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**Monetary Transmission and Financial Indexation:
Evidence from the Chilean Economy**

by

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Abstract

This paper reviews empirical evidence on the operation of the monetary transmission mechanism based on targeting of interest rates on indexed assets in the Chilean economy. The empirical evidence has two policy implications. First, interest rates on indexed assets do not fully reflect real interest rates because of imperfections of backward indexation magnified by the variability of monthly inflation. Second, while substantial adjustments to interest rates on indexed assets affect the cyclical position of output and inflation, there is no evidence of a stable, systematic relationship between these three variables. In contrast, money growth and unexpected inflation play a significant role in the transmission mechanism. This evidence calls for an eclectic approach to monetary policy.

JEL Classification Numbers:

E52; E43; E31

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I. Introduction

Most financial instruments in Chile are denominated in terms of a unit of account known as the development unit or "unidad de fomento" (UF), which indexes credit contracts to the evolution of consumer prices with a delay of one month. The use of the UF as a unit of account is also widespread in other sectors of the economy; prices of real state, automobiles, and even school fees are set in UF units. Moreover, with such large sectors of the economy formally indexed, informal indexation mechanisms exert inflationary pressures in other sectors, including labor markets.

Despite theoretical arguments, the fact is that widespread indexation has not hampered the stabilization and strong economic growth that the Chilean economy has achieved in recent years. 1/ Nevertheless, the stickiness that inflation has displayed by remaining in a range between 12-15 percent since 1992, despite tight financial policies, is an issue of concern. In this context, the need to examine options for reducing inflation under indexation seems more pressing than the need to study the desirability of indexation. Thus, this paper takes indexation as a fact and examines the transmission mechanism of monetary policy. 2/ This approach is in line with ongoing research projects in Chile.

The key instrument of monetary policy in Chile is the interest rate on 90-day indexed Central Bank promissory notes. This interest rate

1/ Classic studies on indexation are Fischer (1986), Friedman (1974) and Gray (1976). A general review is included in Parkin and Bade (1992). For an empirical study applied to Chile see Mendoza (1992).

2/ The use of the UF in Chile has been in practice since 1967. In the 17 years since then the economy has experienced marked fluctuations in savings, inflation, and growth rates, all of which should be taken into account in a cost-benefit analysis of macroeconomic effects of indexation.

influences market-determined interest rates on indexed loans and deposits in the financial system--we refer to these interest rates as UF rates throughout the paper. UF interest rates are commonly interpreted as real interest rates, and a widely-accepted interpretation of the transmission mechanism is that, by adjusting UF interest rates, the monetary authority influences aggregate demand to maintain consistency with inflation goals.

This paper examines two aspects of this monetary policy framework. First, it discusses whether UF interest rates are equivalent to real interest rates under the existing backward indexation rule. By extending the work of Mendoza (1992), we show that the one-month lag of the indexation system, together with the high variance of monthly inflation, imply that UF rates and real interest rates on 90-day loans differ markedly.

The fact that UF interest rates are not equivalent to real interest rates does not imply that targeting the former is an ineffective policy. UF rates could be viewed as a form of nominal rates, and be treated as instruments of monetary policy, keeping in mind that they incorporate an imperfect degree of monetary correction. This raises the second question examined in this paper, which is how are adjustments in UF rates transmitted into the real economy and ultimately to the rate of inflation. This question is a matter of concern to Chilean policymakers and of continuous academic debate. This paper intends to contribute to that debate.

The paper reviews results of several econometric tests that raise questions on a monetary transmission mechanism based on UF interest rates. While there is evidence that the large increase in UF rates implemented in 1989-90 helped to cool down the economy and reduce inflation, the tests reject the hypothesis that there is a stable, systematic link between the UF

rate and the output gap, money, or inflation. The evidence also suggests that the difference between actual and expected inflation helps explain deviations from trend in output, as predicted by expectations-augmented Phillips' curve models. There is also evidence showing that the terms of trade explain a fraction of unexpected inflation, suggesting that the output-inflation trade-off in Chile is driven in part by supply shocks. 1/

II. Monetary Policy in Chile: Recent Developments

As noted earlier, the main instrument of monetary policy in Chile is the rate set by the Central Bank on its 90-day indexed promissory notes--known as PRBC. Once this key rate is set, the term structure of interest rates on other Central Bank notes is market-determined in auctions of longer-term paper. Through these open-market operations the Bank influences the level of UF lending and deposit rates in the financial system. The rate of the 90-day PRBC is set at a level estimated to be consistent with objectives for growth and inflation, and monetary aggregates are allowed to adjust accordingly. As a result, the growth of liquidity has been highly variable over time (Chart 1).

Monetary policy and exchange rate policy are linked by the intent to target the real exchange rate via adjustments to a reference rate, which serves as the center of an exchange rate band, according to inflation

1/ Terms-of-trade shocks account for 1/2 of the variability of GDP and explain the cyclical co-movement between real interest rates and real exchange rates in developing economies (see Mendoza (1994)).

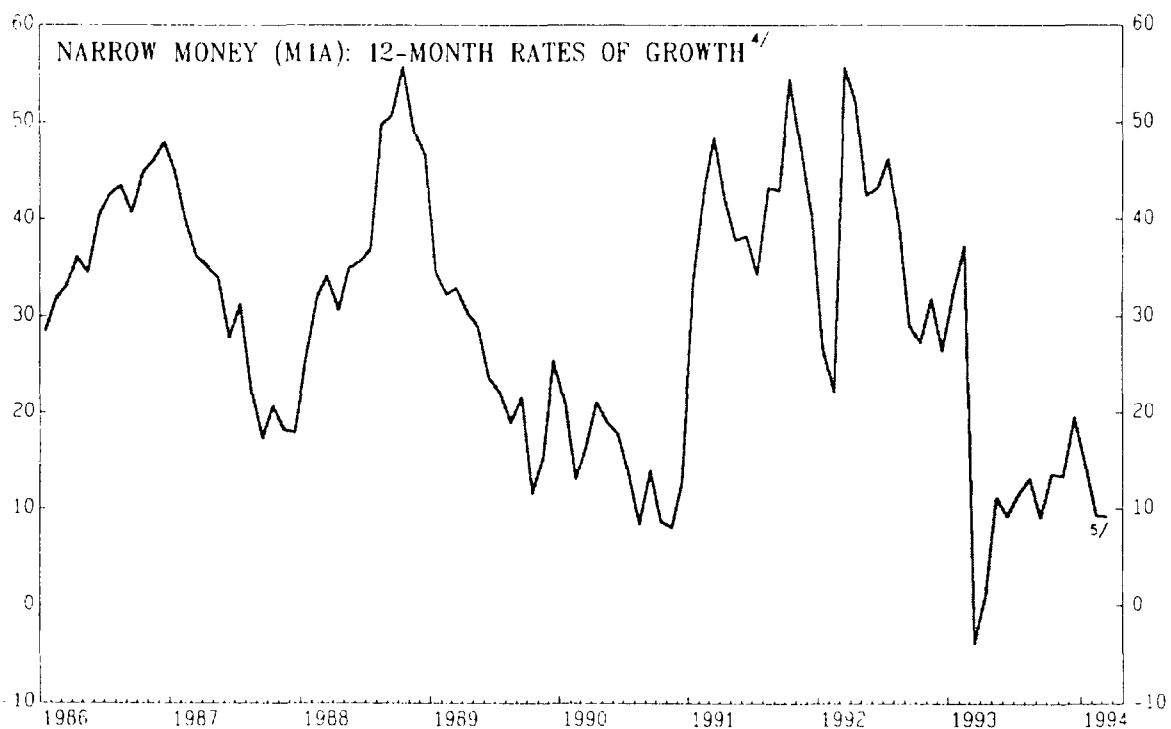
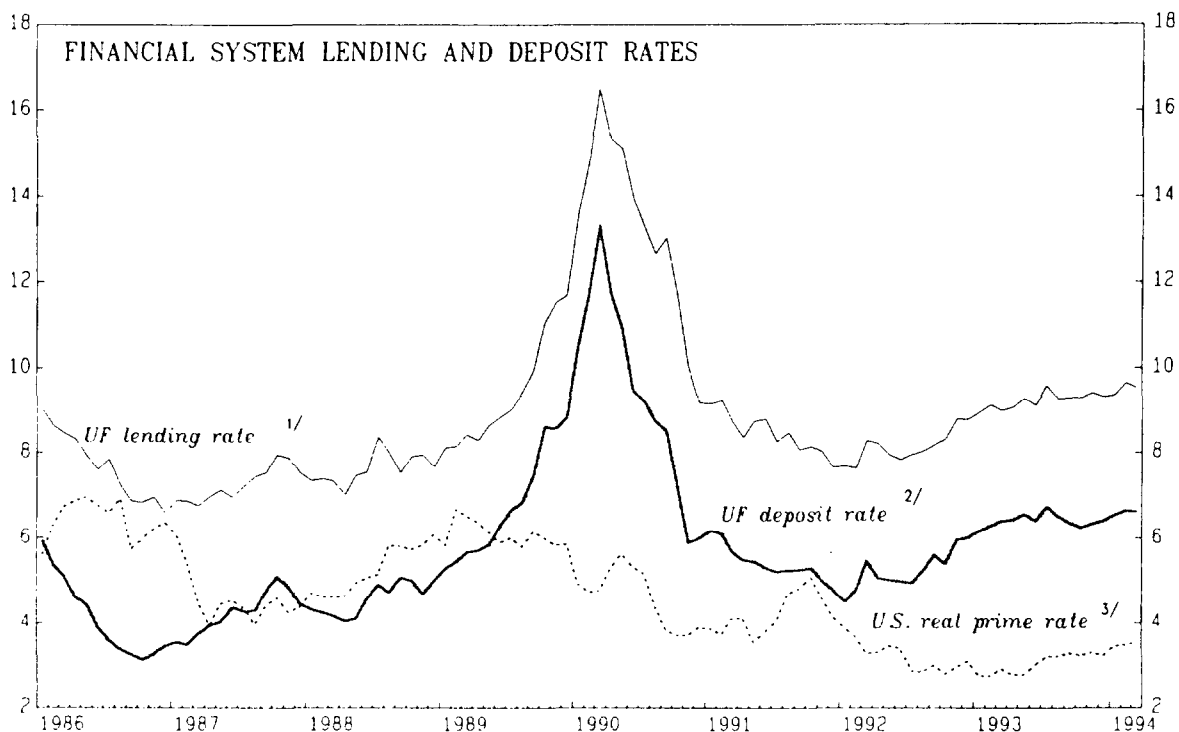
differentials. ^{1/} In practice, this exchange rate policy has prevented the real exchange rate from deviating significantly from the level attained in mid 1988, after a considerable depreciation (Chart 2).

The prevailing hypothesis among Chilean economists with regard to the transmission mechanism of monetary policy is that, by influencing UF rates via the targeting of the 90-day PRBC rate, the monetary authority aims to close the gap between the growth rates of output and expenditure. As this gap narrows, inflation would eventually decline, albeit with some unknown delay reflecting lags in the transmission mechanism. It is argued that given these lags, large and sudden adjustments to the UF rate may reduce inflation only at the expense of a substantial slowdown in economic activity, and hence policymakers may prefer small and gradual adjustments, involving a waiting time to allow the influence of lags operate.

Recent experience provides illustrative insights into the operation of the monetary policy framework described above. During 1985-90, Chile experienced strong real GDP growth accelerating from 2.5 percent in 1985 to 10 percent in 1989. This was accompanied by a reduction in the 12-month inflation rate from 26.5 percent in 1985 to 12.7 percent in 1988. Inflation reached a minimum of 12 percent in the year ended September 1988, but then it accelerated in the last quarter of that year and throughout 1989, boosted by a strong upsurge in aggregate demand. By the last quarter of 1989 inflation had reached 31 percent, despite a gradual tightening of credit conditions. In light of the overheating of the economy and the resilience

^{1/} The reference rate is set with respect to a fixed basket of currencies and is adjusted daily by the difference between domestic and foreign inflation. The interbank rate is allowed to float within a 10 percent range around the reference rate.

CHART 1
CHILE
INTEREST RATES AND MONETARY GROWTH



Source: Central Bank of Chile and IMF International Financial Statistics.

1/ Annual interest rate charged on indexed loans with a maturity of 90 to 365 days.

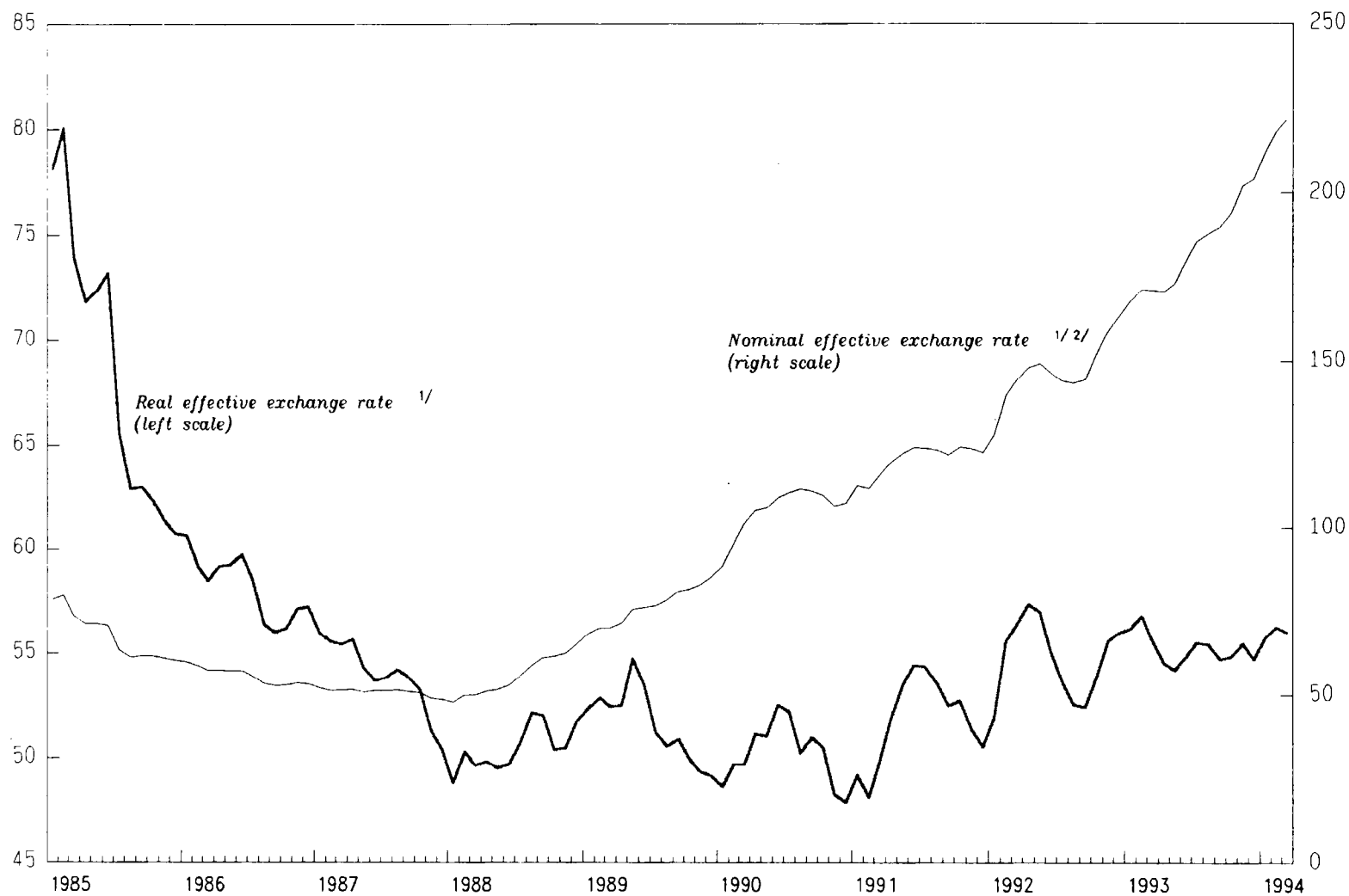
2/ Annual interest paid on indexed deposits with a maturity of 90 to 365 days.

3/ 12-month U.S. prime rate less U.S. consumer price index.

4/ Calculated from average monthly stock.

5/ Negative growth rate of M1A in March 1993 reflects unusually large money growth in March 1992; a consequence of negative inflation in February 1992.

CHART 2
CHILE
EXCHANGE RATE DEVELOPMENTS
(1980=100)



Source: IMF Information Notice System.

1/ An increase (decrease) indicates appreciation (depreciation).

2/ Nominal exchange rate adjusted by a weighted index of exchange rates of major trading partners.

of inflation, monetary policy was tightened further in January of 1990, when the PRBC UF interest rate increased by about 2 percentage points to 8.7 percent. The PRBC UF rate remained at that level for over six months, pushing 90-day UF commercial lending rates to a peak of 16.5 percent in March. As a result, inflation fell by about 8.5 percentage points during 1991 to end at 18.7 percent. Real GDP growth decelerated to 3 percent in 1990, preceding the decline in inflation. Credit expansion and domestic expenditure also slowed down sharply. In late 1990 the Central Bank began to reduce gradually the PRBC UF interest rate to end 1991 at 4.7 percent.

This recent experience on the output-inflation trade-off in Chile can be interpreted in terms of the monetary transmission mechanism proposed earlier. We characterize the transmission mechanism using monthly data for the period January 1986-March 1994 for the revised monthly index of economic activity IMACEC, the monthly average of the stock of narrow money (M1A), the average UF lending rate on 90-365 day loans of the banking system, and the consumer price index. Due to limitations of monthly data available for expenditures, our measure of real activity is not the output-expenditure gap, but the deviation from trend, or "potential," in the seasonally-adjusted IMACEC. ^{1/} We define this deviation from trend as the output gap. Chart 3 plots the output gap (left axis), the annual UF lending rate and the 12-month growth rates of M1A and the CPI (right axis).

Consider first the link between intermediate variables (money or the output gap) and the objective variable (inflation). Large inflationary

^{1/} For simplicity, the potential level of IMACEC is set by a quadratic time trend. The separation of cyclical and trend components of indicators of economic activity is subject of debate (see Mendoza and Fernández (1994)).

spikes in 1987 and 1990 were preceded by positive output gaps and a sharp acceleration in money growth; similarly decelerations of inflation in 1988 and 1991 were preceded by negative output gaps and a decline in the growth of M1A--both of which were particularly severe in the late part of 1990. 1/ The delay in the transmission between the "heating" or "cooling" of the economy, or the acceleration or deceleration in money growth, and inflation may reflect long and variable lags, which may be due in part to the inertia induced by indexation--in addition to traditional causes. 2/

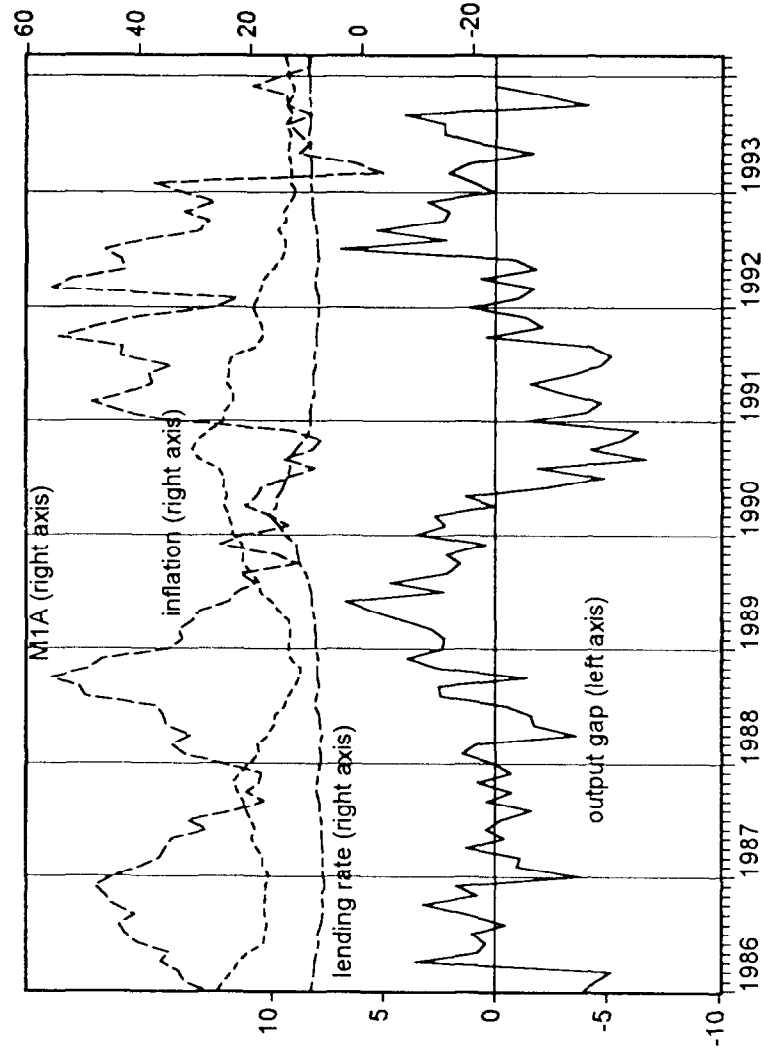
Consider now the link between the instrument variable (the UF lending rate) and the intermediate variables. The single episode of a large increase in the UF lending rate in 1989-90 was followed by negative output gaps from mid-1990 to mid-1991. The deceleration in money growth came earlier--by the end of 1990 the growth of M1A had fallen from near 40 percent in January 1989 to about 10 percent. The retrenchment of both the rhythm of economic expansion and the rate of growth of money explain much of the subsequent reduction of inflation, from a 12-month rate of about 30 percent in late 1990 to the range of 12-15 percent.

After the initial success of the 1989-90 UF interest-rate hike in reducing inflation, inflation stopped falling. To the contrary, late in 1992, faced with signs that the economy was overheating and inflation was accelerating, the Central Bank implemented a moderate increase in interest

1/ A worsening fiscal imbalance also contributed to inflationary pressures. Unfortunately, high-frequency data on the evolution of public finances are not available.

2/ Parkin and Bade (1992) discuss the various lags that affect monetary policy (observation, interpretation, decision, implementation, and effectiveness lags). The classic discussion on long and variable effectiveness lags is in Friedman and Schwartz (1963).

CHART 3
CHILE
INFLATION, OUTPUT GAP, INTEREST RATE AND MONEY



Note: Output gap is the deviation from trend of the seasonally adjusted imacec, inflation is the twelve-month change of the CPI, M1A is the twelve-month growth in the narrow money supply, and lending rate is the UF rate on 90-365 day loans.

rates that was maintained throughout 1993 and the first quarter of 1994--between August and October, 1992, the 90-day PRBC UF rate rose from 5.2 percent to 6.5 percent. The maintenance of this level of interest rates, together with short-term liquidity constraints induced by exogenous developments, tightened the monetary stance in 1993. UF lending rates increased moderately although the 90-day PRBC rate remained unchanged. ^{1/} Narrow money growth fell from 25.4 percent in 1992 to 20.2 percent in 1993. Moreover, the combined effect of higher interest rates and adverse terms-of-trade developments reduced the growth of credit to the private sector by 7 percentage points to 12 1/2 percent in 1993.

Despite this tight monetary policy, there was no evidence as late as of the first quarter of 1994 that inflation expectations or actual inflation were abating. The dampening of the growth of demand and credit, which followed the interest rate hike with a delay of more than a year and reflected in part the adverse external environment, has yet to affect inflation. The 12-month inflation in June stands at 12.7 percent, slightly higher than the annual rate at end-1993. Moreover, public finance figures suggest that the stickiness of the inflation rate cannot be attributed to a worsening fiscal imbalance. Thus, while it is clear that the large UF interest rate adjustment of 1989-90 contributed to close the output gap and reduce inflation, recent developments cast doubt on the effectiveness of moderate adjustments to UF interest rates.

^{1/} Strong capital inflows observed in 1992 decelerated in 1993, and hence the source of liquidity resulting from the unsterilized portion of the inflows dried up. Moreover, the lengthening in the average maturity of Central Bank paper resulted in declining amounts falling due and also tightened liquidity.

III. Interest Rates on Indexed Assets vs. Real Interest Rates

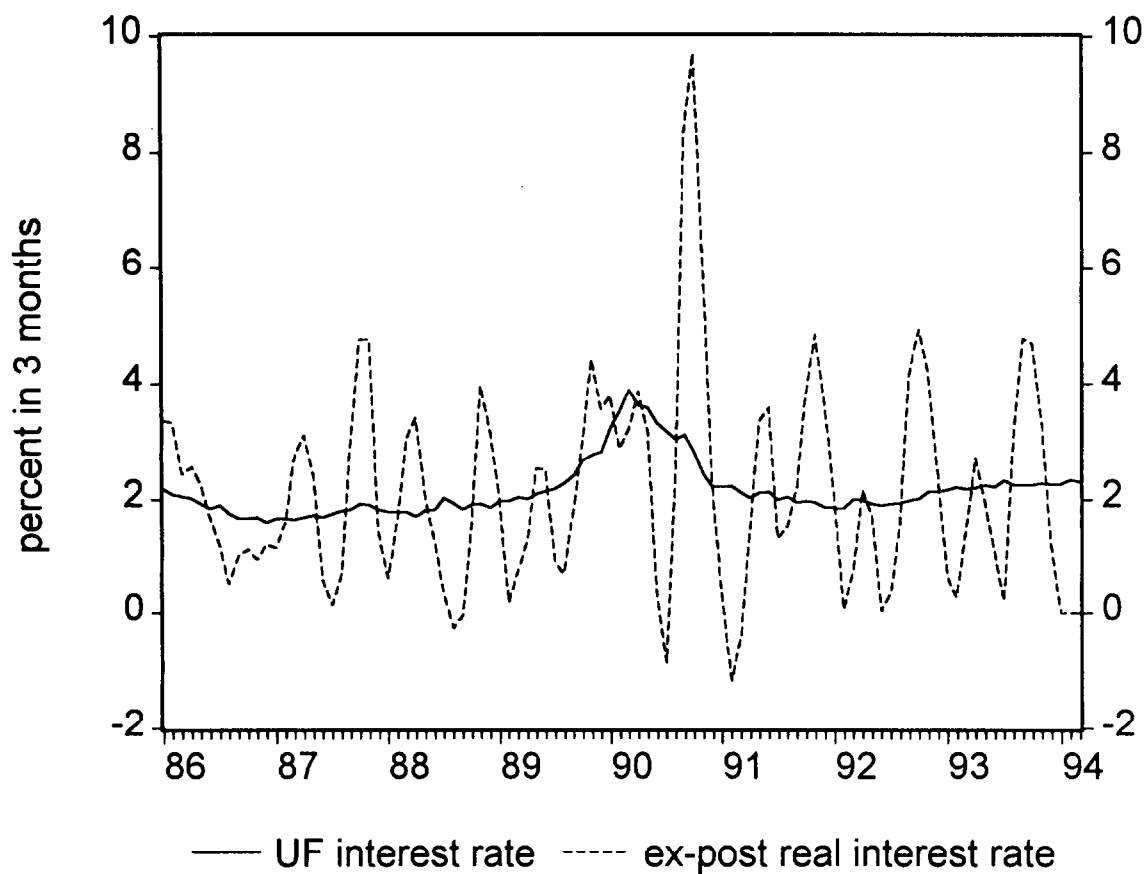
The UF is a unit of account that represents an exchange rate between Chilean pesos and an index number linked to CPI inflation with a delay of roughly one month. 1/ The UF begins to be adjusted in the tenth day of month t by a proportional amount each day, so that by the ninth day of month $t+1$ it has increased by as much as the CPI did in month $t-1$. Interest on indexed contracts is charged to balances denominated in UF. Because the UF is linked to inflation, the UF interest rate is viewed as identical to the real interest rate. However, this sections shows that this view may be incorrect.

The imperfection of this backward indexation rule is reflected in the fact that UF and ex post real interest rates are not equivalent, as they would be under perfect indexation. Chart 4, plots the ex post real interest rate on 90-day loans and the corresponding UF interest rate, both expressed as quarterly returns from monthly weighted averages of banking system operations. The UF rate, r^{UF} , is the quarterly equivalent of the annual interest rates on 90-365 day indexed loans reported in Central Bank publications. 2/ The ex post real rate, r , is equal to r^{UF} times the change in the value of the average UF over the three following months divided over the change in the CPI during the same period. Thus, there is a wedge between r^{UF} and r reflecting the difference between the ex post growth of the UF and the CPI, which is in turn roughly equal to the difference between inflation in the month before a loan is contracted and

1/ For details on the operation of indexed contracts in Chile and implications for market efficiency between short-run indexed and nonindexed assets see Mendoza (1992). Section III borrows heavily from that study.

2/ The data are from the Monthly Bulletin of the Central Bank of Chile.

CHART 4
CHILE
INTEREST RATES ON 90-365 DAY LOANS
(quarterly returns from monthly financial system averages)



inflation in the last month of the contract. ^{1/} As Chart 4 shows, the wedge between r and r^{UF} is large, particularly when annual inflation is rising or declining, or when monthly inflation fluctuates sharply (Chart 5).

It is reasonable to expect that at longer maturities the wedge between r^{UF} and r should be smaller, reflecting a tendency for the discrepancy between CPI and UF growth to be smaller. While the variability of the indexation error is smaller at 12 than at 3 months (the standard deviation of the former is 1.69 compared to 1.75 for the latter), the error does not always fluctuate less with the lengthening of maturity. The error over 1-month has a smaller standard deviation (0.97) than either the 3- or 12-month errors.

The above comparisons between UF and ex post rates may be questionable because the interest rates relevant for economic decisions are ex ante rates, which incorporate expectations of inflation. In this case, the key expectation agents formulate when assessing 90-day loans in January of any year, for example, is a forecast of inflation in April *given* what is known in January. Thus, ex ante real interest rates require three-step ahead forecasts of inflation--i.e. a forecast of inflation three months from month t conditional on information available at t .

One simple model of expectations of inflation assumes that inflation expected for $t+3$ is simply inflation observed at t . This criterion can be referred to as a "random walk" rule or "rule of thumb". The "rule of thumb" has the appealing feature that it yields ex ante real interest rates that

^{1/} Formally, because we work with UF monthly averages and the adjustment of UF is revised on the 10th day of the month, the growth of UF in month t reflects monthly inflation at $t-2$. Thus, the wedge between r^{UF} and r at t is equal to inflation at $t+2$ and $t+3$ minus inflation at t and $t-1$.

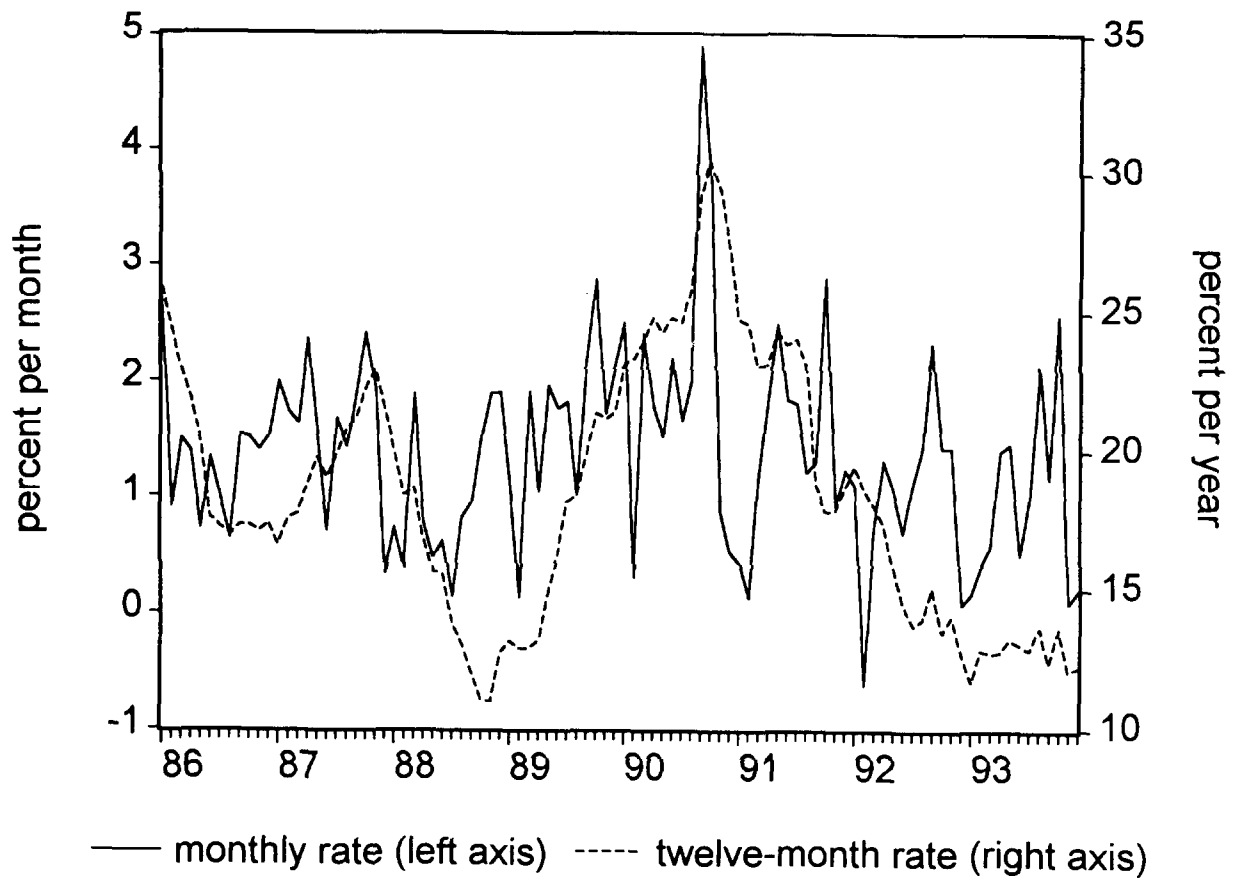
correspond, on average, to UF interest rates. 1/ However, there are two compelling reasons why this rule fails, and hence ex ante real interest rates and UF interest rates are not equivalent. First, monthly inflation in Chile does not follow a random walk, as noted below. Second, the degree of sophistication and inflation-awareness of Chilean financial markets suggests that agents may follow a more rational approach in formulating expectations of inflation. 2/ This view is supported by the results of tests of market efficiency and rational expectations in Mendoza (1992).

Given that the ex post real interest rate is the ex ante rate of a perfect-foresight economy, and that the UF rate is the ex ante rate of a naive economy where the rule-of-thumb holds, we construct an ex ante real interest rate based on rational expectations as a third alternative. A rational expectation corresponds to an expected value for inflation at $t+1$, conditional on information available at t , such that the forecasting error is zero on average and randomly distributed over time. For expectations of inflation at $t+2$ or later, conditional on information available at t , the forecasting error may be autocorrelated over time reflecting unknown information emerging between t and the date for which the forecast applies. This is important because, ex ante real interest rates at t of an indexed asset include expected inflation for $t+3$. Thus, we construct ex ante real interest rates based on rational expectations by examining the statistical

1/ Moreover, if the true probabilistic process that governs monthly inflation is a random walk, the difference between the two rates follows a moving average representation with two lags.

2/ The close attention paid to recurrent "signals" of monthly inflation sent by the Central Bank when agents compare interest rates for the Bank's indexed and nonindexed documents is a clear example of this awareness.

CHART 5
CHILE
INFLATION RATES



process that governs monthly inflation in Chile and using it to compute three-step ahead forecasts. 1/

Using monthly data from January, 1985 to March, 1994, we found that monthly inflation follows a process explained by four lags. 2/ The process also includes monthly dummies to capture seasonality, and two dummies to prevent inflationary surges of September and October, 1990, from biasing end-of-sample forecasts. Inflation forecasts from this model are used to construct the ex ante real interest rate on 90-365 day loans.

Chart 6 plots the ex ante real interest rate together with the UF and ex post rates discussed earlier. The ex ante rate follows a path similar to that of the ex post rate, with the difference between the two being zero on average but displaying some time-dependence due to the nature of the three-step ahead forecast error. Clearly, 90-day ex ante and ex post rates differ significantly from UF rates on a monthly basis.

The long-run implications for financial savings, of the form of imperfect indexation illustrated here are minimal. A lender considering a 96-month holding period of subsequent 90-day UF credit contracts could proxy the long-term real return following UF rates. Over the 96-months covered in the sample, the UF rate is a rough approximation to the *averages* of ex ante and ex post rates--the approximation is not exact because inflation is not a random walk. However, the fact remains that the UF rate is not exactly equivalent to the real interest rate over the quarterly horizon relevant for

1/ We do not test whether the hypothesis of rational expectations is supported by the data as in Lucas (1976) or Barro (1981). Instead, we assume that the hypothesis is true and construct a series of expected inflation that satisfies the conditions of a rational expectation.

2/ Technical details are minimized to keep the focus on policy issues. For details on the econometric analysis see Mendoza and Fernández (1994).

stabilization policy. This finding may have considerable implications for the efficiency of the transmission mechanism of monetary policy. We now turn our attention to these implications.

IV. Interest Rates, Real Activity, and Inflation

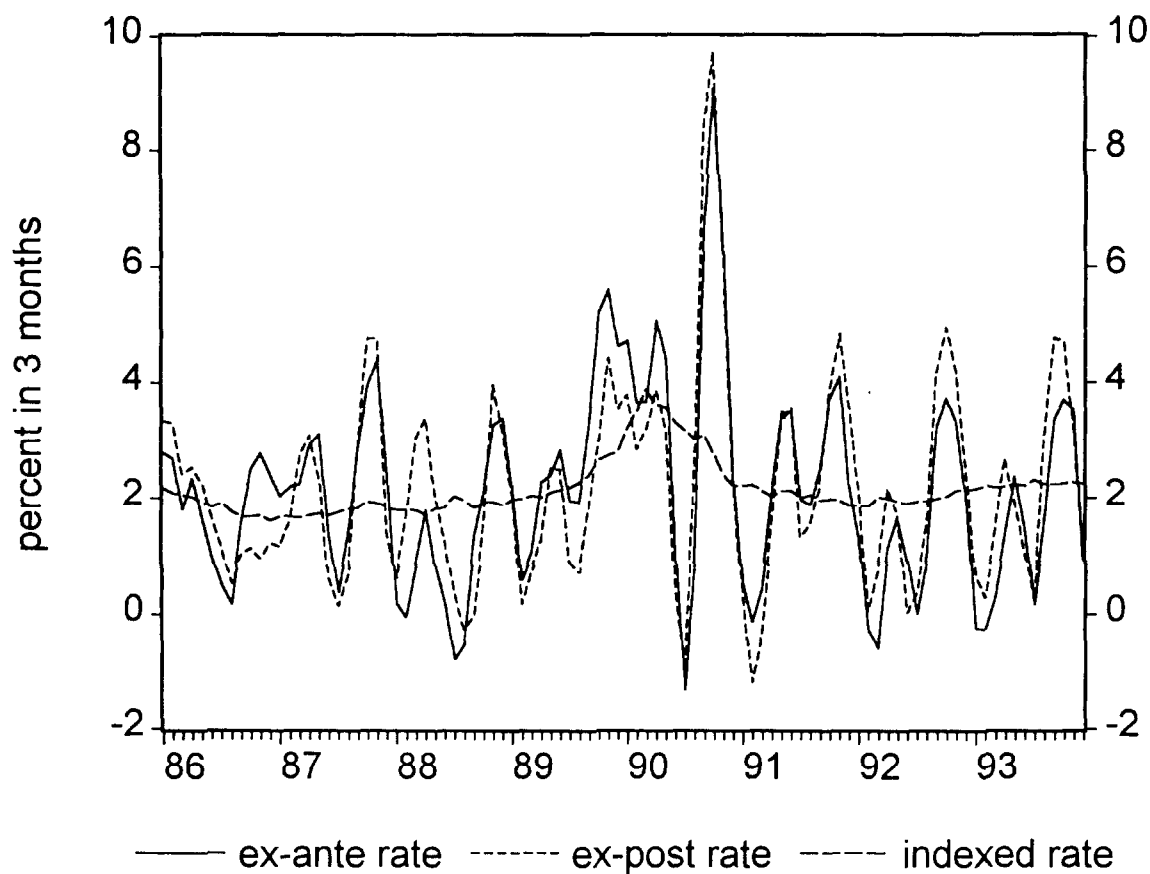
This section reviews results of econometric tests that examine the extent to which the "instrument variable" (i.e. the UF rate) affects first "intermediate variables" (i.e. the output gap and the supply of money) and finally the "objective variable" (i.e. inflation). ^{1/} Note, however, that the behavior of these variables may not be uniquely determined by the causal relationship assumed. All variables may be endogenous in a large structural model and may be affected by exogenous shocks.

The first tests that we review examine statistical causality based on the work of Granger (1969) and Sims (1972). The tests examine whether the history of x is significant for explaining y in a linear regression. If it is, x is said to Granger-cause y . These tests are powerful for examining economic dynamics when precise knowledge of the structural model governing those dynamics is not required or not feasible. This feature makes Granger-Sims tests appealing for our study. We seek to provide evidence on the operation of the monetary transmission mechanism without developing a structural model of inflation dynamics.

Granger tests are used to examine whether the UF lending rate Granger-causes the output gap or money, and whether money or the gap Granger-cause

^{1/} This evidence is documented in detail in Mendoza and Fernández (1994). Similar approaches based on quarterly data have been followed by Rosende and Herrera (1991) and Rojas (1993).

CHART 6
CHILE
EX ANTE AND EX POST REAL INTEREST RATES ON 90-365 DAY LOANS
(quarterly returns from monthly financial system averages)



Note: Ex-ante rate is a staff estimate based on forecasts of an AR(4) seasonally-adjusted model of monthly inflation.

the inflation rate. The transmission mechanism, as a systematic link that can be exploited in the design of policy, would be in question if the hypotheses that the UF lending rate causes money or the output gap, and/or that money or the output gap cause the inflation rate are rejected.

Alternatively, we explore the hypothesis that the UF rate causes the inflation rate directly, as a means for examining whether the instrument influences the objective even if intermediate variables are misspecified. We also consider replacing the UF rate with the *ex ante* real interest rate and with a measure of unexpected inflation.

Table 1 reports the results of Granger causality tests. The results pose serious doubt on the relevance of the transmission mechanism. The main conclusions are the following:

- (1) There is no evidence that the UF rate causes the output gap, money growth, or the inflation rate--the only exception is that at 18 lags the UF rate seems to Granger-cause M1A growth. In contrast, there is some evidence showing that lagged observations of the output gap help explain the UF lending rate, reflecting some feedback between the cyclical position of the economy and the response of the monetary authority.
- (2) The *ex ante* real interest rate does not cause the output gap, nor does the gap cause the *ex ante* rate. However, the *ex ante* rate and inflation or M1A growth exhibit two-way causality. Thus, the *ex ante* rate seems a better proxy of the true real interest rate than the UF rate for explaining money and inflation, but not for explaining fluctuations in real activity.
- (3) Evidence on causality between the output gap and inflation is weak, reflecting in part the instability of the lag structure. For tests including 6 or 12 lags, there is some indication that the output gap explains inflation. However, at longer lags there is no evidence that the gap causes inflation or viceversa.

Table 1. Bivariate Granger Test of Causality between Interest Rates, Output Gap, Money and Inflation 1/

Null Hypothesis "a" d.n.c. "b" <u>2/</u>	Number of Lags							
	6		12		18		24	
	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value
Instrument vs. Intermediate Variable								
Indexed interest rate								
r^{uf} d.n.c. y^c	1.581	0.164	0.568	0.859	0.369	0.987	0.587	0.898
y^c d.n.c. r^{uf}	1.492	0.192	1.701	0.095*	1.357	0.207	1.088	0.423
Ex ante real interest rate								
r^e d.n.c. y^c	0.583	0.743	1.064	0.407	0.769	0.721	0.869	0.632
y^c d.n.c. r^e	0.591	0.736	0.969	0.489	0.611	0.869	0.468	0.963
Unexpected real interest rate								
$(r-r^e)$ d.n.c. y^c	1.919	0.088*	1.111	0.369	1.685	0.083*	1.933	0.059*
y^c d.n.c. $(r-r^e)$	0.322	0.924	0.597	0.836	0.233	0.999	0.560	0.917
Intermediate Variable vs. Target								
12-month inflation rate								
y^c d.n.c. π^y	2.327	0.041**	1.304	0.241	0.964	0.515	0.924	0.576
π^y d.n.c. y^c	0.963	0.456	1.129	0.354	0.996	0.483	0.885	0.616
Instrument vs. Target								
12-month inflation rate								
r^{uf} d.n.c. π^y	1.413	0.221	1.042	0.425	1.606	0.105	1.282	0.281
π^y d.n.c. r^{uf}	0.320	0.924	1.518	0.144	1.778	0.065*	1.410	0.210
r^e d.n.c. π^y	1.230	0.300	4.242	0.000***	3.696	0.000***	2.476	0.118**
π^y d.n.c. r^e	2.892	0.014**	3.867	0.000***	2.790	0.003***	1.150	0.373
$(r-r^e)$ d.n.c. π^y	8.101	0.000***	4.996	0.000***	4.179	0.000***	2.664	0.012**
π^y d.n.c. $(r-r^e)$	1.474	0.198	1.443	0.173	0.908	0.574	1.042	0.463
Memorandum items								
Causality tests for narrow money growth								
M1A d.n.c. y^c	2.372	0.037**	1.772	0.085*	1.971	0.026**	2.416	0.019**
y^c d.n.c. M1A	1.771	0.116	1.644	0.104	0.723	0.769	1.001	0.500
M1A d.n.c. r^{uf}	0.703	0.648	0.925	0.529	0.711	0.779	1.268	0.289
r^{uf} d.n.c. M1A	0.695	0.655	0.773	0.675	1.664	0.089*	1.135	0.385
M1A d.n.c. r^e	1.265	0.284	1.318	0.234	1.079	0.405	3.022	0.001***
r^e d.n.c. M1A	2.077	0.066*	3.776	0.000***	3.031	0.002***	2.101	0.042**
M1A d.n.c. $(r-r^e)$	1.103	0.367	0.577	0.852	0.732	0.760	0.644	0.855
$(r-r^e)$ d.n.c. M1A	2.256	0.047**	2.252	0.020**	1.807	0.058*	1.757	0.091*
M1A d.n.c. π^y	1.367	0.239	0.889	0.564	0.906	0.576	1.413	0.209
π^y d.n.c. M1A	9.059	0.000***	4.445	0.000***	2.854	0.003***	1.807	0.084*

1/ Interest rates are: the UF indexed interest rate (r^{uf}), the ex ante real interest rate (r^e), and the "unexpected" real interest rate ($r-r^e$), all for 90-365 day loans. Output gap (y^c) is the cyclical component of a quadratic time trend applied to seasonally adjusted IMACEC. Inflation (π^y) is a 12-month rate. Narrow money growth is the 12-month percentage change in the monthly average of M1A. The original sample covers February, 1986 to December, 1993. Variables that did not pass the Augmented-Dickey Fuller test for stationarity in levels were first-differenced (this applies to r^{uf} , r^e and π^y).

2/ Between any two variables "a" and "b", "a" d.n.c. "b" corresponds to the null hypothesis that "a does not cause b" in the Granger sense. Thus, it corresponds to an F test for the hypothesis that lagged values of a in "a" regression of "b" against lagged values of "a" and "b" are not significantly different from zero as a group, low F-statistics (high probability values) denote that the null hypothesis cannot be rejected.

* Null hypothesis rejected at 10 percent confidence level.

** Null hypothesis rejected at 5 percent confidence level.

*** Null hypothesis rejected at 1 percent confidence level.

- (4) Money growth causes the output gap and is not caused by the gap, echoing results of Sims (1972) for the U.S. economy, Leiderman (1984) and Reinhart and Reinhart (1991) for Colombia, and Rosende and Herrera (1991) and Rojas (1993) for Chile. 1/ Despite this evidence of non-neutrality, M1A growth does not Granger-cause inflation, while inflation Granger-causes M1A growth. Thus, narrow money seems to accommodate inflation without influencing it, despite the fact that most of it is not indexed.
- (5) To the extent that there is some evidence that the UF rate causes M1A growth (at 18 lags), M1A growth causes the output gap (at 6, 12, 18, or 24 lags), and the output gap causes inflation (at 6 or 12 lags), it could be argued that there is weak evidence in support of the prevailing transmission mechanism. However, the effectiveness lag would be long and complex.

Consider now an alternative transmission mechanism in which the output gap depends on the difference between actual and expected inflation, as measured by the difference between ex post and ex ante real interest rates. This approach is similar to that of expectations-augmented Phillips' curve models based on the rational-expectations theory of aggregate supply, such as those of Lucas (1973) and Barro (1981). 2/ In these models, agents formulate economic decisions with incomplete information and this produces deviations from trend in output that depend on the difference between expected and actual prices. For instance, if workers negotiate wages on the

1/ The exogeneity of money with respect to the output gap raises two important questions. First, following Reinhart and Reinhart (1991), one could argue that this result, despite the real-exchange-rate targeting, reflects the existence of some barriers to international capital mobility. Second, the exogeneity of money leads to the reconsideration of the assumption that money demand adjusts passively to UF interest rates and their effects on output and inflation.

2/ Tests of Lucas-Barro models examine the role of "unexpected money" in a framework in which a monetary aggregate is the policy instrument and inflation is determined by money growth, so that unexpected money reflects errors in rational expectations of inflation. Here we do not test the rational expectations hypothesis, and simply examine the implications of unexpected inflation resulting from an estimate of expectations of inflation that satisfies the conditions of a rational expectation.

basis of an expected price level, but actual prices are higher, the resulting increase in labor demand induces a rise in nominal wages smaller than the increase in prices. Therefore, actual real wages fall while expected real wages rise. In equilibrium, firms demand more labor and households are willing to supply it, and hence output deviates temporarily from its trend.

This alternative transmission mechanism is very robust to the causality tests. The unexpected component of the real interest rate Granger-causes the output gap, money, and inflation, while the latter three variables do not Granger-cause the unexpected real interest rate. These results hold at 6-, 12-, 18-, or 24-lags. Thus, unexpected inflation over dates t and $t+3$ is an exogenous determinant of the output gap, money growth, and inflation at t . However, the UF rate cannot influence the forecast error on future inflation systematically, so it would not be a useful policy instrument under this alternative interpretation.

There are several technical issues that need to be examined to assess the robustness of Granger-causality tests. Among them are (i) the problems that emerge if residuals of Granger regressions are not well-behaved, (ii) the role of exogenous variables, particularly terms of trade and the real exchange rate, (iii) the stability of the results over different samples, and (iv) the potential for statistically-significant causing variables to reflect the influence of other true causing variables

(see Sims (1980)). ^{1/} The results are not altered significantly when these additional factors are considered (see Mendoza and Fernández (1994)).

The power of the tests showing that unexpected inflation explains the output gap is somewhat reduced when 6- and 12-month lags of the relative price of copper in terms of oil--a proxy for terms of trade--are considered. Thus, part of the unexpected inflation reflects the influence of terms-of-trade fluctuations. Moreover, graphics of the responses of the output gap and inflation to an innovation in unexpected inflation show that when prices are lower than expected there is a boom in real activity and a deceleration of inflation. This suggests that, during the period under study, the unexpected component of the real interest rate was influenced by supply shocks, such as the terms-of-trade shock. In the Lucas-Barro framework, these shocks produce booms accompanied by lower inflation.

When causality tests are repeated for the period January 1988-December 1992, which isolates the episode of the large adjustment in UF lending rates, there continues to be no evidence that the UF rate Granger-causes the output gap or that either the UF rate or the output gap Granger-cause inflation. However, the explanatory power of regressions linking the UF rate to the output gap and inflation increases. Moreover, the ninth lag of the UF rate is statistically significant for explaining the output gap and inflation, with coefficients of -5.2 and -2.2 respectively. Thus, when UF rates increased substantially, as in the period 1988-92, the UF rate

^{1/} Examining the role of the real exchange rate is particularly important since real exchange rate targeting, as practiced in Chile, may exert inflationary pressures (see Calvo, Reinhart and Vegh (1994)), and may result in inconsistencies between targets on the real exchange rate and UF interest rates--which are presumed to be a second real target.

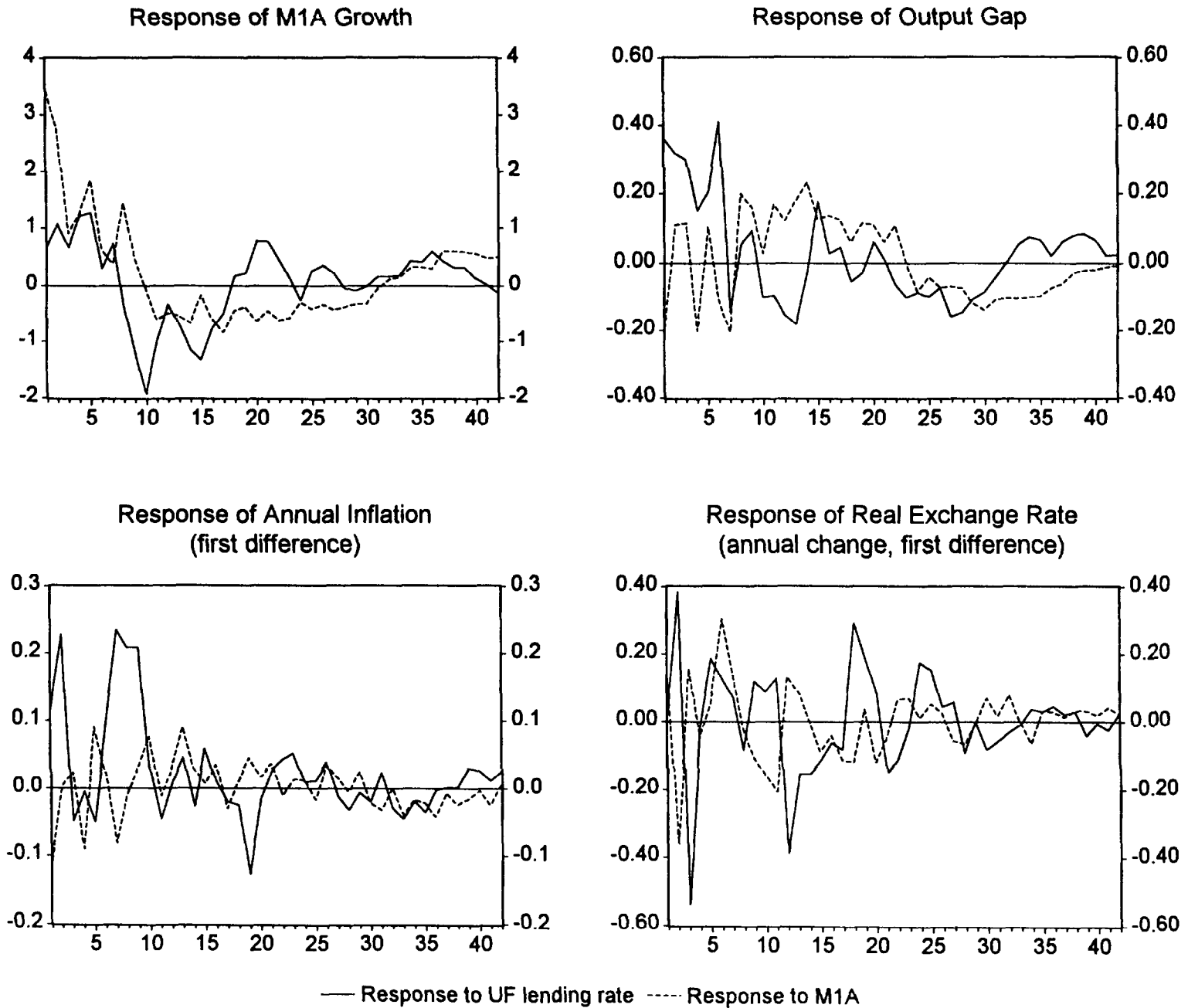
induced a narrowing of the output gap and lower inflation with a delay of nine months.

Granger tests do not say much about the direction of the causality and its magnitude, and they limit the feedback between the variables involved. These issues are better examined in a vector autoregression (VAR) framework. We consider a VAR model in which the UF rate, M1A growth, the output gap, inflation, and the real exchange rate, are determined simultaneously, with the relative price of copper in terms of oil entering as an exogenous variable. Each endogenous variable is a function of 8 lags of all endogenous and exogenous variables. This VAR model produces two sets of results; variance decompositions, which distribute the forecasting error for one variable at different lags among the five variables in the system, and impulse response charts, which illustrate the evolution of all the endogenous variables following an innovation to one of them.

Variance decompositions provide some evidence in favor of the transmission mechanism. First, there is some evidence of dependence of money growth on the UF lending rate--the variability of M1A accounted for by the UF rate can be as high as 17 percent over 36-months, whereas money growth can explain at most 6.5 percent of the variability of the UF rate. Second, about 1/4 of the variability of the output gap is accounted for by the UF rate (15 percent) and money growth (10 percent). Third, nearly 1/2 of the variance of inflation is explained by the instrument and intermediate variables--the UF rate 23 percent, M1A 6 percent, and output gap 21 percent.

Impulse responses caused by shocks to the UF lending rate and M1A growth are plotted in Chart 7. An increase in the UF rate induces lower narrow money growth with a delay of about 8 months. The response of the

CHART 7
CHILE
RESPONSES TO INNOVATIONS IN MONEY AND UF LENDING RATE
(based on VAR model with 8 lags)



output gap is positive on impact, but after 8 months the deviation of output from its trend starts to decline, and this effect persists with varying intensity for over two years. Inflation rises on impact following the increase in the UF rate, it surges again after 10 months, and then it remains approximately stable--except for a sudden deceleration after 20 months. Thus, there is no evidence that the net effect of a UF interest rate hike is a reduction of inflation, even if money growth and the output gap respond as predicted by the transmission mechanism. The response of the real exchange rate reflects the stabilizing influence of adjustments to the reference rate according to inflation differentials.

Impulse responses to a positive money shock are more in line with a conventional view of the transmission mechanism. An increase (decrease) in money growth widens (narrows) the gap between actual and potential GDP and increases (reduces) inflation, with effects that persist over two years. Thus, one may argue that targeting M1A should effectively operate to reduce the inflation rate. However, difficulties in implementing such a strategy, given the instability of the demand for money, cannot be ignored--see Rosende and Herrera (1991), Arrau and De Gregorio (1993), and Rojas (1993).

Finally, we consider a modified VAR model that incorporates long-term, or co-integration, relationships between the *levels* of M1A, interest rate, output, and prices as in Rojas (1993). Impulse response functions of this model indicate that the net effect over 48 months, does not show a significant negative response of money or IMACEC to the higher interest rate. The impact effect on the price level is negative, but after that it follows an increasing trend that is reversed after two years. Thus, there is at best weak evidence suggesting that the transmission mechanism via UF

interest rates, with long and variable lags, is effective. As before, a money shock produces a quicker and stronger response on IMACEC and the CPI than the UF interest rate shock.

V. Concluding Remarks

This paper reviewed empirical evidence that sheds some light on two important elements of the conduct of monetary policy in Chile. First, the paper shows that backward indexation and the variability of monthly inflation introduce a considerable wedge between interest rates quoted on indexed assets (UF interest rates) and ex ante and ex post real interest rates at the maturity relevant for monetary policy instruments. Thus, UF interest rates should not be treated as equivalent to real interest rates in the design of stabilization policies.

Second, the paper examines the link between the instrument variable (UF rates), the intermediate variables (narrow money and output), and the objective variable (inflation) of the monetary transmission mechanism. At first sight the data suggest that the transmission mechanism was effective in response to the substantial adjustment of UF interest rates implemented in 1989-90, but formal analysis (based on tests of statistical causality for a monthly sample covering the period 1986-1993) shows that there is no clear evidence of a systematic link between UF interest rate adjustments and (i) the deviation from trend in an indicator of real activity, (ii) narrow money growth, and (iii) inflation. Nevertheless, for a subsample that isolates the episode of the large interest rate hike (1988-92), it is estimated that the adjustment of the UF rate induced a decline in inflation and a reduction of the output gap, but only after nine months. Thus,

targeting interest rates on indexed assets may effectively reduce inflation only when interest rates are raised substantially.

Further analysis using vector autoregression techniques confirmed the results of causality tests and showed that narrow money is more effective in triggering the transmission mechanism than UF interest rates. Although it can be argued that the transmission mechanism via interest rates on indexed assets may be effective, it operates through a long and unstable lag structure that complicates its predictability. This suggests that targeting monetary aggregates may be a more effective policy strategy than small increases in UF interest rates.

Tests for alternative interpretations of the transmission mechanism showed that the difference between actual and expected inflation is systematically related to the output gap. Thus, there is evidence in favor of a model of an expectations augmented Phillips' curve based on errors in inflationary expectations. This is consistent with the result that supply shocks, represented by the relative price of copper in terms of oil, help explain the output-inflation trade-off in the Chilean economy.

The conclusions reached here should be viewed with caution. The empirical tests reviewed do not establish unequivocally whether an inflation-reduction strategy based on nominal interest or exchange rates, or monetary aggregates dominates one based on UF interest rates. While short-term nominal interest rates exist in Chile, these are arbitrated against interest rates on indexed assets of similar maturity (see Mendoza (1992)), and hence they are not useful for testing the performance of nominal interest rate targets to reduce inflation. Similarly, inflation-differential adjustments to the reference nominal exchange rate complicate

tests of the effectiveness of the exchange rate as a nominal anchor. As for targeting monetary aggregates, Chile has evidence of instability in money demand that makes setting and tracking monetary targets difficult. The relative effectiveness of these different strategies could be studied using the tests proposed by McCallum (1990).

In light of this evidence, an eclectic approach to monetary policy that takes into account different elements of the transmission mechanism seems warranted. This is in line with views that are becoming widespread among Central Banks, including the Central Bank of Chile.

References

- Arrau, Patricio and Jose De Gregorio, "Financial Innovation and Money Demand: Application to Chile and Mexico," mimeo, International Monetary Fund, 1993 (forthcoming Review of Economics and Statistics).
- Barro, Robert J., "The Equilibrium Approach to Business Cycles," in Money, Expectations and Business Cycles, Academic Press, New York, 1981.
- Calvo, Guillermo A., Carmen M. Reinhart and Carlos A. Vegh, "Targeting the Real Exchange Rate: Theory and Evidence," Journal of Development Economics, forthcoming 1994.
- Fischer, Stanley, Indexing, Inflation, and Economic Policy, MIT Press, Cambridge, 1986.
- Friedman, Milton, "Monetary Correction," in Essays on Inflation and Indexation, by Herbert Giersch and others, American Enterprise Institute for Policy Research, Washington, 1974.
- , Anna Schwartz, A Monetary History of the United States 1867-1960, National Bureau of Economic Research, Princeton University Press, Princeton, New Jersey, 1963.
- Granger, C. W. J., "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," Econometrica, Vol. 37, No.3, 1969.
- Gray, Jo Anna, "Wage Indexation: A Macroeconomic Approach," Journal of Monetary Economics, Vol. 2, August 1976, pp. 221-35.
- Leiderman, Leonardo "On the Monetary Macro Dynamics of Colombia and Mexico," Journal of Development Economics, Vol. 14, 183-201, 1984.
- Lucas Jr., Robert E., "Some International Evidence on Output-Inflation Tradeoffs," American Economic Review, Vol. 63, pp. 326-34, (June, 1973).
- McCallum, Bennett T. "Targets, Indicators, and Instruments of Monetary Policy," IMF Working Paper No. WP/90/41, International Monetary Fund, (Washington: April, 1990).
- Mendoza, Enrique G., "Fisherian Transmission and Efficient Arbitrage under Partial Financial Indexation: The Case of Chile," IMF Staff Papers, Vol. 39, No. 1, (March, 1992).
- , "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations," mimeo, International Monetary Fund, 1994 (forthcoming, International Economic Review, February, 1995).

- , and Fernando Fernández, "Inflation and Output Responses to Targets on Interest Rates of Indexed Assets: The Case of Chile," mimeo, International Monetary Fund (forthcoming Working Paper)
- Parkin, Michael and Robin Bade, Modern Macroeconomics, third edition, Prentice-Hall, (Canada: 1992).
- Reinhart, Carmen M. and Vincent R. Reinhart, "Output Fluctuations and Monetary Shocks," IMF Staff Papers, Vol. 38, No. 4, (December, 1991).
- Rojas, Patricio, "El Dinero como un Objetivo Intermedio de la Política Monetaria en Chile," Cuadernos de Economía Vol. 30, No. 90, pp. 139-178, (Agosto, 1993).
- Rosende, Francisco and L. O. Herrera, "Teoría y Política Monetaria: Elementos para el Análisis," Cuadernos de Economía, No. 83, (Abril, 1991).
- Sims, Christopher A., "Money, Income, and Causality," American Economic Review, Vol. 62, No. 4, 1972.
- , "Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered," American Economic Review, Vol. 70, No. 2, (May, 1980).