stabilization program has reduced perceptions of banking-system and cross-border risk, thereby encouraging Argentines to shift their assets closer to home, but to keep them in dollar-denominated form.

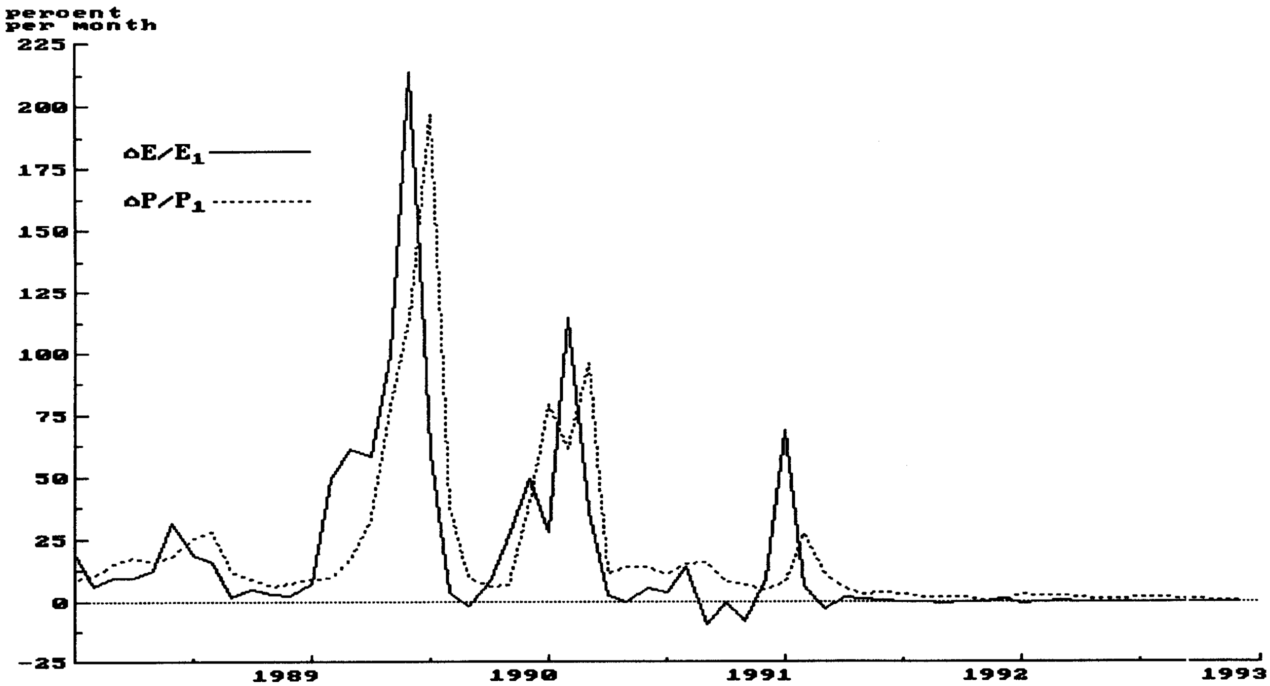

Figure 5a. The rate of nominal exchange rate depreciation ($\Delta E_t/E_{t-1}$) and consumer price inflation ($\Delta P_t/P_{t-1}$).

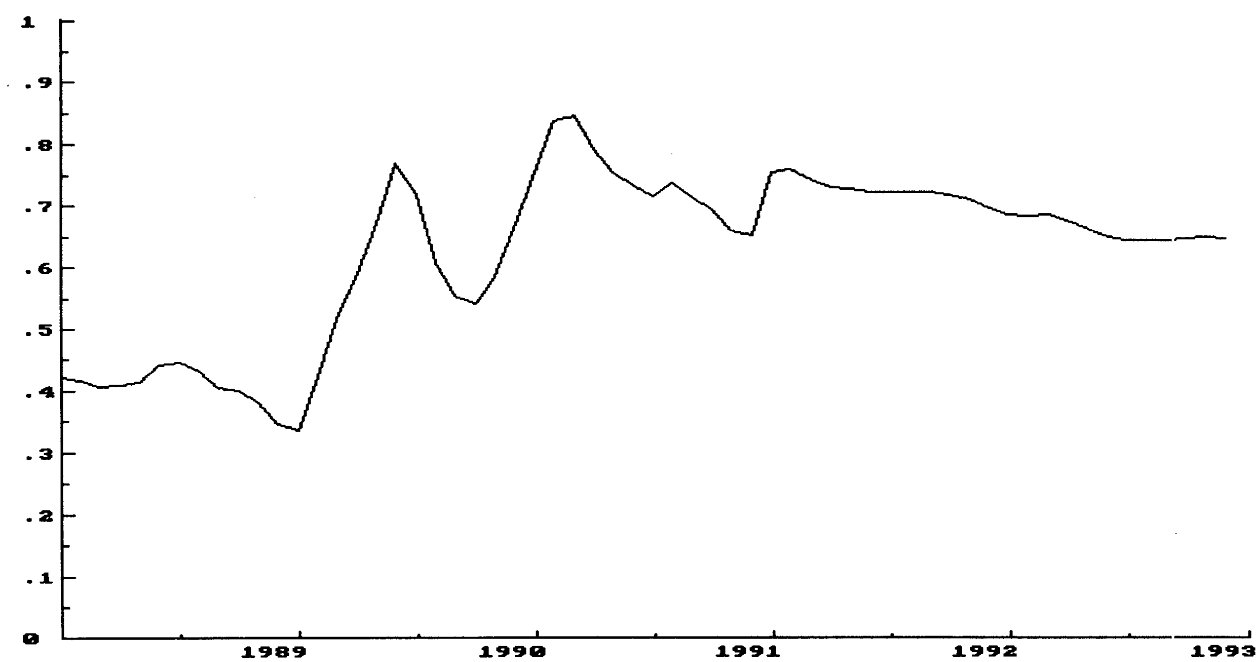

Figure 5b. Fraction of all dollar holdings in total assets ($A/[A+M/E]$).

so facilitated granting loans in dollars, which may have led banks to offer more attractive terms for dollar deposits, thereby increasing dollar deposits. However, the Convertibility Plan was announced well after the surge in dollar-deposit and dollar currency holdings in 1990.

4.4 Irreversibility in Dollarization

The phenomenon of continuing dollarization alongside successful macroeconomic stabilization is not unique to Argentina. In Bolivia, the share of foreign currency deposits in broad money holdings rose steadily from about 10 percent at the beginning of 1986, shortly after their own hyperinflation, to nearly 80 percent in September 1991; see Clements and Schwartz (1992). This occurred in spite of a successful stabilization of inflation to below 20 percent annually in recent years. Similar developments have taken place in Peru, where the share of dollar deposits in broad money has grown rapidly in the past two years and now stands at about 65 percent, notwithstanding a substantial decline in inflation recently.

To explain these trends, Guidotti and Rodriguez (1992) focus on the role of fixed costs in switching from the use of local currency for transactions to the use of foreign currency; see also Sturzenegger (1992). These costs derive from the difficulties (coordination problems, menu costs, etc.) that arise during the transition from using one currency to using another, when agents are forced to deal in both currencies simultaneously. As a result of these costs, small increases in the opportunity cost of holding domestic currency (due to increased inflation and/or exchange rate depreciation) may not induce a switch from domestic currency to dollars. Conversely, once agents have switched to a foreign currency because the cost of holding domestic currency increased substantially, subsequent reductions in inflation may not induce a shift back to local currency. Enzler, Johnson, and Paulus (1976) and Simpson and Porter (1980) developed similar models, but with the choice being between assets in a single currency with different opportunity costs.

Guidotti and Rodriguez's model provides the starting point for an explanation of recent trends in Argentine money demand. It implies that there is a "ratchet effect" of inflation on money demand, reducing money demand when inflation rises, but increasing this demand by a lesser extent when inflation falls. This rationalizes the secular decline in the demand for both M1 and M3 observed over the last 15 years in Argentina, notwithstanding the current historically low levels of inflation. It also explains how the recent surge in dollar holdings may be a response to the spike in inflation during 1989 and 1990, as well as to the Plan Bonex confiscation of bank deposits. These events, which imposed severe losses upon holders of local currency assets, motivated a sharp, substantial shift into dollar-denominated assets. Because these dollar assets are, for almost all purposes, as functional domestically as peso assets, there may be little incentive to switch back to pesos for the foreseeable future.

The Guidotti-Rodriguez model fails to resolve why most of the substitution out of peso-denominated assets appears to have occurred from bank time deposits rather than from transactions media such as demand deposits or peso currency. Presumably, time deposits represent vehicles for savings rather than transactions, and therefore it would have been relatively costless to switch back from dollars to peso-denominated deposits, once inflation declined. This suggests that there may be other reasons for irreversibilities in portfolio choices than the transactions cost of switching currencies.

Somewhat puzzlingly, Argentines shifted their assets out of bank deposits into non-interest-bearing dollar currency rather than into interest-bearing accounts abroad. One possible explanation is that by 1989, the wealthiest and most financially sophisticated Argentines already had moved their savings abroad, so that only less wealthy households with limited access to foreign instruments continued to hold most of their savings in the domestic banking system. When peso-denominated assets were perceived to be too risky, holding dollar currency may have represented the best available alternative. Also, at very high rates of inflation, the extra interest earned abroad is trivially small compared to the rate of exchange rate depreciation, which both dollar currency and dollar deposits abroad earn.

5 Irreversibility and Money Demand

Both peso and dollar holdings would be helpful for investigating irreversibility in dollarization. Unfortunately, data on dollar currency holdings, which probably comprise the bulk of dollar-denominated assets in Argentina, are available only since 1988 and on a quarterly basis. With irreversibility, however, increases in inflation should induce permanent (or at least long-lasting) reductions in peso-denominated assets as well as permanently higher holdings of dollars. Hence, this section models the demand for peso-denominated broad money and test for an inflationary ratchet effect. Section 5.1 sketches the static theory-model for money demand and describes the data. Section 5.2 analyzes integration and cointegration properties of the data. The evidence on cointegration ties back directly to the theory, and provides the foundation for development of a parsimonious single-equation error correction model for money demand in Sections 5.3 and 5.4. From the error correction model, Section 5.5 derives an implicit measure of the demand for dollar assets, which is numerically similar to actual data on dollar holdings. Thus, the ratchet may proxy for dollar holdings, which relaxes the draconian assumption of true irreversibility.

5.1 The Demand for Peso-denominated Assets

The standard theory of money demand posits:

$$M^d/P = q(Y, \mathbf{R}), \tag{1}$$

where M^d is nominal money demanded, P is the price level, Y is a scale variable, and $\mathbf{R}$ (in bold) is a vector of returns on various assets. The function $q(\cdot, \cdot)$ is increasing in Y, decreasing in those elements of $\mathbf{R}$ associated with assets excluded from M, and increasing in those elements of $\mathbf{R}$ for assets included in M.

We consider three assets: broad money (M3), domestic goods, and dollars. Their nominal returns are denoted R, Δp, and Δe, where E is the exchange rate (domestic/foreign), variables in lower case are in logarithms, and Δ is the difference operator. This choice of assets and returns seems reasonable. Relatively few peso instruments outside of M3 were held in significant quantities during most of the sample period.[9] Also, the interest rate on dollar deposits was small and unvarying relative to Δe, so it was excluded in calculating the return on dollar-denominated assets.

We consider (1) in its standard log-linear form, with two modifications. First, the scale variable is omitted, as in Cagan's (1956) money-demand model for hyperinflationary economies.[10] Second, following Enzler, Johnson, and Paulus (1976), Simpson and Porter (1980), Piterman (1988), Melnick (1990), and Ahumada (1992) *inter alia*, we include a ratchet variable, which is the maximum inflation rate to date, denoted Δp^{max}. Thus, (1) has the following form:

$$m - p \;=\; \gamma_0 \;+\; \gamma_1 R \;+\; \gamma_2 \Delta p \;+\; \gamma_3 \Delta e \;+\; \gamma_4 \Delta p^{max}\ . \tag{2}$$

Anticipated signs of coefficients are $\gamma_1 > 0$, $\gamma_2 < 0$, $\gamma_3 < 0$, and $\gamma_4 \leq 0$. Broad money is composed primarily of interest-bearing deposits, so the interest rate R should exert a positive effect on money demand. The coefficients on Δp and Δe should be negative: goods and dollars are alternatives to holding money. Since Δp^{max} rises monotonically throughout the sample, a strictly negative γ_4 implies irreversible reductions in money demand due to increases in the rate of return on alternative assets.[11]

The data are M3, as measured by all peso-denominated currency and domestic bank deposits (M, millions of pesos); the domestic consumer price index (P, 1968 = 1.00); the interest rate on domestic peso-denominated fixed-term bank deposits (R, fraction at a monthly rate); and the free-market exchange rate (E, in pesos per dollar). All data are monthly and seasonally unadjusted for January 1977–January 1993. The Appendix provides further details.

Figure 6 plots the two central variables, m and p. Sharp increases in both are visible around 1985 and 1989. Figure 7 graphs the log of real money $(m - p)$ and the negative of the ratchet variable Δp^{max}. Real money initially increases gradually, then falls abruptly by 20% in 1982. After continuing to fall through 1984, real money increases until the hyperinflation in 1989, when it plummets to approximately half its

[9] However, assets held abroad by Argentine residents are excluded and have been important in discussions of capital flight; see above.

[10] A preliminary investigation found little role for Y in the cointegration analysis or in error-correction modeling. This is consistent with Ahumada's (1992) evidence on currency demand, and may be due to the relatively stationary nature of real GDP in Argentina over the last 15 years.

[11] Ratchet effects are possible for both the rate of inflation and the rate of exchange rate depreciation (i.e., Δp^{max} and Δe^{max}). However, only the inflation ratchet Δp^{max} mattered empirically in either the system or single-equation analysis below, so we omit discussion of Δe^{max}.

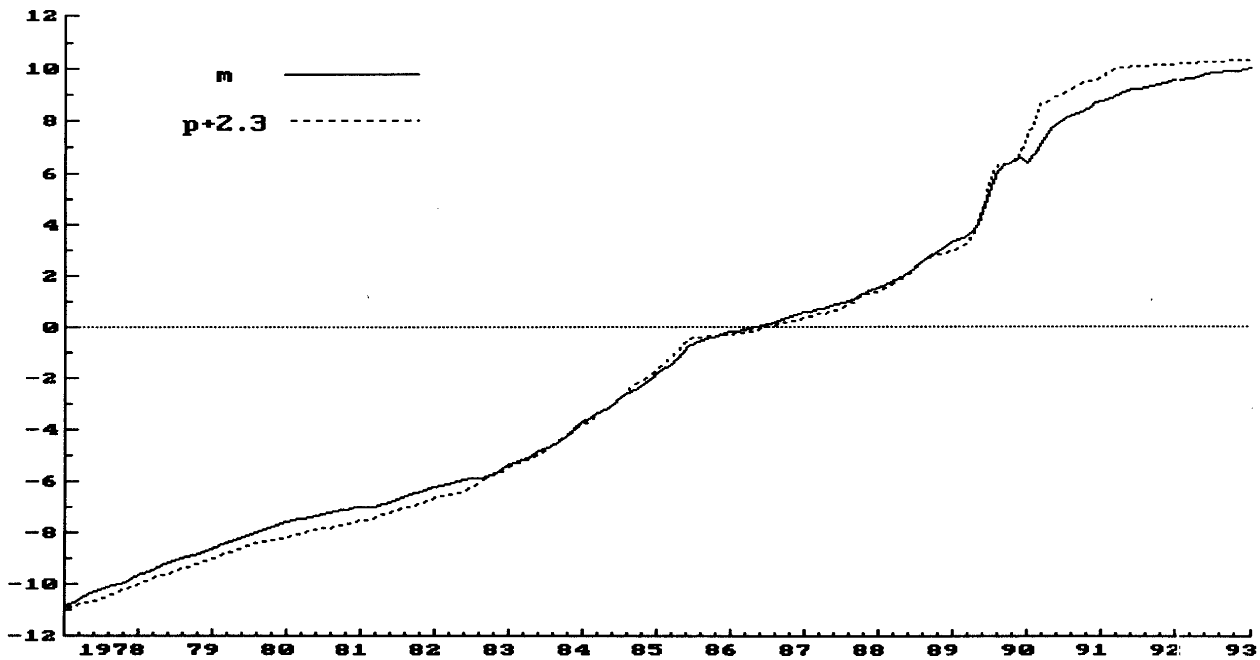

Figure 6. The logarithms of nominal money (m) and the consumer price index (p), adjusted for means.

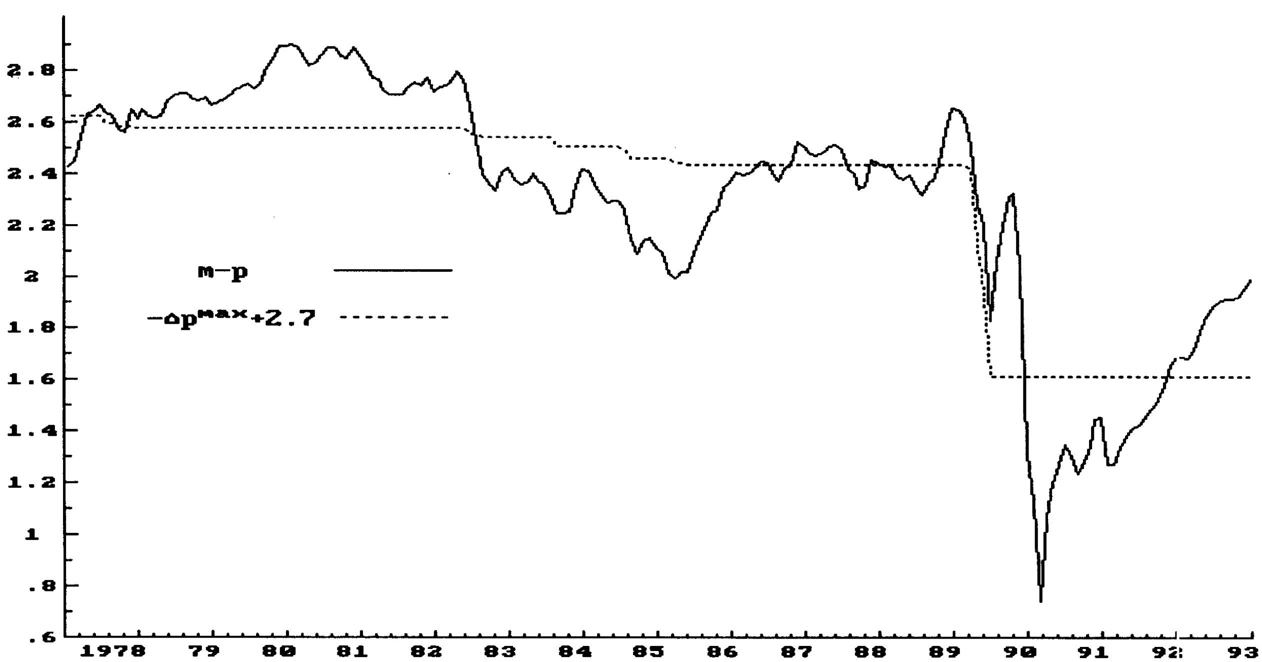

Figure 7. The logarithm of real money ($m - p$) and the negative of the maximal inflation rate (Δp^{max}), adjusted for means.

"pre-hyper" level. Even after very low inflation during 1991–1992, real money had not returned to its level of early 1989. The declines in real money are closely correlated with increases in the ratchet variable, although the stability of a relation between these variables may be an issue, noting the remaining large deviations between them.

Figure 8 plots the (monthly) interest and inflation rates, which move closely together, albeit with inflation being more volatile on a month-to-month basis. Figure 9 graphs the interest rate and the depreciation in the nominal exchange rate, which also move closely together, with exchange rate depreciation being highly volatile. That said, real ex post *monthly* returns are commonly in excess of (plus-or-minus) two per cent, in large part owing to the great variability in the inflation rate.

5.2 Integration and Cointegration

This subsection presents unit root tests for the variables of interest. Then, Johansen's maximum likelihood procedure is applied to test for cointegration among real money, the interest rate, inflation, exchange rate depreciation, and the ratchet variable.

Before modeling peso money demand, it is useful to determine the orders of integration for the variables considered. Table 2 lists augmented Dickey-Fuller (1981) (ADF) statistics for nominal money, prices, the exchange rate, real money, the nominal interest rate, the ratchet variable, the ex post real interest rate, and the spread between the nominal interest rate and the rate of nominal exchange rate depreciation. The deviation of the estimated largest root from unity is in parentheses, and should be zero if there is a unit root in the series. Unit root tests are given for the original variables (in logs where necessary), for their changes, and for the changes of the changes. This permits testing whether a given series is I(0), I(1), I(2), or I(3), albeit in a pairwise fashion for adjacent orders of integration.

Empirically, all variables appear to be integrated of order two or lower. Nominal money, prices, and the exchange rate appear to be I(2). Real money, the nominal interest rate, inflation, and the inflation ratchet variable appear to be I(1).[12] The ex post real interest rate and $R - \Delta e$ appear stationary. Two caveats apply. First, the ADF statistic for testing whether real money is I(1) or I(2) is insignificant at the 5% level ($t_{ADF} = -3.16$). However, the estimated root is 0.48 ($= 1 - 0.62$), which numerically is very far from unity. As is evident from Figure 10, the behavior of $\Delta(m - p)$ over time is suggestive of an I(0) process, with numerous crossings of its mean. The series is highly heteroscedastic in the late 1980s, which could result in the ADF statistic having low power to detect that $\Delta(m - p)$ is I(0) rather than I(1). By contrast, the growth rate of nominal money Δm (plotted in Figure 11) exhibits the long swings characteristic of a unit root process. Thus, $m - p$ is viewed as being I(1).

[12]The variables Δp and Δp^{max} appear to have the same order of integration, which is sensible in light of their algebraic relationship. See Granger and Hallman (1991) on nonlinear transformations of integrated variables.

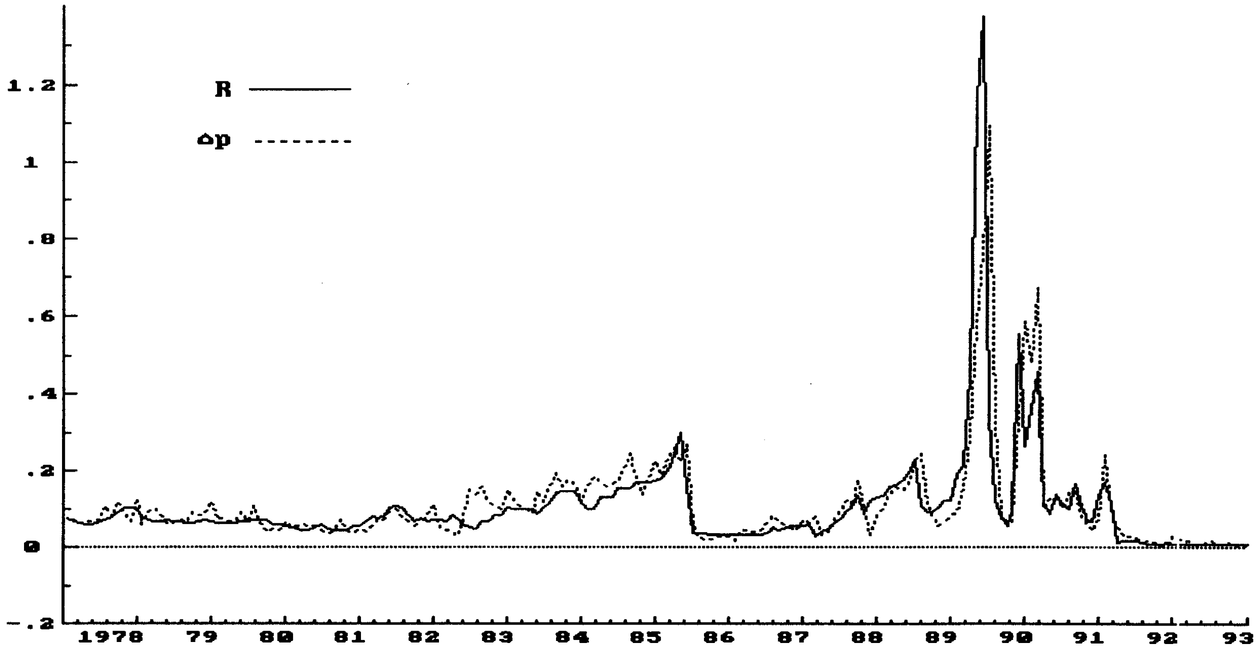

Figure 8. The nominal interest rate (R) and rate of inflation (Δp).

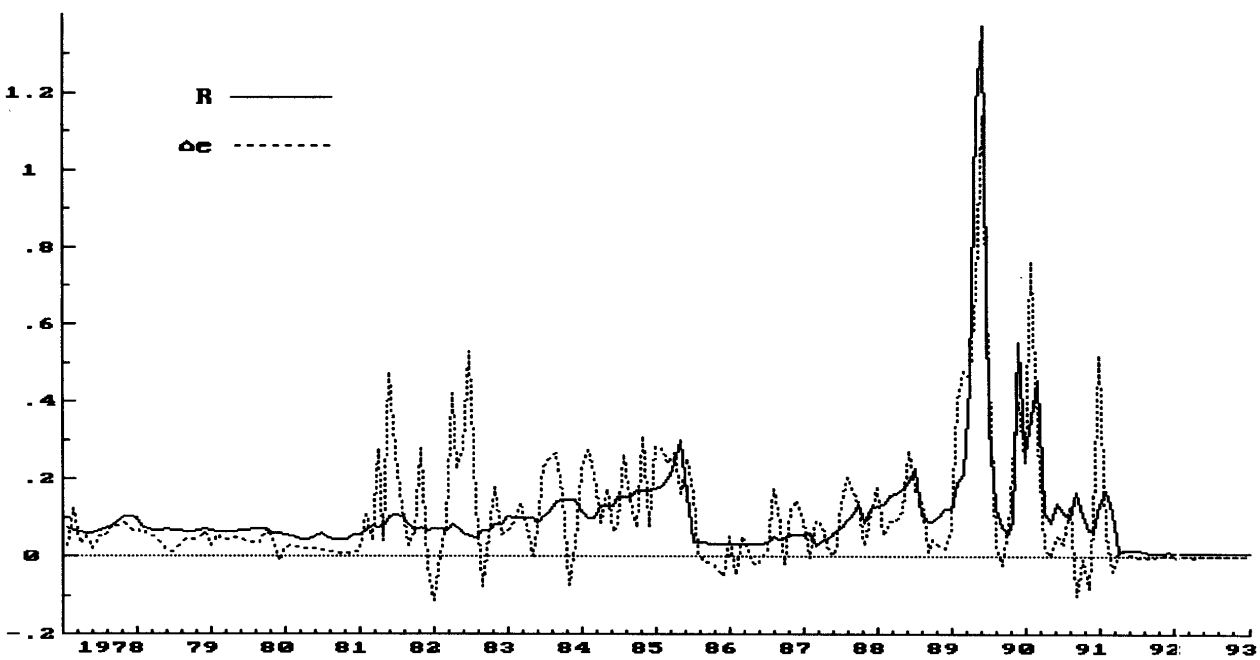

Figure 9. The nominal interest rate (R) and the rate of nominal exchange rate depreciation (Δe).

Table 2.
ADF(12) Statistics for Testing for a Unit Root

	Variable							
Null Order	m	p	e	$m-p$	R	Δp^{max}	$R-\Delta p$	$R-\Delta e$
I(1)	−2.90	−3.20	−3.20	−3.42	−2.11	−2.03	−4.19**	−2.70
	(−0.01)	(−0.02)	(−0.03)	(−0.08)	(−0.18)	(−0.02)	(−1.26)	(−0.67)
I(2)	−2.04	−2.49	−2.34	−3.16	−5.04**	−3.72*	−5.93**	−7.82**
	(−0.16)	(−0.19)	(−0.28)	(−0.62)	(−2.94)	(−0.51)	(−6.65)	(−9.18)
I(3)	−4.98**	−4.31**	−5.22**	−4.99**	−8.36**	−5.51**	−6.91**	−8.93**
	(−2.79)	(−2.46)	(−3.97)	(−4.69)	(−13.07)	(−3.40)	(−19.00)	(−20.98)

Notes:

1. For a given variable and null order, two values are reported: the twelfth order augmented Dickey-Fuller (1981) statistic, denoted ADF(12); and (in parentheses) the estimated coefficient on the lagged variable, where that coefficient should be zero under the null hypothesis. A constant term and trend are included in the corresponding regressions. The maximum available sample is used, and varies slightly across variables and null order.

2. For any variable x and a null order of I(1), the ADF(12) statistic is testing a null hypothesis of a unit root in x against an alternative of a stationary root. For a null order of I(2) [I(3)], the statistic is testing a null hypothesis of a unit root in Δx [$\Delta^2 x$] against an alternative of a stationary root in Δx [$\Delta^2 x$].

3. Here and elsewhere in this paper, asterisks * and ** denote rejection at the 5% and 1% critical values. The critical values for this table are from MacKinnon (1991).

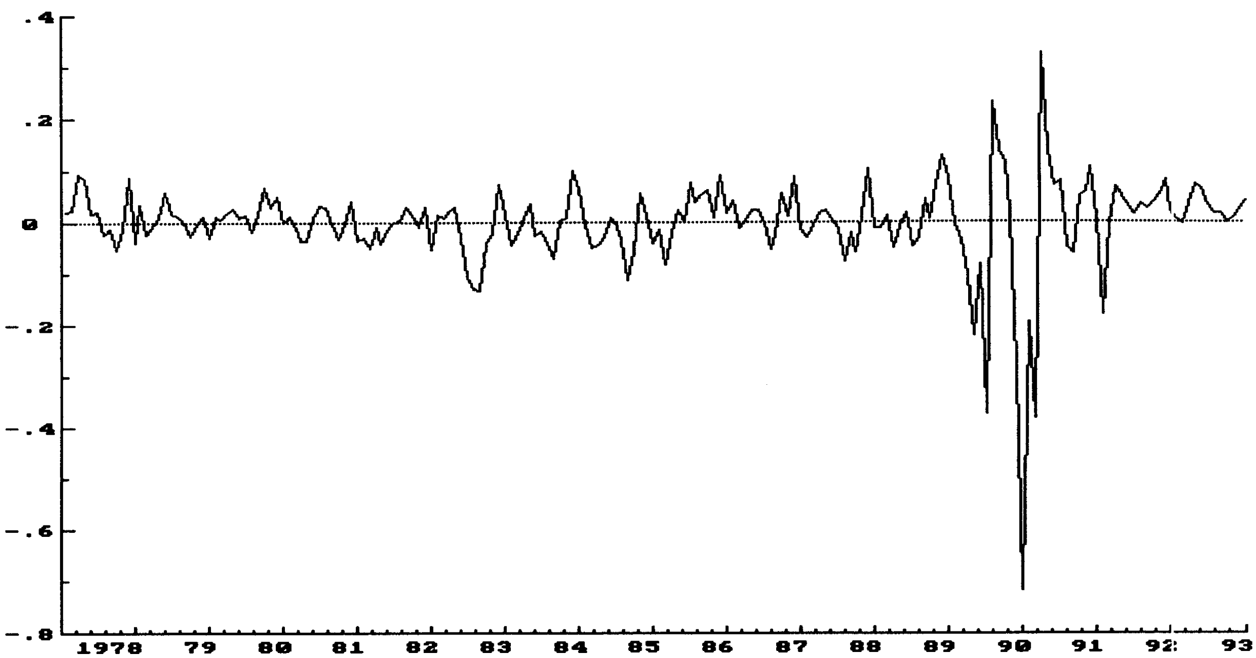

Figure 10. The monthly growth rate of real money ($\Delta[m-p]$).

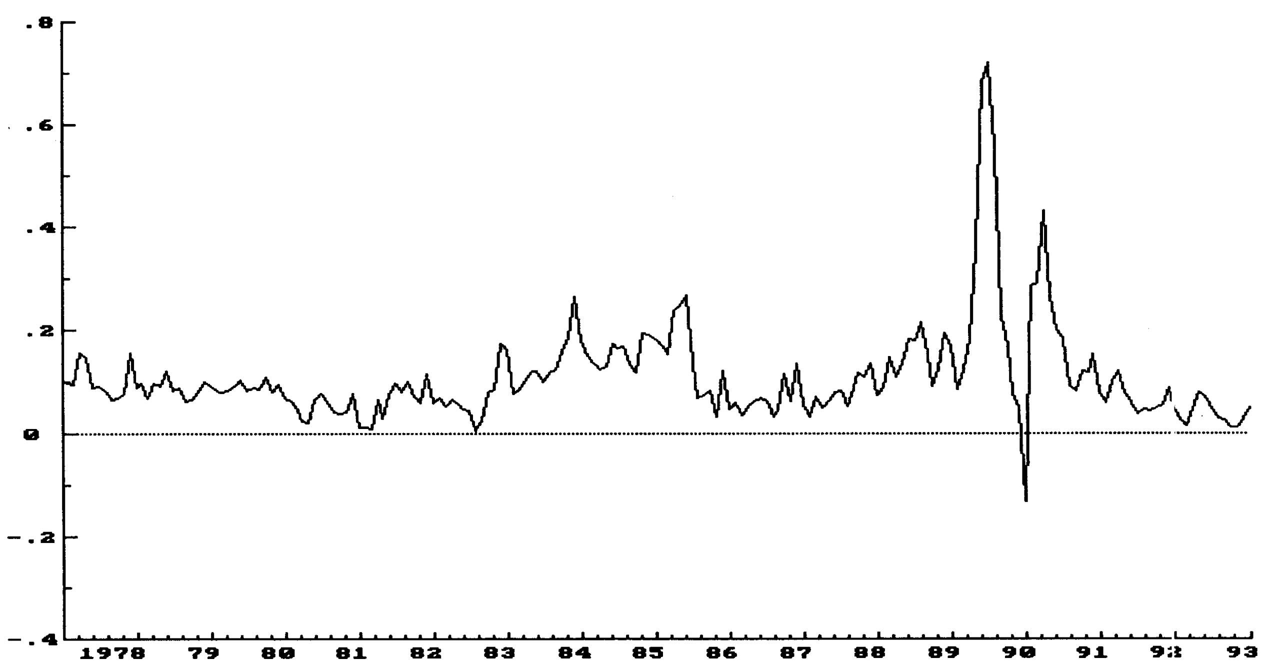

Figure 11. The monthly growth rate of nominal money (Δm).

Second, a parallel situation exists for testing whether $R - \Delta e$ is I(0) or I(1), with the corresponding root being 0.33 and $t_{ADF} = -2.70$.[13]

Different approaches exist for modeling possibly cointegrated I(2) variables. Johansen (1992b) proposes and implements a unified (vector autoregressive) system approach for the entire testing sequence going from I(2) to I(1) to I(0). His empirical application uses data on U.K. narrow money demand, which appear to have the same orders of integration as the Argentine series above. For the U.K. data, Johansen (1992b) tests for and finds that nominal money and prices (which are I(2)) cointegrate with a $(+1 : -1)$ cointegrating vector to give real money, which is I(1). He then tests for and finds that real money, inflation, real income, and interest rates (all of which are I(1)) cointegrate.

While econometrically appealing, Johansen's sequential procedure is not yet generally available or easily programmed, so we adopt a similar but simpler approach. From the ADF statistics, the I(2) Argentine variables m and p appear to cointegrate as the I(1) variable $m - p$. Thus, our cointegration analysis *begins* with the I(1) variables $m - p$, R, Δp, Δe, and Δp^{max}.

Table 3 reports the standard statistics and estimates for Johansen's procedure, as applied to these data.[14] The maximal eigenvalue and trace eigenvalue statistics (λ_{max} and λ_{trace}) strongly reject the null of no cointegration in favor of one cointegrating relationship, and possibly in favor of more than one.[15] Parallel statistics with a degrees-of-freedom adjustment (λ^a_{max} and λ^a_{trace}) give somewhat less strong rejections, but the evidence still favors one cointegrating vector.

Table 3 also reports the standardized eigenvectors and adjustment coefficients, denoted β' and α in a common notation. The first row of β' is the estimated cointegrating vector, which can be written in the form of (2):

$$m - p \;=\; \widehat{\gamma_0} + 6.72R - 6.57\Delta p - 6.14\Delta e - 1.19\Delta p^{max} . \qquad (3)$$

All coefficients have their anticipated signs. Numerically, the coefficients on R and Δp are approximately equal in value and opposite in sign. Statistically, that restriction cannot be rejected: $\chi^2(1) = 0.004$ [0.95], where the p-value is in square brackets; see Johansen and Juselius (1990) for the form of the test. Thus, the nominal interest rate and inflation enter the long-run money demand function as the ex post real rate, with a semi-elasticity of about six, which is about one-half at annual rates. The numerical

[13]It may be surprising that $m - p$ and Δp are I(1). In the United States, real money and inflation usually appear to be stationary, depending upon the sample period and precise definitions of the variables. However, real money and inflation do appear to be I(1) for some developed countries, such as the United Kingdom, as discussed below.

[14]The VAR for Johansen's procedure has seven lags of each variable, thereby allowing for 6-month lags in growth rates of the variables. For seasonally unadjusted data, lags at seasonal frequencies may be important. Additional lags (including annual lags) are statistically insignificant.

[15]Economically, this system might have three cointegrating relations: money demand, $R - \Delta p$, and $\Delta e - \Delta p$.

Table 3.
A Cointegration Analysis of the Argentine Money Demand Data

Eigenvalues	0.194	0.125	0.119	0.036	0.001
Hypotheses	$r=0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 4$
λ_{max}	38.9**	24.0	22.9*	6.7	0.1
λ^a_{max}	31.3	19.3	18.4	5.4	0.1
95% critical value	33.5	27.1	21.0	14.1	3.8
λ_{trace}	92.5**	53.6*	29.7	6.8	0.1
λ^a_{trace}	74.5*	43.2	23.9	5.5	0.1
95% critical value	68.5	47.2	29.7	15.4	3.8
	Standardized eigenvectors β'				
	$m-p$	Δp	R	Δp^{max}	Δe
	1	6.57	−6.72	1.19	6.14
	0.05	1	−0.38	0.06	−0.19
	-0.04	−0.88	1	−0.02	0.01
	1.74	−13.27	21.67	1	−3.70
	2.94	10.16	−9.00	4.28	1
	Standardized adjustment coefficients α				
$m-p$	−0.042	0.266	0.029	−0.007	0.000
Δp	0.027	−0.482	0.118	0.006	0.000
R	0.051	0.016	0.143	0.007	0.002
Δp^{max}	0.015	0.064	0.261	0.002	0.000
Δe	−0.076	0.166	−0.133	0.027	0.001
	Weak exogeneity test statistics				
	$m-p$	Δp	R	Δp^{max}	Δe
	9.30**	3.27	8.09**	3.88*	6.05*

Notes:

1. The vector autoregression includes seven lags on each variable ($m-p$, Δp, R, Δp^{max}, Δe), a constant term, and monthly dummies. The estimation period is 1978(2)–1993(1).

2. The statistics λ_{max} and λ_{trace} are Johansen's maximal eigenvalue and trace eigenvalue statistics for testing cointegration. The null hypothesis is in terms of the cointegration rank r and, e.g., rejection of $r=0$ is evidence in favor of at least one cointegrating vector. The statistics λ^a_{max} and λ^a_{trace} are the same as λ_{max} and λ_{trace}, but with a degrees-of-freedom adjustment. The critical values are taken from Osterwald-Lenum (1992, Table 1).

3. The weak exogeneity test statistics are evaluated under the assumption that $r=1$ and so are asymptotically distributed as $\chi^2(1)$ if weak exogeneity of the specified variable for the cointegrating vector is valid.

values of these elasticities seem reasonable, and are similar to those obtained in studies of broad money demand for other countries. For instance, Taylor's (1986) error correction models of M2 demand for the Netherlands, Germany, and France imply elasticities of -0.91, -2.67, and -0.42 for annual inflation. However, while elasticities may be similar, the implications for actual money demand differ because the paths of interest rates and inflation are not the same across countries. The coefficient on Δe implies lower domestic money holdings at higher rates of exchange rate devaluation. Finally, for each additional percent in the maximal monthly inflation rate over the relative past, the coefficient on the ratchet variable Δp^{max} implies approximately one percent lower money holdings.

The coefficients in the first column of α measure the feedback effect of the (lagged) disequilibrium in the cointegrating relation onto the variables in the VAR. Specifically, -0.042 is the estimated feedback coefficient for the money equation. The negative coefficient implies that lagged excess money induces smaller holdings of current money. Its numerical value implies slow adjustment to remaining disequilibrium. The estimated coefficient is numerically somewhat smaller than those for quarterly broad money demand (-0.26, -0.15, and -0.20 in Taylor (1986)) and monthly currency demand (-0.14 for Argentina in Ahumada (1992)). However, smaller adjustment coefficients are plausible with higher frequency data and for broader aggregates.

The last row of Table 3 reports values of the statistic for testing weak exogeneity of a given variable for the cointegrating vector. Equivalently, the statistic tests whether or not the corresponding row of α is zero; see Johansen (1992a, 1992b). If it is zero, disequilibrium in the cointegrating relationship does not feed back onto that variable. Surprisingly, inflation is weakly exogenous, as may be Δp and Δp^{max} jointly ($\chi^2(2) = 5.56$ [0.062]). However, the interest rate and the exchange rate are not weakly exogenous, justifying a systems approach to analyzing cointegration.

For comparison with (3), Engle and Granger's (1987) test of cointegration obtains:

$$m - p = 2.76 + 0.27R - 0.77\Delta p + 0.11\Delta e - 1.03\Delta p^{max} \tag{4}$$

$$T = 180 \ [1978(2) - 1993(1)] \quad R^2 = 0.7647 \quad \hat{\sigma} = 23.211\% \quad dw = 0.12$$
$$ADF(0) = -2.02 \quad ADF(6) = -2.86 \quad ADF(12) = -2.63.$$

The coefficients are estimated by OLS, and the ADF statistics are calculated on the residuals from that static regression. None of the statistics are significant at MacKinnon's (1991) 90% critical level. Further, even if cointegration is assumed, the coefficient on Δe has the wrong sign, and the coefficients on R and Δp are minuscule economically. These discrepancies between the Johansen and Engle-Granger procedures may arise because the procedures treat dynamics differently. Kremers, Ericsson, and Dolado (1992) show that the ADF test has low power relative to ECM-based and Johansen procedures unless the dynamics of the process satisfies a "common factor restriction". That restriction is rejected at any reasonable significance level

(LR_{comfac} : $F(35, 117) = 10.19$ for the model in Table 5 below); and the ECMs in the next subsection provide additional evidence against that restriction being valid. Banerjee, Dolado, Hendry, and Smith (1986) show that the static estimates have large finite-sample biases for low values of R^2. Here, even 0.76 may be "low", noting that under cointegration R^2 tends to unity as the sample size increases.

5.3 Error Correction Models of Money Demand

In light of the cointegration results using Johansen's procedure, this subsection develops a parsimonious, conditional, single-equation model for money demand. Such a model is of interest for several reasons. First, a conditional money demand model may be constant, even when the reduced form VAR for Johansen's procedure is nonconstant. As Judd and Scadding (1982) emphasize, constancy is particularly important for money demand equations, and the graphs of the Argentine data suggest large structural breaks. Second, obtaining a well-specified, parsimonious model may be simpler in a single-equation context than in a multiple-equation one.

With the choice of variables and lag length in the VAR above, a seventh-order autoregressive distributed lag (ADL) in $m - p$, R, Δp, Δe, and Δp^{max} is a natural starting point for single-equation modeling. This regression is modified in two ways. First, asymmetric effects for changes in inflation are allowed. Ahumada (1992) finds such asymmetries in modeling Argentine currency demand, with demand being more sensitive to increases in inflation than to decreases in inflation. She captures that econometrically by estimating separate coefficients on the variables $\max(0, \Delta^2 p)$ and $\min(0, \Delta^2 p)$, denoted $\Delta^2 p^{pos}$ and $\Delta^2 p^{neg}$. We adopt an equivalent procedure by adding $\Delta^2 p^{pos}$ and its lags to the ADL above, in which case the coefficients on $\Delta^2 p^{pos}$ and its lags measure the differential effect of positive (rather than negative) accelerations in prices.

Second, the interest rate R on fixed-term bank deposits does not exist for January-March 1990, at the time of the Plan Bonex. We have used the interest rate on saving accounts for these months because they are a close substitute for fixed-term deposits. However, both before and after the missing observations, the two interest rates are not always close, with the differential between them sometimes exceeding several percentage points per month. To address this measurement problem, we include four dummy variables, $\{B_t, B_{t-1}, B_{t-2}, B_{t-3}\}$: one for each of these months and one for April 1990, noting that the first lag of R may well enter the error correction term. These dummies preclude testing the constancy of the equation during the four months following the announcement of the Plan Bonex. However, tests of constancy are feasible on the data before January 1989 and after April 1990, as investigated below.

Estimating the modified ADL obtains the following long-run steady-state solution:

$$m - p = \underset{(0.28)}{3.88} + \underset{(3.14)}{8.39}\,R - \underset{(2.57)}{10.03}\,\Delta p - \underset{(0.97)}{1.18}\,\Delta e - \underset{(0.13)}{1.06}\,\Delta p^{max} \qquad (5)$$

$$T = 180\ [1978(2) - 1993(1)]\,.$$

In comparison to (3), the interest rate and inflation rate coefficients are somewhat larger in absolute value (but are still approximately equal and opposite in sign), Δe has a much smaller effect, and the coefficient on Δp^{max} is virtually unchanged. The last is very precisely estimated, remarkably so, given the large number of coefficients in the ADL.

Autoregressive distributed lags have error correction representations. Table 4 lists the estimated coefficients, standard errors, and test statistics for one such representation, which is our starting point for general-to-specific modeling of Argentine money demand. Monthly (*S*easonal) dummies are denoted S_{t-i}. The error correction coefficient on $(m-p)_{t-1}$ is -0.053, virtually identical to that in Table 3. Current inflation has a highly significant and near minus unit effect on the dependent variable $\Delta(m-p)_t$. That implies that in essence the ECM is modeling Δm_t in the short run, although real money is being determined in the long run through the error correction term. Such a relationship is consistent with Ss-type models of money demand, in which short-run factors determine movements in nominal money given desired bands, and longer-run factors (including the price level) determine the bands themselves. See Miller and Orr (1966), Milbourne (1983), and Smith (1986).

Table 4 and the regressions below include diagnostic statistics for testing against various alternative hypotheses: residual autocorrelation (dw and AR), skewness and excess kurtosis ($Normality$), autoregressive conditional heteroscedasticity ($ARCH$), RESET ($RESET$), heteroscedasticity ($Hetero$), heteroscedasticity quadratic in the regressors (alternatively, functional form mis-specification) ($Form$), non-innovation errors relative to a more general model (Inn), and predictive failure ($Chow$, Chow's prediction interval statistic).[16] The null distribution is designated by $\chi^2(\cdot)$ or $F(\cdot,\cdot)$, the degrees of freedom fill the parentheses, and (for AR and $ARCH$) the lag order is the first degree of freedom. Statistically, the ADL appears well-specified, with no rejections from the tests available. Also, the imposed restriction of long-run price homogeneity is not rejected (LM_p).

The model in Table 4 is valuable for obtaining the long-run solution (5), but it has far too many parameters for many other uses. While no rules guarantee obtaining a successful parsimonious model from the ADL, some intuitive guidelines seemed helpful in simplification. First, the variables $m-p$, R, and Δp^{max} were transformed to current and lagged differences and one lagged level, as in Table 4. Those transformations

[16] For references on the test statistics, see Durbin and Watson (1950, 1951), Box and Pierce (1970), Godfrey (1978), and Harvey (1981, p. 173); Jarque and Bera (1980); Engle (1982); Ramsey (1969); White (1980, p 825) and Nicholls and Pagan (1983) (the latter two on both *Hetero* and *Form*); and Chow (1960).

Table 4.
The Unrestricted Error Correction Representation for Real Money Conditional on Inflation, the Interest Rate, and Changes in the Exchange Rate

Variable	Lag i							
	0	1	2	3	4	5	6	7
$\Delta(m-p)_{t-i}$	−1.0	0.270	0.154	−0.019	0.029	0.204	−0.125	
	(−)	(0.088)	(0.093)	(0.094)	(0.079)	(0.079)	(0.072)	
Δp_{t-i}	−0.768	0.177	−0.041	0.144	0.121	0.168	−0.275	−0.053
	(0.101)	(0.149)	(0.140)	(0.136)	(0.117)	(0.119)	(0.122)	(0.079)
ΔR_{t-i}	0.222	0.031	0.172	0.140	−0.039	0.002	−0.131	
	(0.053)	(0.159)	(0.149)	(0.143)	(0.128)	(0.096)	(0.090)	
$\Delta(\Delta p_{t-i}^{max})$	−0.223	−0.169	0.327	0.599	−0.104	−0.211	0.132	
	(0.155)	(0.184)	(0.281)	(0.297)	(0.268)	(0.264)	(0.317)	
$\Delta^2 p_{t-i}^{pos}$	−0.406	−0.049	0.180	−0.114	−0.168	0.003	0.181	−0.017
	(0.162)	(0.154)	(0.161)	(0.156)	(0.133)	(0.137)	(0.130)	(0.112)
Δe_{t-i}	−0.004	−0.040	−0.014	0.025	−0.040	0.011	0.032	−0.032
	(0.020)	(0.022)	(0.023)	(0.022)	(0.022)	(0.023)	(0.023)	(0.022)
$(m-p)_{t-i}$		−0.053						
		(0.015)						
R_{t-i}		0.441						
		(0.158)						
Δp_{t-i}^{max}		−0.055						
		(0.019)						
B_{t-i}	−0.353	0.178	0.058	0.286				
	(0.139)	(0.078)	(0.073)	(0.084)				
S_{t-i}	0.160		−1.62	−0.08	0.41	−0.21	2.81	
	(0.047)		(1.20)	(1.21)	(1.10)	(1.16)	(1.02)	
S_{t-i-6}		0.06	0.10	−0.55	0.86	0.20	4.35	
		(0.97)	(1.03)	(1.01)	(1.03)	(1.02)	(1.02)	

$T = 180$ [1978(2) – 1993(1)] $R^2 = 0.9679$ $\hat{\sigma} = 2.058\%$ $dw = 2.02$
$LM_p : F(1,116) = 0.08$ $AR : F(7,110) = 0.67$ $ARCH : F(7,103) = 0.92$
$Normality : \chi^2(2) = 0.29$ $RESET : F(3,114) = 1.39$

Notes:

1. The dependent variable is $\Delta(m-p)_t$. Even so, the equation is in levels, not in differences, noting the error correction term.

2. The variables $\{S_{t-i}\}$ are the seasonal dummies, except that S_0 is the constant term. February is S_{t-2}, March is S_{t-3}, etc. For readability, the coefficients and estimated standard errors for the seasonal dummies have been multiplied by 100.

helped obtain a relatively orthogonal set of regressors, making interpretation and simplification easier. Second, shorter lag lengths were preferred to longer ones, except that significant semi-annual lags (which include both fifth and sixth lags in growth rates) were retained because the data are seasonally unadjusted. Third, because of their economic importance, variables directly involved in the long-run solution were not deleted. See Ericsson, Campos, and Tran (1990) and Hendry and Ericsson (1991a, 1991b) for more discussion on general-to-specific modeling.

Straightforward simplification results in the ECM in Table 5. While this ECM is parsimonious relative to the model in Table 4, a variety of additional simplifications are possible. They lead to two separate specifications with virtually identical short- and long-run properties but with substantially different economic interpretations. For reasons that will be readily apparent, the two resulting models are referred to as the real and nominal ECMs, even though both have long-run solutions in terms of real money.

One set of simplifications, which leads to the real ECM, is the following:

1. equal magnitude-opposite sign restrictions on the coefficients in each of the pairs $\{\Delta(m-p)_{t-5}, \Delta(m-p)_{t-6}\}$ and $\{\Delta R_t, \Delta R_{t-1}\}$;
2. reparameterization of $\{\Delta p_t,\ \Delta p_{t-1},\ \Delta p_{t-5},\ \Delta p_{t-6},\ R_{t-1}\}$ as $\{\Delta^2 p_t,\ \Delta^2 p_{t-5},\ \Delta\Delta_6 p_t,\ (\Delta p - R)_{t-1},\ \Delta p_{t-6}\}$, with Δp_{t-6} then restricted to have a zero coefficient;
3. exclusion of all monthly dummies except those for June and December; and
4. exclusion of the dummies for February and March 1990.

The resulting "real" equation is (6).

$$
\begin{aligned}
\widehat{\Delta(m-p)_t} = \; & \underset{\substack{(0.028)\\ [0.035]}}{0.264}\ \Delta(m-p)_{t-1} + \underset{\substack{(0.031)\\ [0.032]}}{0.091}\ \Delta^2(m-p)_{t-5} - \underset{\substack{(0.040)\\ [0.041]}}{0.740}\ \Delta^2 p_t \\
& + \underset{\substack{(0.040)\\ [0.054]}}{0.101}\ \Delta^2 p_{t-5} - \underset{\substack{(0.078)\\ [0.089]}}{0.594}\ \Delta^2 p_t^{pos} + \underset{\substack{(0.018)\\ [0.021]}}{0.059}\ \Delta\Delta_6 p_t \\
& + \underset{\substack{(0.022)\\ [0.018]}}{0.182}\ \Delta^2 R_t + \underset{\substack{(0.044)\\ [0.045]}}{0.536}\ (R-\Delta p)_{t-1} + \underset{\substack{(0.022)\\ [0.022]}}{0.103} \\
& - \underset{\substack{(0.0078)\\ [0.0080]}}{0.0337}\ (m-p)_{t-1} - \underset{\substack{(0.017)\\ [0.019]}}{0.069}\ \Delta e_{t-1} - \underset{\substack{(0.010)\\ [0.010]}}{0.028}\ \Delta p_{t-1}^{max} \\
& - \underset{\substack{(0.038)\\ [0.039]}}{0.216}\ B_t + \underset{\substack{(0.032)\\ [0.020]}}{0.179}\ B_{t-3} + \underset{\substack{(0.64)\\ [0.43]}}{2.45}\ S_{t-6} + \underset{\substack{(0.62)\\ [0.74]}}{5.09}\ S_{t-12}
\end{aligned}
\qquad (6)
$$

Table 5.
The "Intermediate" Error Correction Representation for Real Money Conditional on Inflation, the Interest Rate, and Changes in the Exchange Rate

Variable	Lag i							
	0	1	2	3	4	5	6	7
$\Delta(m-p)_{t-i}$	−1.0	0.295				0.140	−0.153	
	(−)	(0.049)				(0.045)	(0.038)	
Δp_{t-i}	−0.788	0.240				0.146	−0.236	
	(0.081)	(0.083)				(0.051)	(0.055)	
ΔR_{t-i}	0.165	−0.176						
	(0.025)	(0.052)						
$\Delta(\Delta p^{max}_{t-i})$								
$\Delta^2 p^{pos}_{t-i}$	−0.395							
	(0.123)							
Δe_{t-i}		−0.051						
		(0.019)						
$(m-p)_{t-i}$		−0.0452						
		(0.0090)						
R_{t-i}		0.535						
		(0.064)						
Δp^{max}_{t-i}		−0.044						
		(0.011)						
B_{t-i}	−0.185	0.111	−0.006	0.157				
	(0.042)	(0.043)	(0.030)	(0.042)				
S_{t-i}	0.142		−0.96	−0.72	0.39	−0.69	2.74	
	(0.028)		(0.86)	(0.88)	(0.89)	(0.92)	(0.87)	
S_{t-i-6}		0.31	−0.34	−0.82	0.83	−0.09	5.08	
		(0.85)	(0.88)	(0.86)	(0.86)	(0.89)	(0.86)	

$T = 180$ [1978(2) – 1993(1)] $\quad R^2 = 0.9550 \quad \hat{\sigma} = 2.150\% \quad dw = 2.07$
$Inn : F(33, 117) = 1.42 \quad AR : F(7, 143) = 0.49 \quad ARCH : F(7, 136) = 1.32$
$Normality : \chi^2(2) = 0.62 \quad Hetero : F(43, 106) = 1.32 \quad RESET : F(3, 147) = 1.24$

Notes:

1. See notes 1 and 2 for Table 4.

2. The statistic $Inn : F(33, 117)$ tests the restrictions of model in Table 5 relative to the model in Table 4.

$$T = 180\,[1978(2) - 1993(1)] \quad R^2 = 0.9489 \quad \hat{\sigma} = 2.192\% \quad dw = 2.08$$
$$Inn_3 : F(47, 117) = 1.47 \quad Inn_4 : F(14, 150) = 1.46 \quad AR : F(7, 157) = 0.61$$
$$ARCH : F(7, 150) = 2.75^* \quad Normality : \chi^2(2) = 0.78 \quad RESET : F(3, 161) = 0.44$$
$$Hetero : F(26, 137) = 0.98 \quad Form : F(102, 61) = 0.71 \quad Chow : F(33, 131) = 0.76$$

The long-run solution to (6) is:

$$m - p \;=\; 3.05 + 15.93(R - \Delta p) - 2.04\Delta e - 0.84\Delta p^{max} . \qquad (7)$$

Economically, the coefficients in (7) satisfy sign restrictions to be interpretable as a money demand function. Further, the short-run variables and coefficients in (6) have a straightforward interpretation. Each short-term variable enters as a second difference (an acceleration), which is a natural transformation to stationarity for a potentially I(2) variable. The lag lengths on $\Delta^2(m-p)_{t-5}$, $\Delta^2 p_{t-5}$, and $\Delta\Delta_6 p_t$ are consistent with agents' adjustments for seasonality in the data. Finally, the coefficient on $\Delta^2 p_t^{pos}$ is very negative and significant, implying stronger reactions to increasing inflation than to decreasing inflation.

Equation (6) has numerous desirable statistical properties. The restrictions in (6) are not rejected relative to Table 4 (Inn_3) or Table 5 (Inn_4), and the diagnostic tests appear fine other than for the possible presence of ARCH.

Parameter constancy is a critical issue for money demand equations. The Chow statistic is insignificant for estimation through April 1990 and prediction thereafter. Recursive estimation is feasible through December 1989 and provides additional insight on constancy. Figure 12a plots the one-step residuals and the corresponding equation standard errors, i.e., $\{y_t - \hat{\beta}_t' x_t\}$ and $\{0 \pm 2\hat{\sigma}_t\}$ in a common notation. The equation standard error $\hat{\sigma}$ varies little over time. Figure 12b records the "break-point" Chow statistics for the sequence {1984(1)–1989(12), 1984(2)–1989(12), ..., 1989(11)–1989(12), 1989(12)}. While some of the Chow statistics are significant at their one-off 1% critical values, parameter nonconstancy is numerically small (if present at all) for the following reasons. First, $\hat{\sigma}_t$ increases very little over the sample. This constancy is remarkable, given the enormous economic upheavals during the sample period. Second, only three of the 72 corresponding (approximately independent) one-step Chow statistics are significant at their 5% critical values, i.e., about 4% of the sample. Third, none of Hansen's (1992) tests against coefficient nonconstancy with an unknown break point are significant at the 5% level, possibly reflecting inadequate control of size for the sequences of Chow statistics. Figures 12c and 12d plot the recursive estimates and standard error bands for two central variables, $(m-p)_{t-1}$ and Δp_{t-1}^{max}. Both are reasonably constant over time, with narrowing standard error bands reflecting the high information content of the data. While Δp_{t-1}^{max} in the ECM is only moderately significant by the end of the sample, its implied long-run effect is highly significant, as seen in (5).

The simplifications leading to the real ECM are statistically and economically plausible. Still, another set of simplifications is appealing as well:

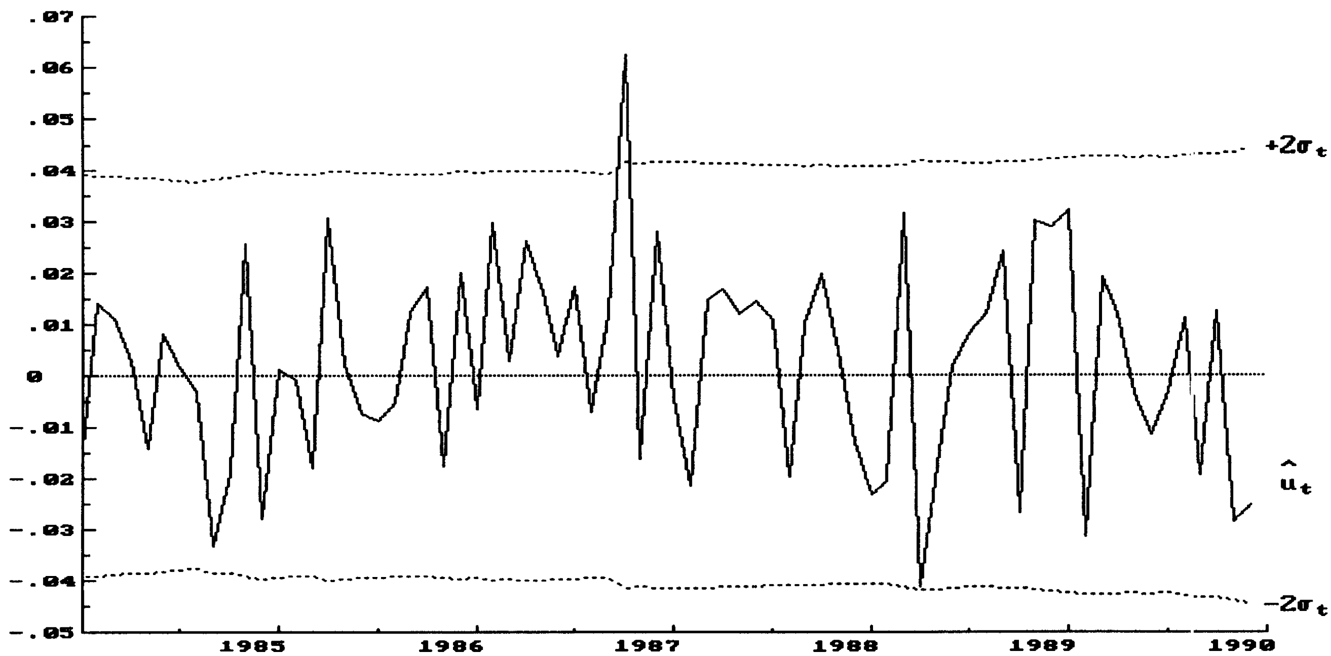

Figure 12a. One-step residuals and the corresponding calculated equation standard errors for a model of $\Delta(m-p)_t$.

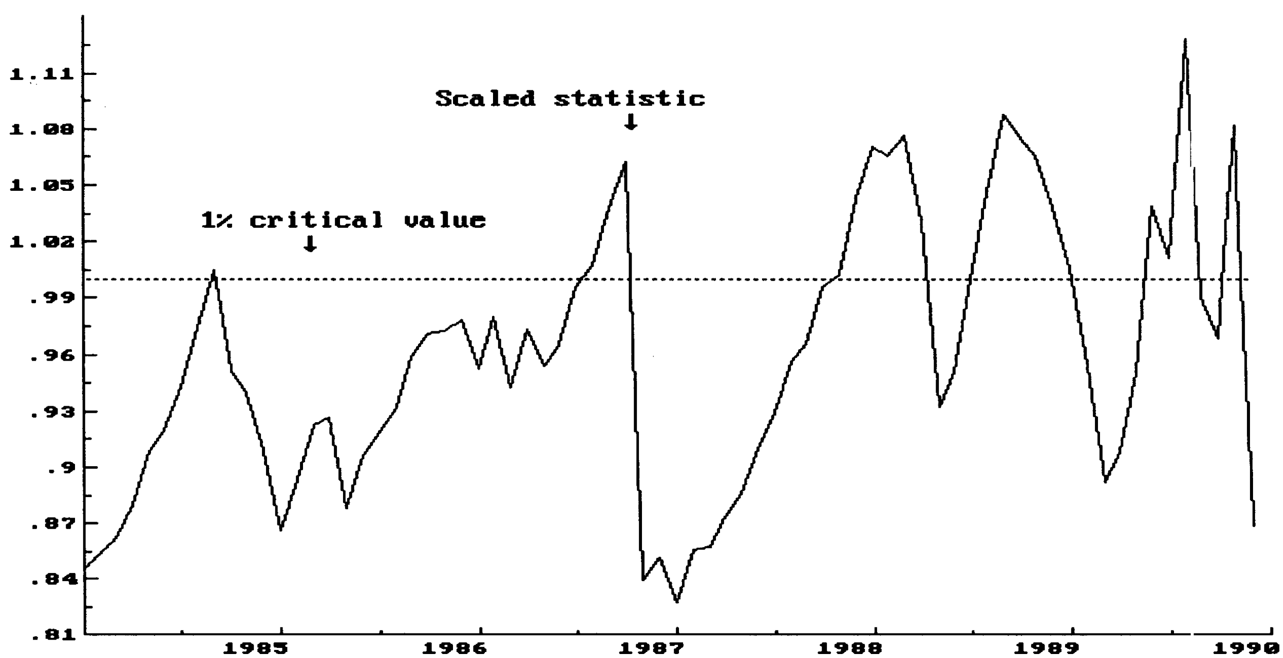

Figure 12b. The sequence of break-point Chow statistics over 1984(1)–1989(12) for a model of $\Delta(m-p)_t$.

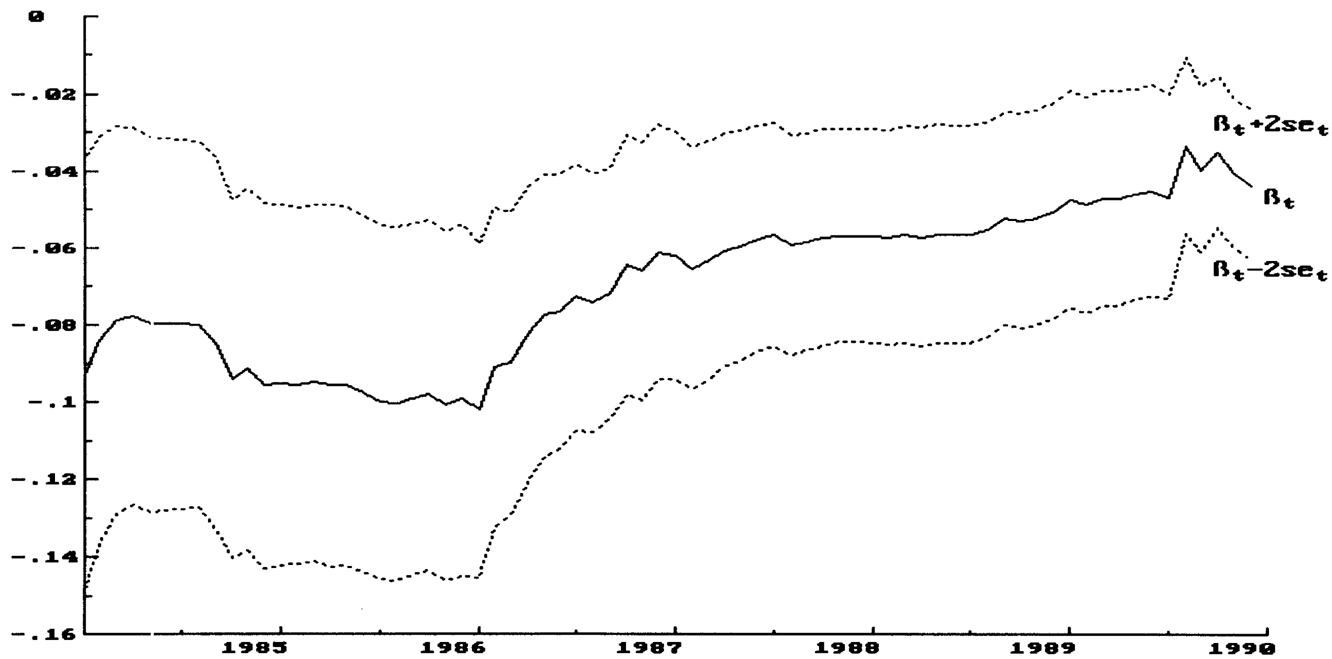

Figure 12c. Recursive estimates of the coefficient on the error correction $(m-p)_{t-1}$ in a model of $\Delta(m-p)_t$.

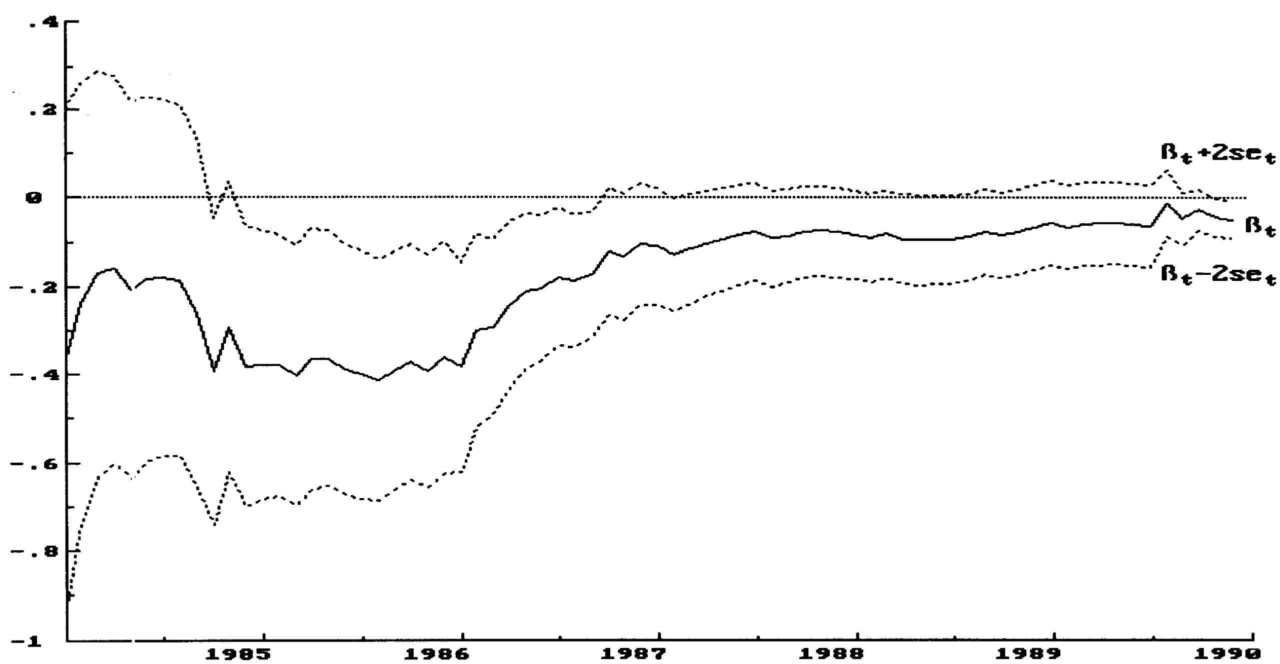

Figure 12d. Recursive estimates of the coefficient on the ratchet variable Δp_{t-1}^{max} in a model of $\Delta(m-p)_t$.

1. equal magnitude-opposite sign restrictions on coefficients in each of the pairs $\{\Delta(m-p)_{t-5}, \Delta(m-p)_{t-6}\}$ and $\{\Delta R_t, \Delta R_{t-1}\}$;
2. equal coefficients on $\Delta(m-p)_{t-5}$ and Δp_{t-5}, which, with #1, implies a reparameterization of $\{\Delta(m-p)_{t-5}, \Delta(m-p)_{t-6}, \Delta p_{t-5}, \Delta p_{t-6}\}$ as $\{\Delta^2 m_{t-5}, \Delta p_{t-6}\}$;
3. reparameterization of $\{\Delta(m-p)_t, \Delta(m-p)_{t-1}, \Delta p_t, \Delta p_{t-1}\}$ as $\{\Delta m_t, \Delta m_{t-1}, \Delta p_t, \Delta p_{t-1}\}$, with Δp_{t-1} then restricted to have a zero coefficient;
4. reparameterization of $\{\Delta p_t, \Delta p_{t-6}\}$ as $\{(\Delta p + \Delta\Delta_6 p)_t, \Delta p_{t-6}\}$, with Δp_{t-6} then restricted to have a zero coefficient; and
5. exclusion of all monthly dummies except those for June and December.

The resulting "nominal" equation is (8).

$$
\begin{aligned}
\widehat{\Delta m_t} = \; & \underset{\substack{(0.029) \\ [0.032]}}{0.295}\, \Delta m_{t-1} + \underset{\substack{(0.032) \\ [0.032]}}{0.142}\, \Delta^2 m_{t-5} + \underset{\substack{(0.017) \\ [0.020]}}{0.083}\, (\Delta p + \Delta\Delta_6 p)_t \\
& - \underset{\substack{(0.060) \\ [0.060]}}{0.302}\, \Delta^2 p_t^{pos} + \underset{\substack{(0.018) \\ [0.012]}}{0.144}\, \Delta^2 R_t + \underset{\substack{(0.038) \\ [0.034]}}{0.508}\, R_{t-1} + \underset{\substack{(0.021) \\ [0.023]}}{0.144} \\
& - \underset{\substack{(0.0076) \\ [0.0083]}}{0.0465}\, (m-p)_{t-1} - \underset{\substack{(0.017) \\ [0.019]}}{0.059}\, \Delta e_{t-1} - \underset{\substack{(0.009) \\ [0.011]}}{0.046}\, \Delta p_{t-1}^{max} \\
& - \underset{\substack{(0.029) \\ [0.021]}}{0.206}\, B_t + \underset{\substack{(0.030) \\ [0.020]}}{0.108}\, B_{t-1} - \underset{\substack{(0.026) \\ [0.014]}}{0.013}\, B_{t-2} + \underset{\substack{(0.024) \\ [0.011]}}{0.133}\, B_{t-3} \\
& + \underset{\substack{(0.62) \\ [0.46]}}{2.94}\, S_{t-6} + \underset{\substack{(0.60) \\ [0.75]}}{5.29}\, S_{t-12}
\end{aligned}
\tag{8}
$$

$T = 180\ [1978(2) - 1993(1)]$ $\quad R^2 = 0.9571$ $\quad \hat{\sigma} = 2.129\%$ $\quad dw = 2.06$
$Inn_3 : F(47, 117) = 1.24$ $\quad Inn_4 : F(14, 150) = 0.77$ $\quad AR : F(7, 157) = 0.32$
$ARCH : F(7, 150) = 1.79$ $\quad Normality : \chi^2(2) = 1.53$ $\quad RESET : F(3, 161) = 0.97$
$Hetero : F(24, 139) = 0.99$ $\quad Form : F(78, 85) = 1.05$ $\quad Chow : F(33, 131) = 0.71$

The long-run solution to (8) is:

$$
m - p \;=\; 3.10 + 10.93R - 13.37\Delta p - 1.26\Delta e - 0.98\Delta p^{max} . \tag{9}
$$

These long-run coefficients are very similar to those in (7). However, the transformation of the dependent variable from $\Delta(m-p)_t$ to Δm_t, along with the resulting near-zero coefficient on inflation, implies short-run adjustment by agents of nominal (not real) money. Hendry and Ericsson (1991b, p. 853) and Baba, Hendry, and Starr (1992) find similar results for narrow money demand in the United Kingdom and the United States. The short-run variables $\{\Delta^2 m_{t-5}, (\Delta p + \Delta\Delta_6 p)_t, \Delta^2 R_t\}$ are interpretable as filters for a potentially I(2) variables, with adjustments for seasonality. Additionally, $(\Delta p + \Delta\Delta_6 p)_t$ is a natural data-based predictor of future (seasonal) inflation, extending the theoretical and empirical developments on such predictors in Flemming (1976), Campos and Ericsson (1988), and Hendry and Ericsson (1991b). As in (7), the coefficient on $\Delta^2 p_t^{pos}$ is large, negative, and very significant.

Statistically, (8) appears reasonably well specified. The restrictions in (8) are not rejected relative to Tables 4 or 5, and no diagnostic tests are rejected. Figure 13a plots the one-step residuals and the corresponding equation standard errors, and the latter are very constant numerically. As Figure 13b shows, the "break-point" Chow statistics for (8) generally are smaller than those for (6), so parameter constancy is plausible. The recursive estimates in Figures 13c and 13d for $(m-p)_{t-1}$ and Δp_{t-1}^{max} are somewhat more constant than those in Figures 12c and 12d.

5.4 Some Properties of the ECMs

Distinguishing between the nominal and real ECMs at an empirical level seems unfruitful because the two models have virtually identical derived coefficients for their solved (restricted) ADL representations. Rather, the two models provide different economic interpretations of the same data evidence. Thus, we discuss several empirical commonalities of these models while allowing for alternative, mutually compatible views on the underlying behavioral patterns generating the data.

First, the long-run solutions to the nominal and real ECMs are very similar. Second, their short-run dynamics imply a large immediate response to changes in the nominal interest rate and a strong asymmetric response to changes in inflation. Adjustment to remaining disequilibria is slow, as implied by their numerically small error correction coefficients. Figure 14 plots the disequilibria as measured by (9). While the series appears stationary, many values are enormous. Fourteen exceed unity in absolute value, meaning that money holdings were more than 250% or less than 40% their desired value. By comparison, Ericsson, Hendry, and Tran (1993) find that disequilibria in U.K. narrow money holdings never approached those levels at any time during the last thirty years. Most of the fluctuations in the Argentine disequilibria are associated with movements in $R - \Delta p$, with the correlation between the two being -0.90.

Third, some of the dummies $\{B_{t-i}\}$ for the months directly following the announcement of the Plan Bonex are significant. However, as implied by the insignificant $Chow(33, 131)$ statistics in (6) and (8), the Plan Bonex had no permanent effect on money demand, separate from its effects on inflation, the nominal interest rate, and the exchange rate. This may be surprising because the Plan Bonex strongly affected the government's credibility in financial markets at the time. However, the implied response of money demand to the dummies is a long distributed lag, given the small adjustment coefficient on the ECM. That feature also may make it difficult to distinguish a persistent but temporary effect from a permanent one, given that the Plan Bonex occurred near the end of the sample.

Fourth, the rate of exchange rate depreciation has a significant long-run effect

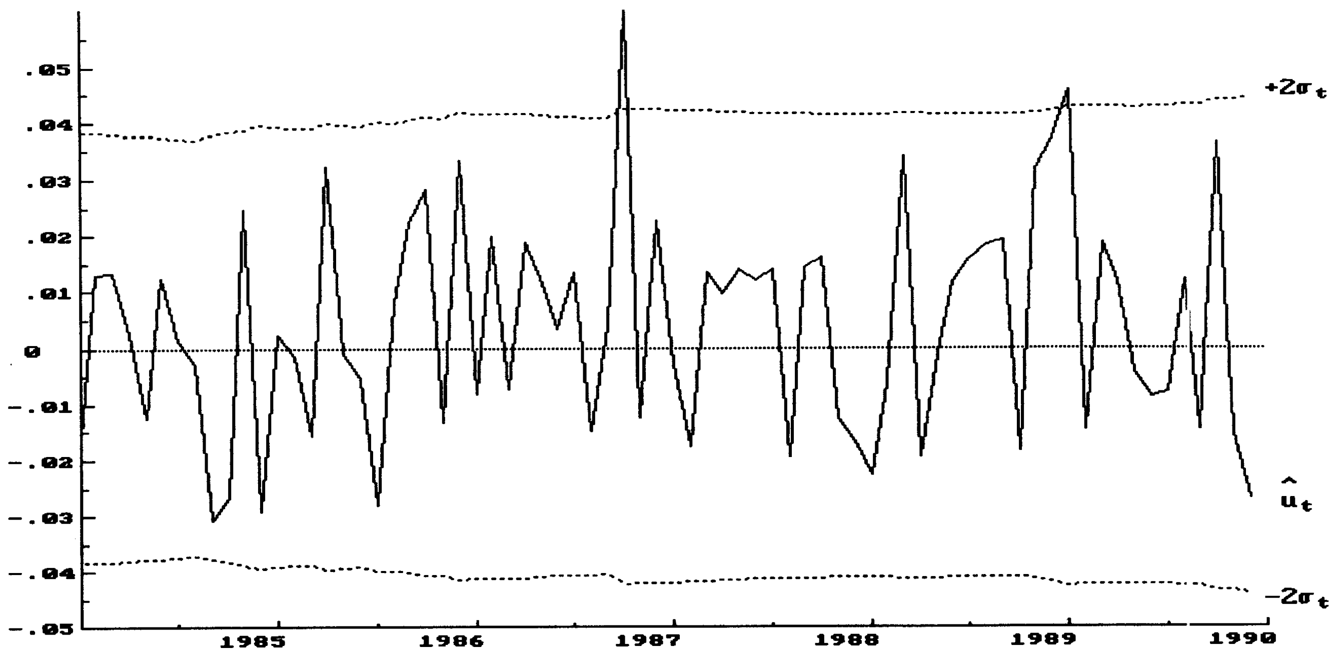

Figure 13a. One-step residuals and the corresponding calculated equation standard errors for a model of Δm_t.

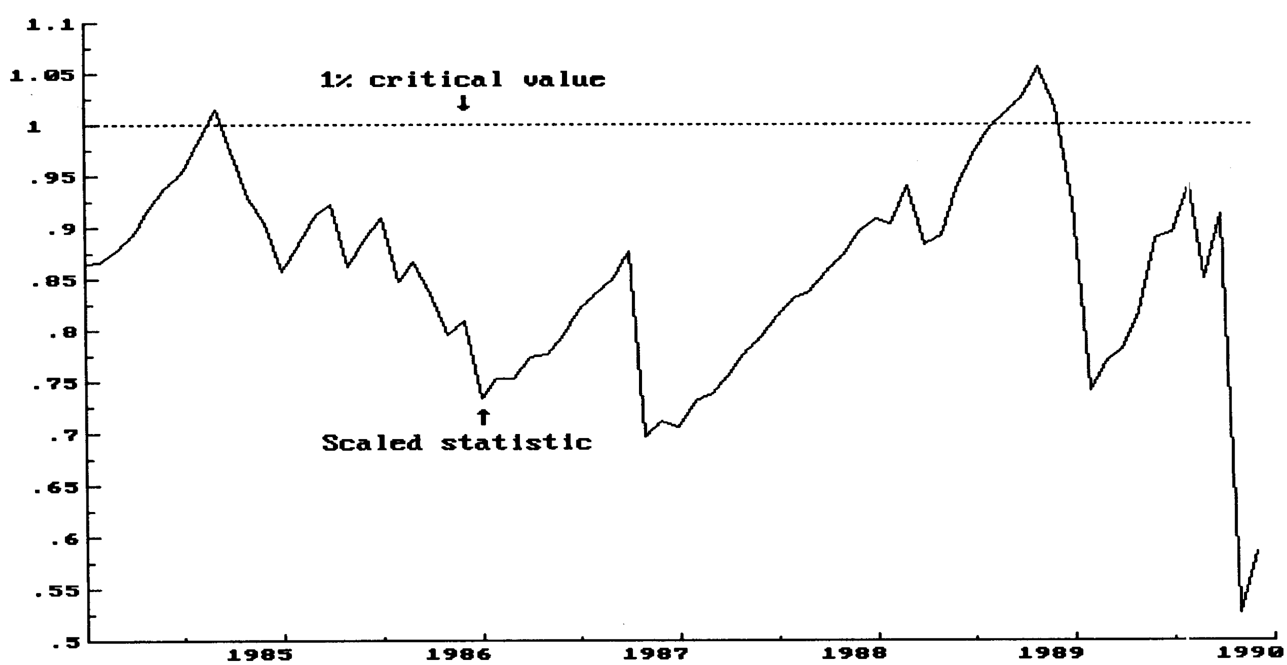

Figure 13b. The sequence of break-point Chow statistics over 1984(1)–1989(12) for a model of Δm_t.

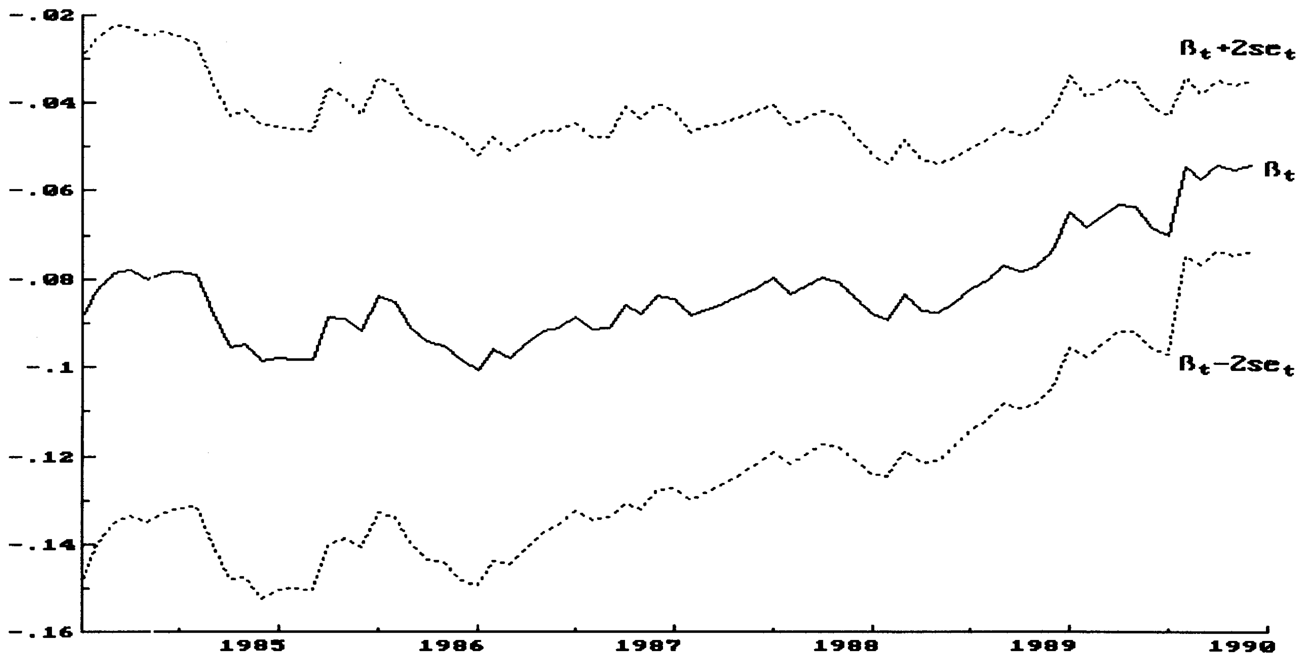

Figure 13c. Recursive estimates of the coefficient on the error correction $(m-p)_{t-1}$ in a model of Δm_t.

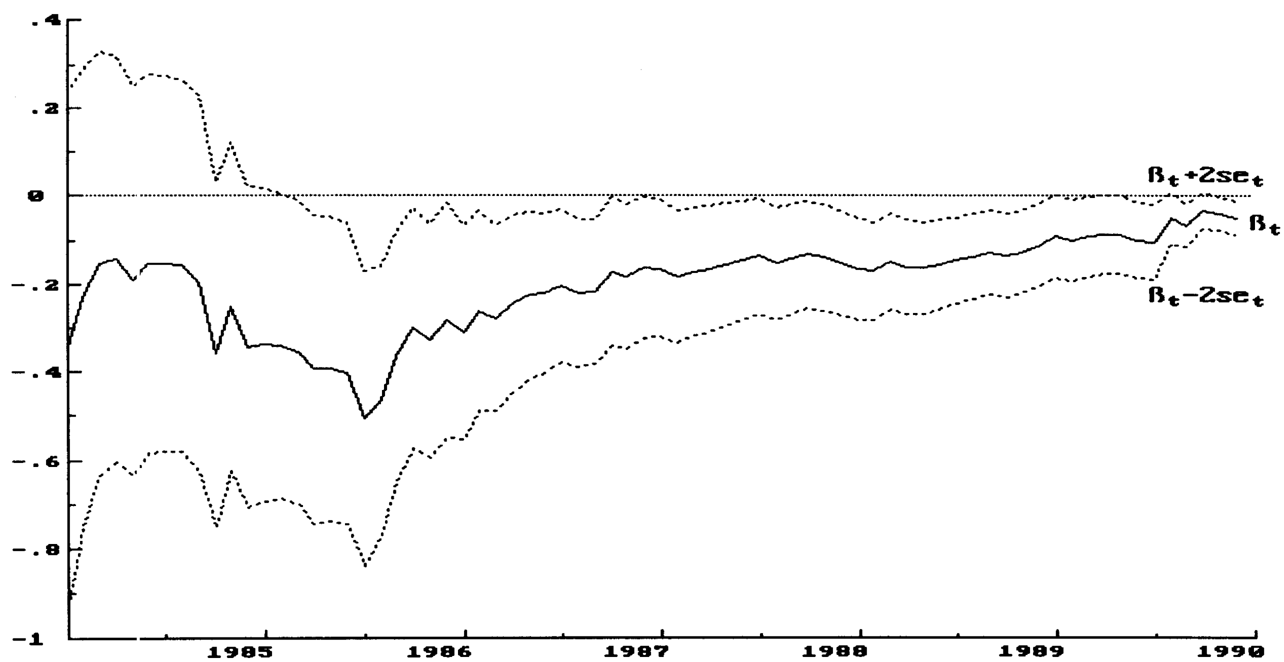

Figure 13d. Recursive estimates of the coefficient on the ratchet variable Δp_{t-1}^{max} in a model of Δm_t.

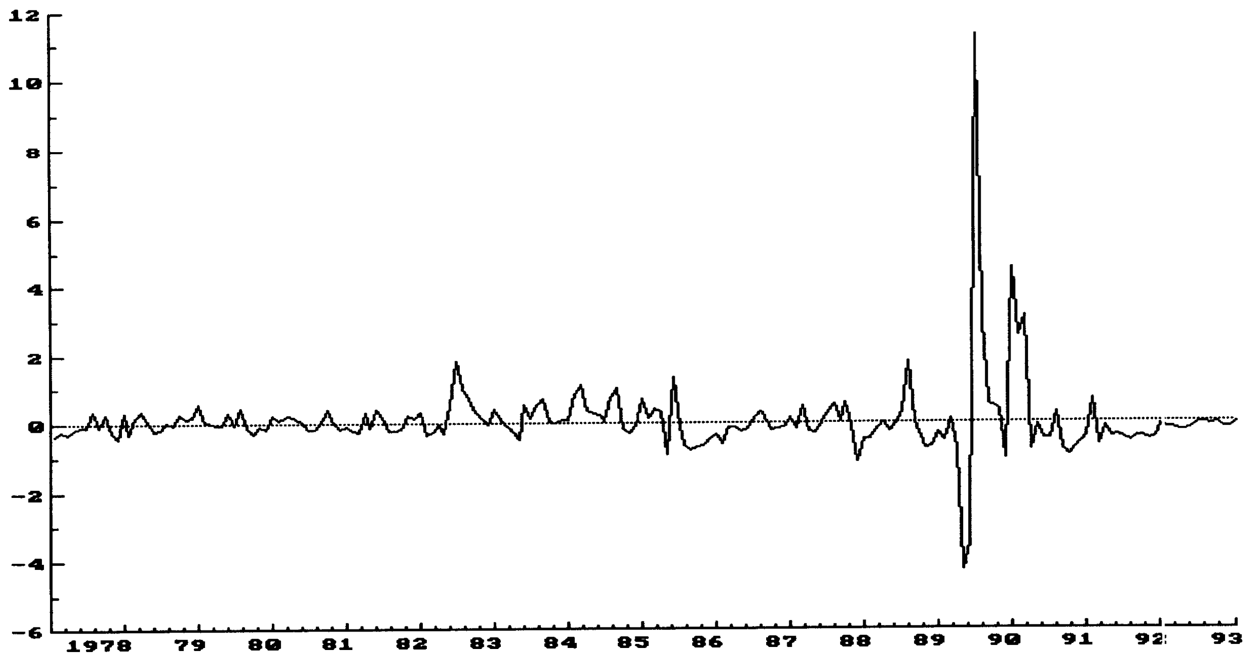

Figure 14. Disequilibrium in the logarithm of money as measured by a model of Δm_t.

on money demand. Since Δe enters the opportunity cost of holding pesos rather than dollars, its statistical significance is some support for the currency-substitution hypothesis. The long-run coefficient on Δe is numerically smaller than those on R and Δp: domestic inflation and interest rates may have had a more visceral effect upon many Argentines than exchange rate depreciation. Equally, inflation and the nominal interest rate may serve as crude predictors of Δe, noting their high correlations with Δe (see Figures 8 and 9).[17]

Fifth, irreversibility in money demand is apparent, at least within the existing data sample. While Δp^{max} has only a tenth the long-run effect that a change in the *level* of inflation has, the long-run effect of Δp^{max} is highly significant in even the unrestricted ADL. Its coefficient is nearly unchanged in the more parsimonious models. Also, Δp^{max} is not merely proxying for a time trend. Real money does decline secularly, but a trend is not statistically significant in either (6) or (8) ($LM_{trend} : F(1, 163) = 0.27$ and $LM_{trend} : F(1, 163) = 0.13$); and Δp^{max} remains highly significant when a trend is included.

The effect of Δp^{max} on Argentine money demand has implications for irreversibility in other countries. From (8) and (9), the coefficient on Δp^{max} is approximately -0.04 in the short run and -1 in the long run, where Δp is measured as monthly inflation. If post-war U.S. or U.K. narrow money demand were affected by Δp^{max} to the same degree as Argentine money demand, the effect of Δp^{max} probably would have gone undetected. Maximum monthly post-war inflation rates in the United States and the United Kingdom are approximately 1% and 2%, implying short-run effects of -0.04% and -0.08% and long-run effects of -1% and -2%. Typical values of $\hat{\sigma}$ for U.S. and U.K. narrow money demand functions are 0.4% and 1.3%, making even the long-run effects hard to detect. By contrast, the maximum value of Δp for Argentina is approximately 100%, so short- and long-run effects are -4% and -100%, whereas $\hat{\sigma}$ is about 2.3%. The large shocks to the economy are principally responsible for being able to detect irreversibility in money demand.

The inclusion of Δp^{max} implies a literally permanent effect of some inflationary shocks on money demand, and such permanency is unlikely. However, for the existing sample, inflation's empirical effect appears so persistent that the effect's diminution over time is not apparent. For instance, real money, inflation, the interest rate, and exchange rate depreciation do not appear cointegrated if Δp^{max} is excluded. That said, the following subsection re-interprets the ratchet effect in a way that permits long-lasting but reversible dollarization.

[17]In related work, Phylaktis and Taylor (1993) find cointegration between real narrow money, domestic inflation, and the rate of return on U.S. goods ($\approx \Delta e$) for Argentina, Bolivia, Brazil, Chile, and Peru. For all five countries, the effect of domestic inflation dominates that of the rate of return on U.S. goods.

5.5 A Constructed Measure of the Demand for Dollar Assets

Using the inflationary ratchet effect from the ECM of peso-denominated assets, this subsection constructs a measure of the demand for dollar-denominated assets. Actual Argentine holdings of U.S. currency and dollar-denominated assets can be estimated for 1988–1992 from the U.S. Treasury data. For that period, the effect of the ratchet variable on the demand for peso-denominated assets matches the total holdings of dollar-denominated assets almost one-for-one.[18]

Consider what money holdings would have been if Δp_t^{max} had had no effect on money demand. A complete solution would involve setting all coefficients of Δp_t^{max} and its lags to zero in the VAR for Johansen's procedure and solving period by period for the new series of $m-p$. A simpler, approximate method is to subtract the long-run effect of Δp_t^{max} from observed money holdings:

$$m_t^a - p_t \;=\; m_t \;-\; p_t \;+\; 0.98\Delta p_t^{max} \;, \tag{10}$$

where the calculation in (10) uses the long-run solution (9) for the nominal ECM.[19] Because Δp_t^{max} enters (9) with a negative coefficient, it enters (10) with a positive coefficient, where the coefficient is of the same magnitude as in (9). Equation (10) ignores transient effects of Δp_t^{max}, but it should provide an indication of the general behavior of money demand under this hypothetical situation.[20] Figure 15 shows that, with no ratchet effect, the demand for M3 would have been close to its actual level through late 1988, but would have soared relative to its actual level in the last four years. At the end of the sample, peso money holdings would have been nearly 300% their actual value. Alternatively expressed, recent values of real peso M3 would have been approximately those observed in the late 1970s.

The difference between actual M3 and the counterfactual values from (10) may be attributed to two factors: substitution into dollars, and other means of economizing on money balances that collectively may be referred to as financial innovation; see Arrau, De Gregorio, Reinhart, and Wickham (1991). With the data at hand, no obvious way exists to decompose the "missing money" into these two components. That said, Figure 16 plots total dollar assets (A_t) and the ratchet effect's dollar value (denoted Q_t), where the latter is calculated as:

[18]Melvin and Afcha de la Parra (1989) conduct a similar exercise, using a velocity equation to compare Bolivia's actual money holdings with predicted values and interpreting the difference between the two as dollar currency holdings. However, unlike ourselves, they were unable to compare their calculated dollar currency holdings with independent estimates of those holdings.

[19]The results are insensitive to using the real ECM, the unrestricted ADL, or the estimate from Johansen's procedure instead. Also, setting the initial observation of $m^a - p$ equal to the actual initial observation of $m-p$ has little effect on the comparison between $m^a - p$ and $m-p$; see Figure 15.

[20]This calculation also assumes invariance of the parameters associated with Δp_t^{max} to changes in the path of Δp_t^{max}.

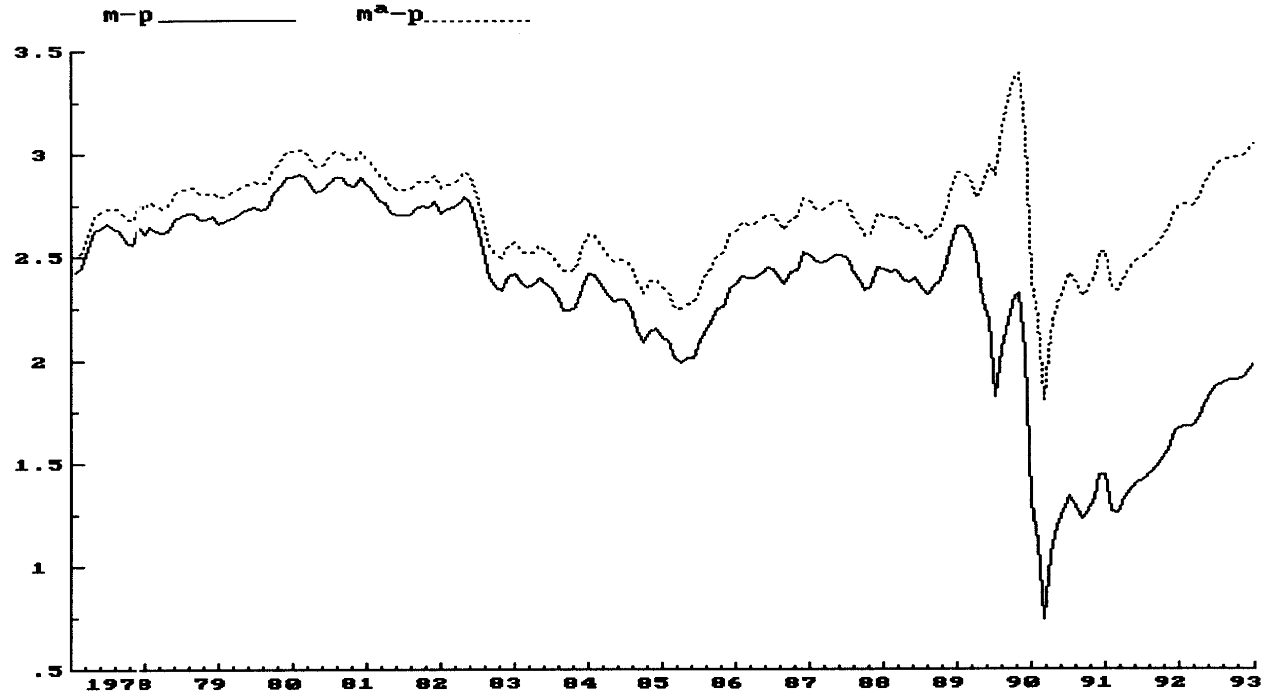

Figure 15. Logarithms of real money: actual $(m - p)$ and adjusted $(m^a - p)$.

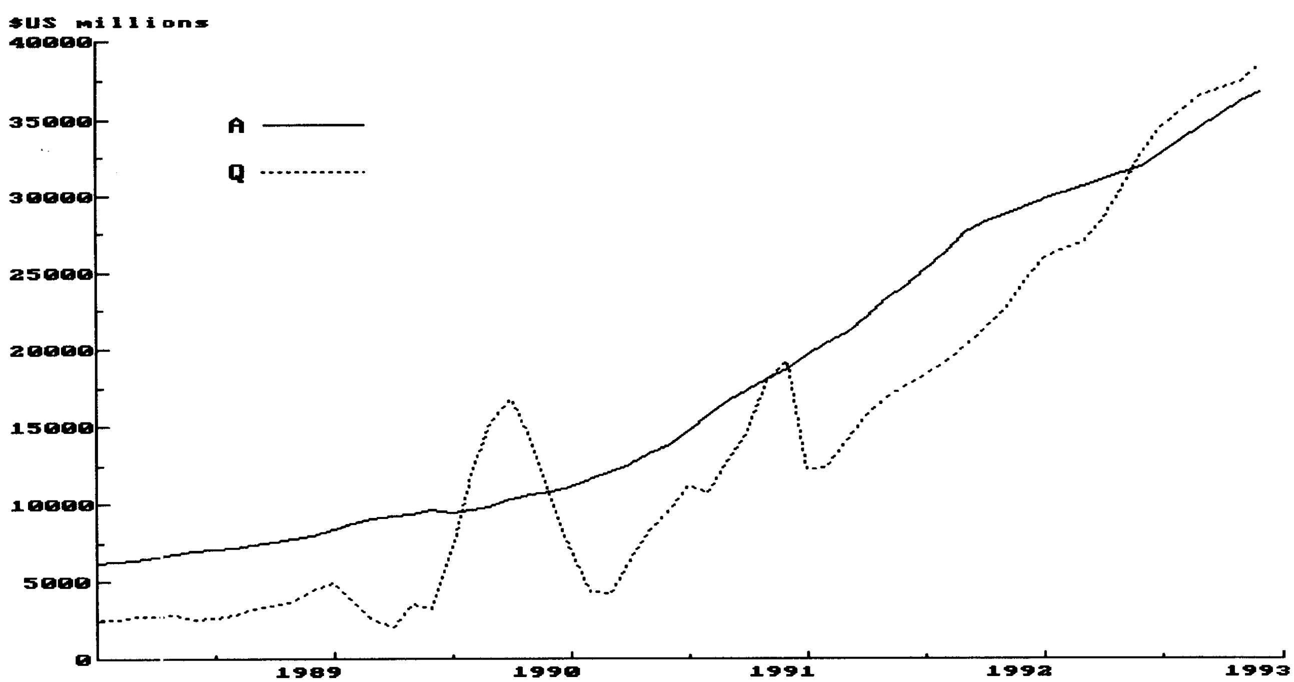

Figure 16. Dollar assets (A) and the ratchet variable's long-run effect (Q).

$$Q_t \;=\; \left(\frac{M_t}{E_t}\right) \cdot \left(\exp\left[0.98\Delta p_t^{max}\right] - 1\right) \;, \tag{11}$$

noting that the ratchet effect in (9) is calculated for the logarithm of real money demand, valued in pesos. For much of the sample, Q_t is a substantial fraction of A_t, with the two being virtually equal by the end of 1992.[21] These results are consistent with most of the reduction in M3 reflecting a substitution into dollars. They also reinforce the view that the continued large holdings of dollar-denominated assets since 1990 are a permanent response to the preceding hyperinflations.

The similarity between Q_t and A_t suggests a reinterpretation of the estimated models, namely, that the ratchet effect proxies for dollar holdings A_t. Thus, peso holdings M_t might be modeled conditional upon prices, interest rates, the exchange rate, and dollar holdings. Such a formulation allows dollarization to be long-lasting without being irreversible, which is appealing since actual irreversibility is a a very strong proposition. With the accumulation of more data on currency flows, this approach will become econometrically practical.

6 Dollar Deposits versus Dollar Currency Holdings

Dollar deposits and dollar currency holdings exhibit somewhat different properties over time. This section explores some reasons why that may be so. Because the series on dollar deposits and (especially) dollar currency holdings are so short, our analysis is graphical rather than econometric.

6.1 The Recent Behavior of Dollar Deposits

Previous studies of dollarization have developed regression models of currency substitution, using data on relative holdings of domestic assets and dollar deposits.[22] These analyses generally have found that dollar deposits behave as predicted by the conventional currency-substitution model: higher inflation and higher rates of exchange rate depreciation increase the demand for dollar deposits relative to domestic currency holdings. As Figure 17a indicates, the ratio of dollar deposits to M3 in Argentina follows that pattern, rising during the hyperinflations of 1989 and 1990 and falling thereafter. It also shows the irreversibility effect, since the ratio grows throughout 1991, when inflation falls.

Looking at only the ratio of these two aggregates obscures important similarities in the behavior of the aggregates themselves. Figure 17b shows that, since 1989, dollar deposits and peso M3 have moved broadly in parallel. Both fell in response to

[21]The construct Q_t does not incorporate the short-run response of peso holdings to changes in Δp^{max}. Thus, the low correlation between month-to-month movements in Q_t and A_t, as evident in Figure 16, is unsurprising.

[22]See Ortiz (1983), Ramirez-Rojas (1985), Marquez (1987), Clements and Schwartz (1992), Agénor and Khan (1992), Rogers (1992), and Rojas-Suarez (1992). See also Giovannini and Turtelboom (1992), who summarize the literature on currency substitution.

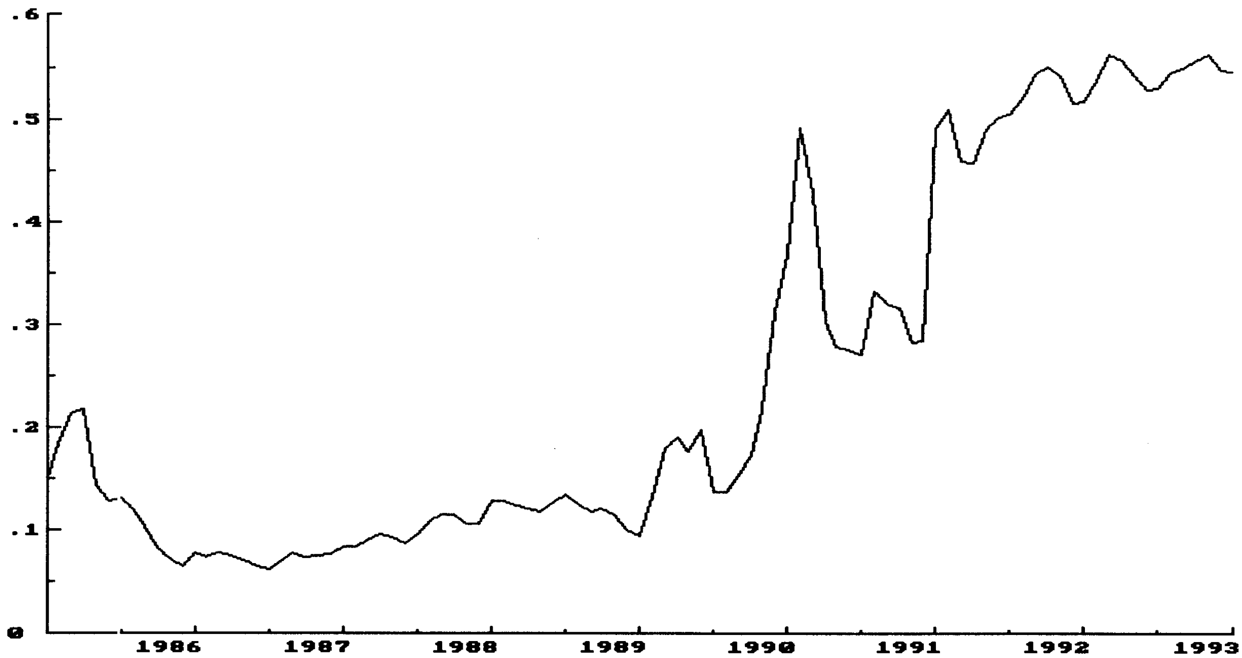

Figure 17a. The ratio of dollar deposits to M3 ($D/[M/E]$).

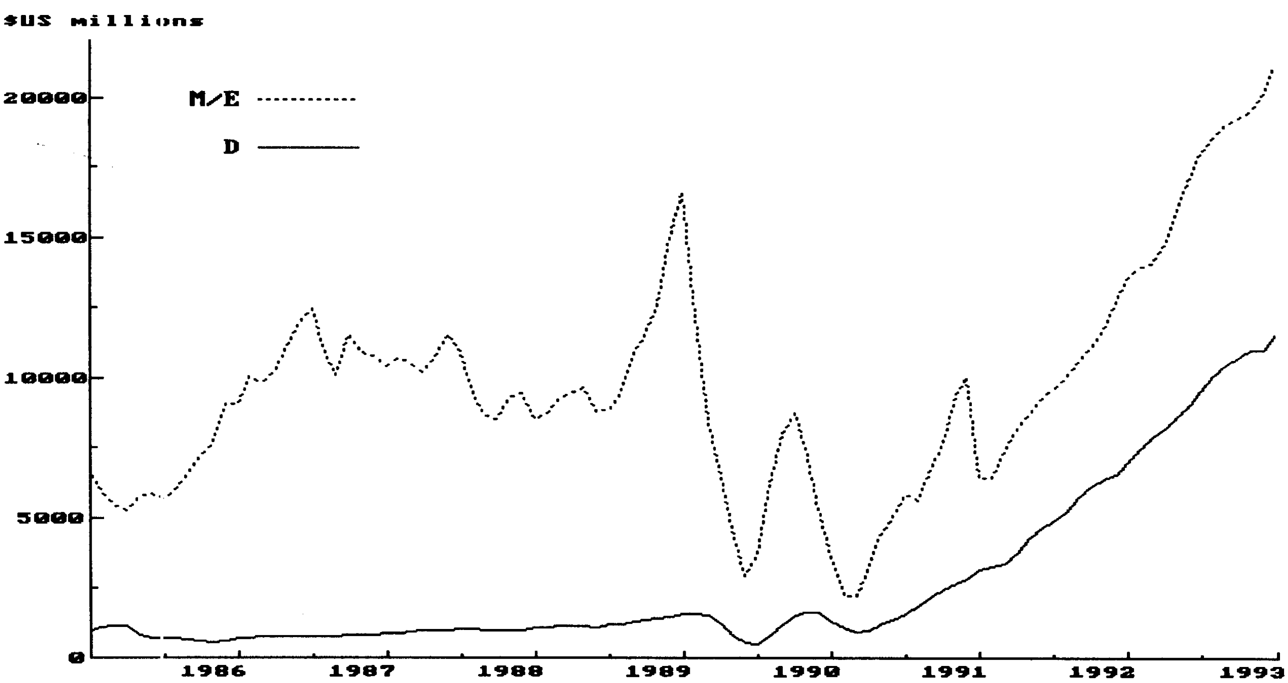

Figure 17b. Dollar deposits (D) and the dollar value of M3 (M/E).

increased inflation and recovered with subsequent reductions in inflation. They each reached low points during the hyperinflations of 1989 and 1990, and have recovered strongly since then. Figure 17a shows the secular shift from peso M3 to dollar deposits but misses the shorter-term similarities.

The dollar deposits' close correlation with peso M3, and their negative correlation with inflation and exchange rate depreciation, may reflect fears of bankruptcy and confiscation. The two pronounced dips in dollar deposits — in mid-1989 and in early 1990 — coincide with periods of hyperinflation, scarcity of foreign exchange, and macroeconomic upheaval. These factors put dollar deposits at risk, both because these deposits might have been confiscated or frozen by the government and because the banks holding the deposits might have closed. In fact, only peso-denominated deposits were frozen under the Plan Bonex, but it was not obvious at the time that dollar deposits would emerge unscathed.[23] While Argentine dollar deposits may share dollar currency's positive responses to inflation and exchange rate depreciation in the long run, dollar deposits also may exhibit perverse responses to the same factors in the short run. Because error correction models permit a general dynamic structure, they provide a natural framework in which to characterize such effects, and we plan to investigate this in the future.

6.2 The Composition of Dollar Assets

Figure 18a breaks down the contributions of dollar currency and dollar deposits to total dollar assets. Dollar deposits not only have recovered strongly after the 1990 hyperinflation; they are gradually replacing holdings of U.S. currency by Argentine residents.

Figure 18b graphs the fraction of dollar deposits in total dollar assets. The share of dollar deposits in total dollar-denominated assets initially moved inversely with inflation, even though both dollar deposits and currency are protected from exchange rate loss. Since March 1990, that ratio has increased steadily from 8% to 30% (in December 1992). Dollar currency holdings do not earn interest, whereas dollar deposits have paid in excess of 300 basis points above LIBOR, so it seems likely that the share of dollar deposits in total dollar-denominated assets will continue growing as the stabilization program solidifies.[24] Such movement eventually could reduce the

[23] Rogers (1992) finds a similar episode in Mexico during the early 1980s. He argues that increases in exchange rate depreciation led to concerns that the convertibility of dollar deposits would be suspended and so to withdrawals from these deposits. Gruben and Welch (1993) claim that concerns about the suspension of convertibility were not responsible for the withdrawals of deposits. Rather, it was the fear that a devaluation would induce defaults on dollar loans extended by Mexican banks and thereby prevent these banks from covering their dollar liabilities. Regardless of which of these factors dominated in Mexico, both probably were important in Argentina in 1990.

[24] The spread over LIBOR appears to reflect a premium compensating depositors for continued risk of confiscation and bankruptcy. Presumably, this spread has declined since the crisis period of early 1990, but a reliable time series on dollar deposit interest rates is not available.

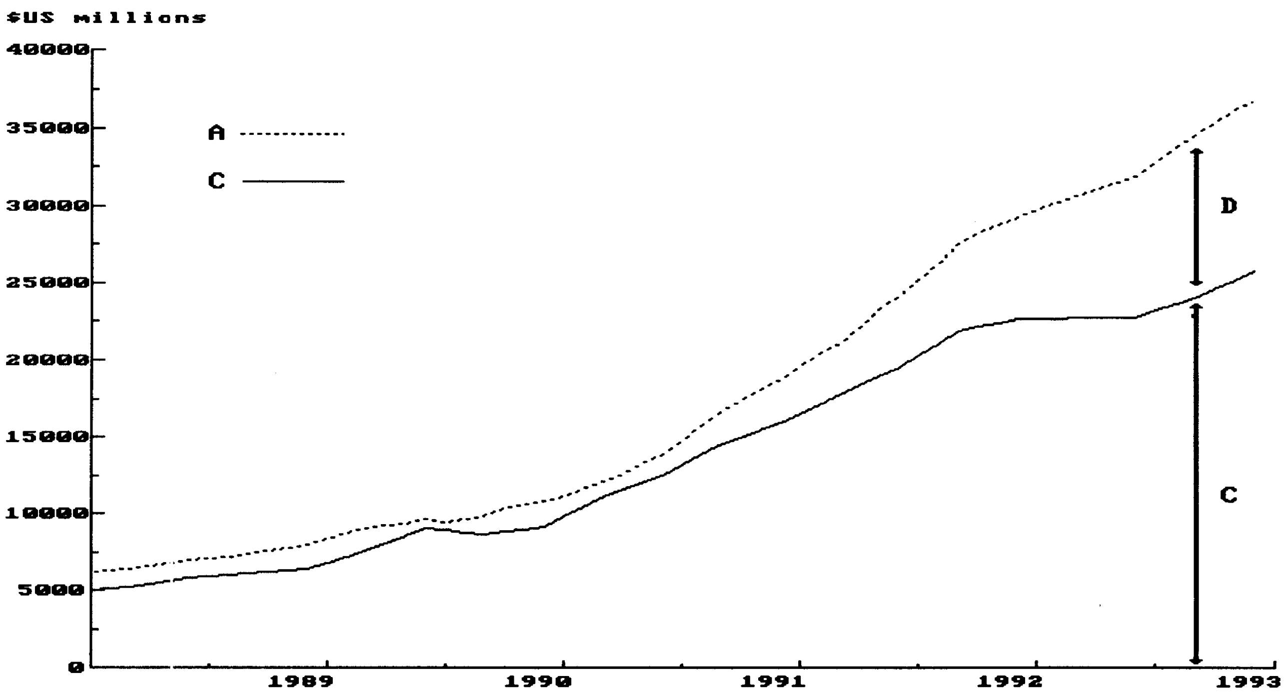

Figure 18a. The composition of total dollar holdings (A): currency (C) and dollar deposits (D).

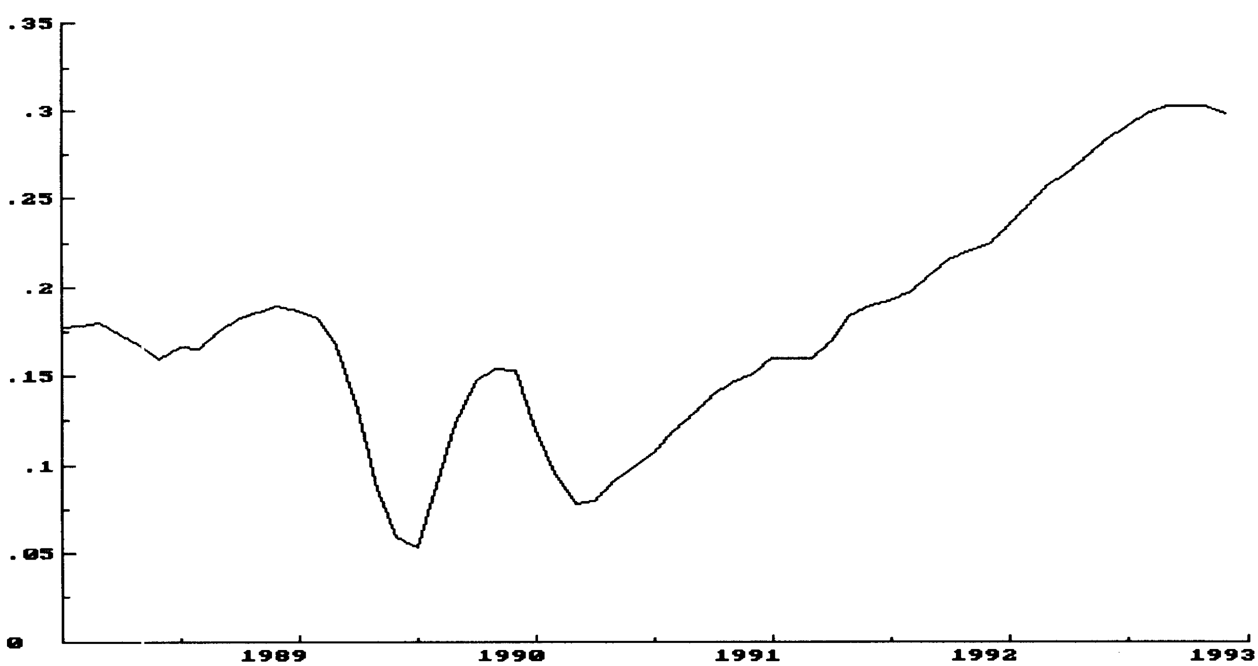

Figure 18b. The fraction of dollar deposits (D) in total dollar assets (A).

demand for U.S. currency in absolute terms and lead to net flows of currency back to the United States.

Thus, further increases in Argentine-based dollar deposits should not be interpreted as reflecting declines in the credibility of Argentina's stabilization program. On the contrary, given that Argentines already have decided to hold most of their financial assets in dollar-denominated form, substitutions from dollar currency to dollar deposits may reflect increasing confidence in the stability of Argentina's financial system and general macroeconomic situation.

7 Conclusions

The main results of our analysis are both methodological and substantive. First, the U.S. Treasury data provides a new measure of dollar currency circulating in foreign countries, and it should advance our ability to analyze dollarization and currency substitution. For Argentina in particular, this measure indicates dollar currency holdings well in excess of what many observers thought.

Second, dollar deposits and dollar currency holdings in Argentina have responded differently to recent macroeconomic shocks. With the hyperinflation and the confiscation of peso bank deposits, dollar currency holdings surged while dollar deposits plunged. Dollar deposits showed a positive (albeit lagged) response to these developments only when the economic situation began to stabilize.

A common measure of currency substitution, the ratio of dollar deposits to local money, did show the expected positive correlation with inflation over this period. That correlation is much weaker than when dollar currency holdings are included in the dollar aggregate. Consequently, data on dollar deposits alone may be inadequate for testing hypotheses about currency substitution. Dollar deposits also may be misleading for inferring short-run trends in dollarization because dollar currency and deposit holdings may respond differently to shocks in the short run.

Third, cointegration analysis of peso money demand in Argentina finds a negative "ratchet effect" from inflation on the demand for pesos. Our (reasonably) constant, parsimonious, single-equation error correction models further support that evidence. Long-run money demand in the ECMs is driven by the ratchet, and by the opportunity cost of holding peso-denominated financial assets rather than Argentine goods or U.S. dollars. Short-run dynamics are consistent with an Ss-type inventory model that is interpretable as having either real or nominal short-run bounds.

Since 1988, the degree of dollarization has increased to and remained at historically unprecedented levels, notwithstanding the decline in inflation to record lows in 1991 and 1992. The failure of dollar holdings to decline with inflation suggests systematic irreversibilities associated with the effect of inflation on dollar holdings. The reduction in peso money demand attributable to the ECM's ratchet effect is similar in magnitude to the stock of dollar assets held domestically by Argentine residents, lending further credence to the hypothesis of irreversible (or at least long-lasting) dollarization.

Appendix. Data

Table A1. Data Definitions

Variable	Definition	Source
A	Estimated dollar assets held in Argentina ($= C + D$) (millions of \$US, end-of-month)	—
B	Dummy variable for the Plan Bonex (January 1990 = 1, zero otherwise)	—
C	Estimated holdings of U.S. currency in Argentina ($C_t = C_{t-1} + F_t$; $C_{(\mathbf{December 1987})} = 5000$) (millions of \$US, end-of-period)	—
D	Depositos en moneda extranjera, total (millions of \$US) [Total domestic deposits in foreign currency]	B.C.R.A.; C.E., M–14
E	Nominal exchange rate: parallel rate (sell) through 1989, market exchange rate thereafter (Pesos/\$US)	F.I.E.L.; I.F.S., 213ae
F	Net shipments of U.S. currency from the United States to Argentina ($= O - I$) (millions of \$US)	—
I	Gross shipments of U.S. currency from Argentina to the United States ("inflows to the United States") (millions of \$US, quarterly)	C.M.I.R.
M	Peso M3: billetes y monedas, depósitos a la vista, depósitos regulados a plazo y caja de ahorros, depósitos a plazo a tasa no regulada, y aceptaciones (millions of pesos, average of daily balances) [Peso bills and coins, and domestic sight deposits and savings accounts denominated in pesos]	B.C.R.A.; C.E., B–3
$M1$	Peso M1: billetes y monedas, depósitos a la vista (millions of pesos, average of daily balances) [Peso bills and coins, and domestic sight deposits denominated in pesos]	F.I.E.L.; B.C.R.A.; I.E.; C.E., B–3
M^a	Estimated value of peso M3 without the ratchet effect (millions of pesos)	Eq. (10)
O	Gross shipments of U.S. currency from the United States to Argentina ("outflows from the United States") (millions of \$US, quarterly)	C.M.I.R.
P	Precios al consumidor, nivel general (1968=1.00) [General consumer price index for Argentina]	F.I.E.L.; C.E., B–10
Q	Quantity of dollars associated with the ratchet effect (millions of \$US)	Eq. (11)
R	Tasa de interes, 30 dias, efectiva mensual, plazo fijo (fraction, per month) [Interest rate on domestic peso-denominated fixed-term deposits]	F.I.E.L.; B.C.R.A.; C.E., M–16
Y	Producto bruto interno (1970 australes, quarterly at annual rates) [Argentine gross domestic product]	C.E., B–10

Sources. The data sources are:

B.C.R.A., Banco Central de la Republica Argentina (Central Bank of Argentina);

C.E., *Carta Económica* (Economic Letter), various issues;

C.M.I.R., Currency and Monetary Instrument Report, the U.S. Treasury, summaries (internal documents);

F.I.E.L., Fundación de Investigaciones Económicos Latinoamericanos (Foundation for Latin American Economic Research);

I.E., *Indicadores Económicos* (Economic Indicators), various issues; and

I.F.S., *International Financial Statistics*, various issues.

Data from the B.C.R.A. were obtained from press releases (Comunicados No. 12112 for D and No. 13351 for M and $M1$) and from the Bank itself. *Carta Económica* is a commercial publication by Miguel A.M. Broda y Asoc. (Buenos Aires) and is a central source of macro-economic statistics for Argentina. Data from F.I.E.L. were obtained from F.I.E.L. itself (in Buenos Aires). *Indicadores Económicos* is published by the B.C.R.A. *International Financial Statistics* is published by the International Monetary Fund (Washington, D.C.).

The number with a source indicates the relevant page (for C.E.) or the line in the Argentina country table (for I.F.S.). The most recent data from the C.E. are from the March 1993 issue, and the page numbers in Table A1 correspond to that issue. The definition as it appears in the source is given first. Where applicable, an English translation appears in brackets.

Units. Unless otherwise noted, all data are monthly and seasonally unadjusted. Where necessary, conversions of the original units were made. On June 1, 1983, 10,000 pesos became 1 peso argentino. On June 14, 1985, 1,000 pesos argentinos became 1 austral. On January 1, 1992, 10,000 australes became 1 (new) peso (argentino).

Adjustments. For January-March 1990, the interest rate series R is the rate for "caja de ahorros" (savings accounts) because no rate was reported for "plazo fijo". Some splicing of other interest rate series was necessary for earlier values. Also, before 1989, M and $M1$ contain balances held by the non-financial private sector only.

The C.M.I.R. data on U.S. currency flows are quarterly, whereas most of the remaining data (including those on dollar deposits) are monthly. To construct aggregates such as "all dollar assets" (A), each observation on a quarterly currency flow was divided evenly among its constituent months and a monthly estimated stock of U.S. currency (C) was constructed from the usual stock-flow relationship.

Acknowledgments. We are grateful to the U.S. Treasury for allowing us to use their data on currency flows and to reproduce it in Table A2 below.

Table A2.
C.M.I.R. Data on United States–Argentine Currency Flows

Year	Quarter 1	2	3	4
	Inflows to the United States: I			
1988	40.	16.	88.	85.
1989	107.	77.	569.	195.
1990	90.	173.	148.	324.
1991	255.986	193.772	173.008	396.700
1992	652.501	556.198	173.565	158.294
	Outflows from the United States: O			
1988	283.	631.	328.	424.
1989	1238.	1572.	163.	672.
1990	2056.	1540.	2186.	1682.
1991	2125.497	1982.000	2508.376	1184.449
1992	713.840	620.978	1419.665	1908.436

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