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Efficient Arbitrage Under Financial Indexation: The Case of Chile

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Abstract

Legal restrictions governing financial transactions in Chile have produced a system in which most financial assets are either 30-day non-indexed assets or 90-day indexed assets. This paper analyzes data on the rates of return of these assets to determine the extent to which efficient arbitrage takes place under conditions of partial financial indexation. The data cannot reject the joint hypothesis that participants in financial markets formulate their expectations rationally and that these markets operate efficiently. The data also shows that the indexed/non-indexed interest spread is an accurate predictor of future changes in inflation. The significant implications of these findings for the conduct of monetary policy are also discussed in some detail.

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<u>Table of Contents</u>   <u>Page</u>

Summary

Indexed financial transactions taking place in Chile since 1967 have been the subject of continuing debate. Advocates claim that financial indexation eliminates the adverse effects of unanticipated price changes and facilitates credit operations under inflationary conditions. Critics argue that indexation unnecessarily increases interest rates and stimulates inflation by imparting inertia to price changes. This paper undertakes a series of empirical tests intended to shed light on issues in this debate.

Legal restrictions have induced individuals to concentrate their holdings of time deposits in the form of either 30-day non-indexed deposits or 90-day indexed deposits. This paper analyzes financial markets operating under these conditions with a view to assessing the effectiveness of indexation in eliminating the inflation-risk factor of nominal interest rates. The paper argues that indexation takes place in an environment of competitive and efficient financial markets with rational expectations where a given change in expectations of inflation induced a change of identical magnitude in interest rates, as predicted by the Fisher effect. To support the case that indexation eliminates the inflation risk and does not validate higher interest rates than a non-indexed system, this paper tests the joint hypothesis of market efficiency, rational expectations, and Fisherian transmission.

Market efficiency holds in the sense that agents expect to make no gain or loss, other than a modest liquidity premium, by shifting three-month investments from 30-days non-indexed to 90-days indexed time deposits. The econometric analysis does not find evidence of an inflation-risk premium on the rates of return of non-indexed assets. The data also support the hypothesis that inflation changes are consistent with the Fisherian effect. The interest rate spread between 90-day indexed deposits and 30-day non-indexed deposits is an accurate indicator of future changes in inflation exceeding the adjustment of the indexation factor. The analysis also shows that the one-month lag with which indexation is undertaken introduces a significant imperfection in the indexation mechanism. Consequently, the interest rate quoted on indexed deposits is not equivalent to the ex ante real interest rate relevant for savings decisions and hence should not be considered as a target or indicator for the conduct of monetary policy. The interest rate spread between indexed and non-indexed assets is a better indicator of the public's perception regarding the stance of monetary policy.

"All variations in the value of the circulating medium are
mischievous: they disturb existing contracts and expectations,
and the liability to such changes renders every pecuniary
engagement of long date entirely precarious."

John Stuart Mill, _Principles of Political Economy_, 1848.

I. Introduction

The purpose of this paper is to study the mechanism of financial
indexation currently operating in Chile and its influence on the recent
evolution of the country's financial system. A number of econometric tests
were undertaken which provide support for three hypotheses: (1) there is
efficient arbitrage in Chilean financial markets--in the sense that changes
in the return of 90-day indexed assets result in identical changes in the
return of 3-month investments on 30-day non-indexed assets, (2) inflationary
expectations are formed rationally--in the sense that the predictions of
economic agents are not _systematically_ erroneous, and (3) the interest
spread between indexed and non-indexed assets is an accurate predictor of
future increases in inflation.

These three hypotheses have significant implications for key
operational issues related to the desirability of indexing the financial
system and the formulation of monetary policy. In particular, the results
of the tests support the view that financial indexation diminishes the risks
associated with inflation and does not necessarily induce an unjustified
increase in interest rates. Moreover, the results also indicate that the
premium over inflation that indexed assets offer _cannot_ be treated as a
proxy for the relevant real interest rate of the economy, and that the
interest rate spread between indexed and non-indexed assets is a better
indicator of the public's perception of the stance of monetary policy.

The debate on the effects of financial indexation is closely related to
the recurrent controversy involving the costs of inflation. 1/ Advocates
of financial indexation argue that the introduction of indexed financial
assets eliminates income-redistribution effects and the inflation-risk
component of interest rates because it neutralizes the effects of

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1/ The adverse effects of inflation on the distribution of income between
creditors and debtors and on the degree of uncertainty affecting credit
markets have been a cause of concern for a long time (see Mill (1848)
Chapter XIII). Two classic papers on indexation and the costs of inflation
are Friedman (1974) and Gray (1976). For a textbook discussion of financial
indexation, see Gordon (1978), and for wage indexation, see Parkin and Bade
(1986). The advantages of financial indexation are explored from the
perspective of the more recent intertemporal equilibrium approach by Calvo
and Guidotti (1989). The risk of indeterminacy of the price level due to
excessive inertia and other issues regarding the public's aversion toward
indexed contracts and the determination of the relevant price index are
reviewed by Leijonhufvud (1981).

unanticipated inflation. Thus, indexation reduces the degree of uncertainty affecting credit transactions and facilitates the operation of financial markets under inflationary conditions. In contrast, critics of financial indexation argue that indexing the financial system fuels the inflationary process by exacerbating the inertia of price changes. 1/ Moreover, when coexisting with non-indexed labor and goods markets, financial indexation causes income-redistribution effects that affect those firms and households facing indexed debts with non-indexed revenue and income streams. 2/

Most of the arguments for and against financial indexation can be simply stated in terms of the Fisher effect, according to which the nominal interest rate i is equivalent to the ex ante real interest rate r plus expected inflation p^e: $i=r+p^e$. For a given ex ante real rate of interest, the Fisher effect dictates that a higher nominal interest rate applies to financial transactions if prices are expected to rise. The case in favor of financial indexation can be presented by considering an environment in which errors in inflationary expectations are not made systematically and markets operate efficiently. Under these conditions, the Fisher effect implies that the evolution of interest rates in an indexed system cannot deviate systematically from the evolution of interest rates in a non-indexed system. The main advantage of indexation is that it flattens the term structure of interest rates because risk premia associated with the variance of errors in forecasting inflation are eliminated, thereby easing the operation of financial markets under conditions of high and variable inflation.

The case against financial indexation, on the other hand, is often based on the hypothesis that complete Fisherian transmission never takes place because expectations underestimate inflation systematically and markets are inefficient. Thus, indexation forces nominal interest rates to be higher than under normal market conditions and induces persistent disturbances to the cost of credit and the demand for real money balances. The demand for money fluctuates because of the increments in the interest rates and also because indexation sends distabilizing signals that fuel inflationary expectations even if fundamentals remain unaltered.

1/ A stronger version of this critique, as explained by Leijonhufvud (1981), argues that because indexation is equivalent to forcing price expectations to exhibit unitary elasticity, any small price change could cause an exploding inflationary spiral. However, advocates of financial indexation have shown that although changes in inflation are likely to be larger in indexed economies, the price level and inflation are well-defined and stable as long as the supply of money is not fully indexed (see Parkin and Bade (1986)).

2/ Critics of indexation would argue that the social costs of the redistributive effects that occur when interest rates are not indexed are less important than those that occur under a partial indexation system. Issues related to income redistribution and its social cost are not addressed in this paper.

The previous arguments show that the conflicting views on financial indexation are founded on different notions regarding the efficiency of credit markets and the manner in which individuals formulate expectations about future inflation. In economies where financial markets are well-organized and competitive, and where market participants formulate expectations rationally, indexation eliminates the inflation-risk component of interest rates and cannot result in systematically higher interest rates than a system without indexation. This paper attempts to establish the extent to which the Chilean financial system fits this framework by undertaking two empirical tests: one that provides evidence on the degree of efficiency of the financial system, and another that extracts the information conveyed by the differential between indexed and non-indexed interest rates regarding future increases in inflation. Both tests are conducted jointly with the hypothesis that agents formulate their expectations rationally, i.e., that their projections of future inflation are not systematically biased.

The paper is organized as follows. The next section describes the operation of Chile's financial indexation mechanism, with a brief description of its role in the banking crash of 1983, and illustrates its impact on the structure of the deposit base of the banking system. Section III studies the efficiency of the financial system, taking advantage of the existing regulations that force short-term non-indexed assets to coexist with medium- and long-term indexed assets. Section IV analyses the information contained in the interest rate spread between indexed and non-indexed time deposits regarding future changes in the inflation rate, and also provides some evidence on the real interest rate that is relevant for financial decisions. The last section presents some concluding remarks.

II. Chile: Indexation and Financial Markets

This section is divided in two parts. The first part describes how financial indexation operates in Chile, focusing on some of the imperfections of the mechanism being used. The second part is a brief review of some of the characteristics of the Chilean financial system that helps illustrate some of the effects of the indexation regime.

1. Financial indexation in Chile

Financial indexation in Chile is based on the use of a unit of account known as the "Unidad de Fomento" (UF) or Development Unit. The UF operates as an exchange rate between Chilean pesos and development units that is linked to the inflation rate with a delay of approximately one month, and that serves to denominate all indexed financial transactions. For example, an indexed time deposit operates as follows. The deposit is entered by converting the amount in Chilean pesos into development units at the current UF exchange rate. Interest is paid with respect to the balance denominated in UF on the basis of an annual rate compounded monthly. This interest rate will be referred to as the premium over UF. Upon maturity, principal and

interest are converted back into Chilean pesos at the corresponding UF exchange rate. The deposit is indexed because the value of the UF grows each month at about the same rate as last month's inflation, and for this reason the premium over UF is viewed as a real interest rate.

The timing and methodology by which the value of the UF is adjusted have important implications. The UF begins to be adjusted in the tenth day of month t by a proportional amount each day, so as to ensure that by the ninth day of month t+1 it has increased by as much as the price level did in month t-1. Figure 1 depicts the ex post nominal yield that was actually paid on 90-day indexed time deposits, as a 3-month percentage rate that considers both the interest rate and the observed change in the UF, and the ex post 90-day inflation rate. The figure illustrates the degree of imperfection affecting the adjustment of the yield on indexed deposits to inflation because of the one-month lag imbedded in the indexation mechanism.

The imperfection of the indexation mechanism is also reflected in the fact that, as shown in Figures 2 and 3, the premium over UF and the ex post real interest rate on indexed assets are not equivalent, as they should be under a perfect indexation system. 1/ Figure 2 presents the premium over UF paid on 90-day indexed time deposits as a percentage rate over three months. Figure 3 depicts the ex post real interest rates actually paid on 30-day non-indexed and 90-day indexed deposits as a percentage rate over three months (i.e., the difference between the two curves in Figure 1 for the case of 90-day indexed time deposits). According to these charts, there is a significant discrepancy between the premium over UF and the ex post real interest rate paid on 90-day indexed deposits. For instance, in March of 1989 a 90-day indexed time deposit offered a premium over UF of about 1.4 percent (5.7 percent on an annual basis), but the real return of this investment was in fact slightly negative. However, because the relevant real interest rate for economic decisions is the ex ante rate, which incorporates expectations of inflation rather than actual inflation, it is necessary to explore whether this discrepancy is also present in ex ante rates. This issue is studied later in the paper.

The indexation mechanism was complemented with a set of regulations that governs the coexistence of indexed and non-indexed deposits. These regulations prevent the full indexation of the money supply, as well as the complete displacement of the Chilean peso from the financial system by risk-

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1/ The ex post real interest rate on a 90-day indexed time deposit entered at date t is computed as the difference between the effective yield, which is the sum of the premium over UF quoted at t plus the change in the value of the UF in the 90 days following t, and the inflation observed 90 days after t. The premium over UF is quoted in annual terms and compounds monthly. The rates in Figures 1-3 are returns over a period of three months.

Figure 1

EX POST INDEXED INTEREST AND INFLATION
(deposits, 90d – 1y.term)

□ indexed deposits   + inflation
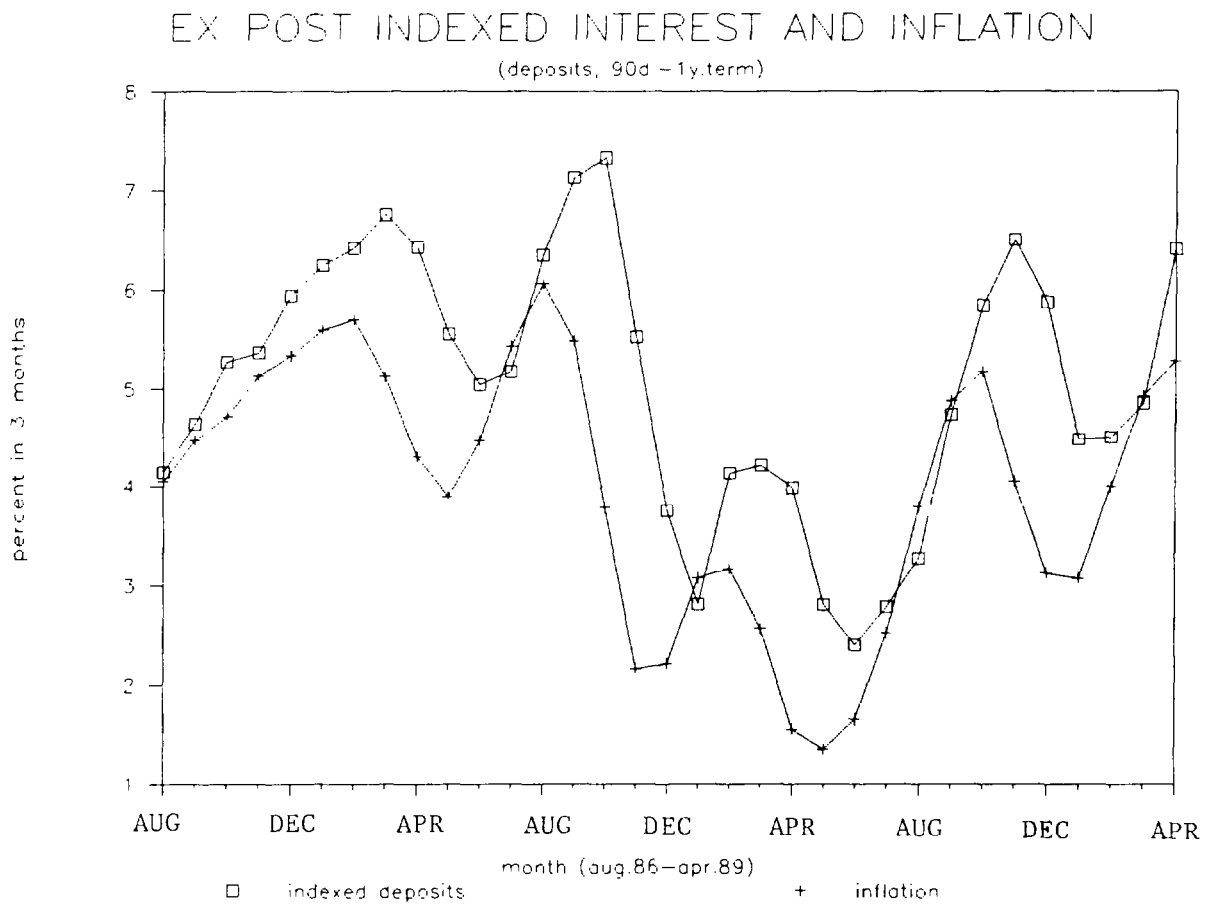
Figures 2 and 3

EFFECTIVE PREMIUM ON INDEXED DEPOSITS

(90 day-1 year term)

month (aug.86-apr.89)

□ premium over U.F.
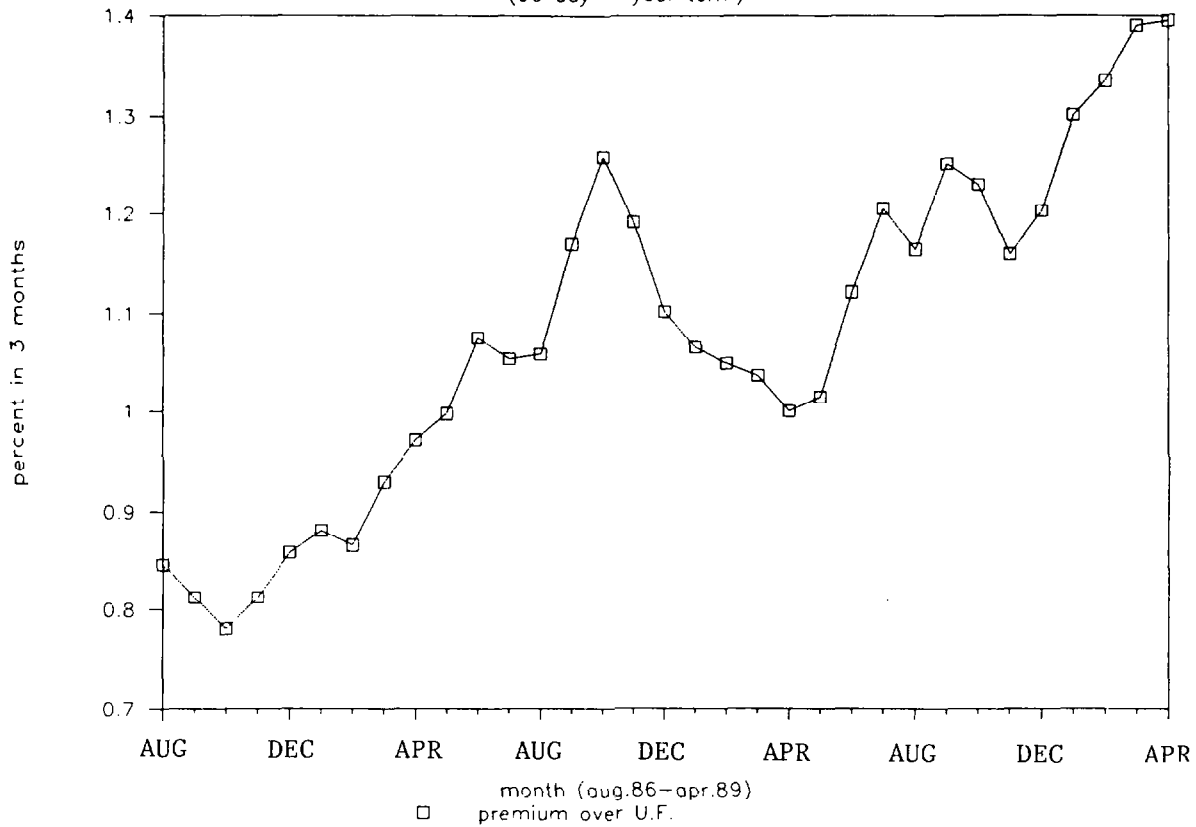
EX POST REAL INTEREST RATES

(deposits, 30d.-89d. and 90d-1y. terms)

month (aug.86-apr.89)

□ indexed   + nonindexed 3m. inv.
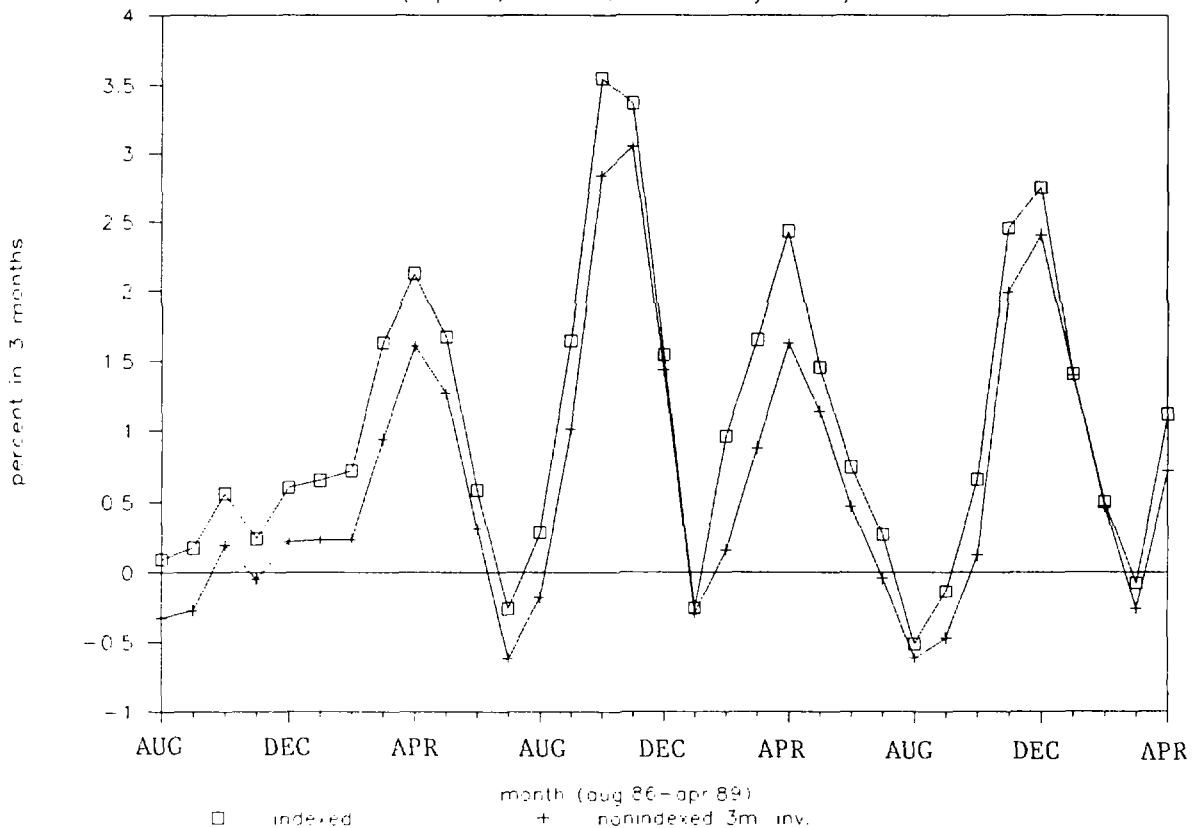
averse agents seeking insurance against inflation. 1/ Indexed time deposits are allowed only for maturities of 90 days or longer, whereas non-indexed interest-bearing deposits are legal for maturities of 30 days. The treatment is slightly different with respect to loans; indexed loans are allowed for terms as short as 30 days, but non-indexed lending operations are legal for less than 30 days maturity.

2. Indexation and the Chilean financial system

Chile's financial markets are well organized and free from the distortions that result from excessive direct government intervention. This however, does not mean that financial transactions are not supervised by the monetary authorities. Banking operations are strictly supervised by the Superintendencia de Bancos e Instituciones Financieras (Superintendency of Banks and Financial Institutions), which strengthened its regulatory role after the major financial crisis that occurred in 1983.

That financial crisis resulted from the accumulation of a large stock of nonperforming assets in the banking system, apparently as a result of high real interest rates, high debt-to-equity ratios of business firms, poor practices regarding risk management of the bank's assets, and a significant decline in economic activity during 1981-82. The subsequent sharp depreciation of the peso in 1982-83 caused further damage by generating widespread defaults on loans contracted in foreign currency, and by causing significant operational losses to banks financing loans denominated in domestic currency with resources borrowed in foreign currencies. After 1983 the financial system started to recover slowly from the crisis, following the gradual improvement in economic conditions and the adoption of a set of policies aimed at increasing liquidity and restoring solvency. 2/

The role that the indexation system may have played in generating the financial crisis must be evaluated with caution and a thorough discussion of the issue is beyond the scope of this paper. Financial indexation had been in place without causing any major disturbance long before the crisis started, and it was maintained throughout and continued after it ended. 3/

1/ These regulations are consistent with some of the recent literature on monetary legal restrictions, e.g., Smith (1988), in which restrictions serve the purpose of preventing the private sector from issuing close substitutes of money so as to avoid large price fluctuations and adjustments in financial markets.

2/ These policies included the intervention and closing of banks, the provision of massive liquidity support by the Central Bank, the temporary public guarantee of bank deposits, the establishment of credit lines in support of private debtors, and a program of recapitalization based on voluntary sale of a fraction of bad loans to the Central Bank.

3/ Daily adjustments in the UF on the basis of the inflation from the previous month have been undertaken since 1977. The UF was first introduced in January of 1967 under a system of quarterly adjustments.

For some firms and banks, particularly those involved in industries with declining relative prices, indexed loans and deposits were an important factor contributing to liquidity problems and inability to repay debts. To this extent the indexation system contributed to speeding up the rate at which the crisis propagated. However, the prices cf goods sold by the average firm increased at least as fast as indexed debt commitments, and possibly faster because of the one-month lag in the indexation system. Thus, it is likely that the widespread inability to service debts had to do more with the recession and poor banking practices than with indexation itself. Unless it could be shown that a non-indexed market would have underestimated future inflation substantially in setting interest rates, resulting in lower interest rates than under indexation, the chain of business failures would have followed in a similar manner even without indexation. Moreover, by partially eliminating the risk of unanticipated *inflation, financial indexation gave credibility to some of the policies* used to attack the crisis, particularly the guarantee on bank deposits and the recapitalization programs.

Nevertheless, there is evidence suggesting that financial indexation has induced important permanent changes in the structure of the Chilean financial system. In principle, partial financial indexation differentiates a subset of financial assets on the basis of the increased degree of protection against inflation that they provide. Consequently, risk-averse individuals are likely to show a preference for indexed assets in the allocation of their portfolio.

A review of the term-structure of time deposits supports this hypothesis. Figure 4 illustrates the term-structure of time deposits in the financial system using monthly averages for the period January 1986-May 1990. It shows that approximately 80 percent of all time deposits are concentrated in terms between 30 days and 1 year. 1/ On average, 30- to 90-day deposits account for 38 percent and 90-day to 1-year deposits account for 41 percent of total time deposits. 2/ Figure 5 details the distribution of 90-day to 1-year deposits in terms of indexed and non-indexed deposits, and shows that the vast majority of them are indexed (about 98 percent on average). 3/ Thus, the existing regime of partial financial indexation, operating in an environment of moderately high and

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1/ The secular growth in deposits with more than 1 year maturity reflects the growth of deposits from the pension funds, which should not be viewed as pertaining to the private sector but to nonbank financial intermediaries.

2/ Deposits in U.S. dollars are allowed for maturities of 30 days or longer, with adjustments in the exchange rate of the Chilean peso vis a vis the U.S. dollar that fluctuate around the difference between the movement of the UF and an estimate of foreign inflation. During the period January 1986-May 1990 these deposits were equivalent to less than one third of the total of deposits denominated in Chilean currency.

3/ A similar result is obtained from the data on total daily banking operations of time deposits.

Figures 4 and 5

TERM STRUCTURE OF TIME DEPOSITS

(monthly averages)

30–90 days   90 days–1 year   1 year or more
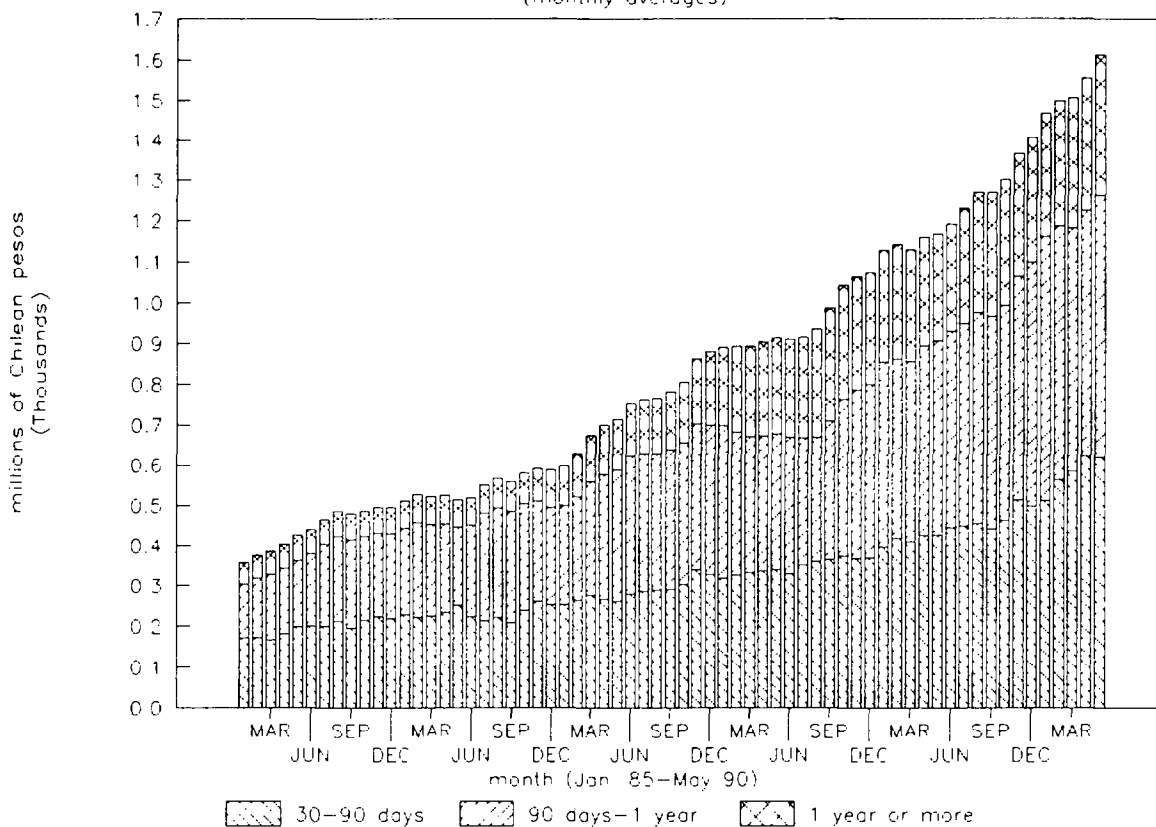
STRUCTURE OF 90–DAY DEPOSITS

(monthly averages)

month (Jan 85–May 90)

indexed deposits   nonindexed deposits

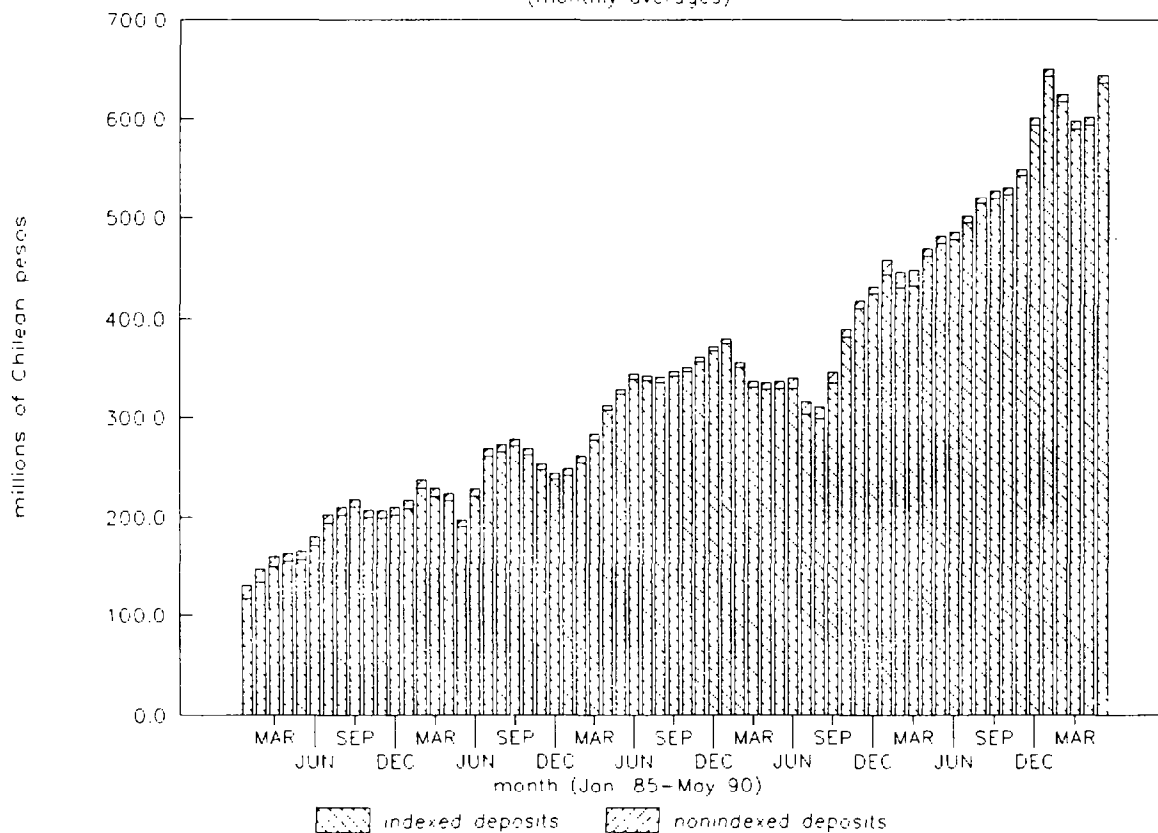variable inflation rates, has resulted in a market in which depositors seek the best possible protection against inflation, which is found either in short-term non-indexed deposits that are highly liquid, or in the most liquid indexed deposit available.

The fact that individuals hold substantial amounts of 30-day non-indexed deposits suggests that, in addition to liquidity considerations, they regard them as relatively safe from the eroding effects of inflation. This may reflect in part the policy of setting an indicative nominal interest rate for 30-day deposits according to past and expected inflation plus a premium, which was followed until June of 1987. On the other hand, as documented in the next section, efficient arbitrage with 90-day indexed deposits has also played a major role in ensuring that 30-day non-indexed deposits provide a good safeguard against inflation.

III. Efficiency of Chilean Financial Markets

This section undertakes various tests of the efficiency of Chilean financial markets. These tests focus on the effective rates of return paid on 30-day non-indexed and 90-day indexed time deposits. The rationale for dealing only with these two maturities is that, as noted above, the majority of time deposits in the Chilean financial system fall in these two categories.

Consider a perfectly competitive financial market in which there is no uncertainty. In this environment, the public is endowed with perfect foresight regarding future values of short-term interest rates and the evolution of the UF, and arbitrage equalizes the ex post effective returns of 3-month investments on 30-day non-indexed deposits and a 90-day indexed deposit:

$$(1+i_t)(1+i_{t+1})(1+i_{t+2}) = (1+{}_tUF_{t+3})(1+r_t). \tag{1}$$

The notation here is as follows: (a) i_t is the _monthly_ nominal interest rate on a 30-day non-indexed time deposit entered at date t, with i_{t+1} and i_{t+2} denoting the same rate as quoted 30 and 60 days after t, (b) ${}_tUF_{t+3}$ is the percentage change actually observed in the UF in the 90 days following t, and (c) r_t is the 90-day premium over UF quoted at date t on an indexed time deposit. 1/ Thus, the left-hand side of (1) measures the actual effective yield of a 3-month investment in deposits with a maturity of 30 days, which is denominated as the Ex Post Nominal Interest, whereas the right-hand side measures the actual effective yield in Chilean pesos of a 3-month investment in a 90-day indexed deposit, which is referred to as the Ex Post Indexed Interest.

1/ These rates are published in annual terms, but in evaluating equation (1) care must be taken of the fact that they are compounded monthly.

Figure 6 depicts the recent monthly evolution of the ex post nominal and indexed interest rates, as measured by the left- and right-hand sides of equation (1) respectively. The chart shows that both rates follow similar trends, although the effective yield of a 3-month investment on a 90-day indexed deposit is systematically higher than that on 30-day non-indexed deposits. Indexed deposits may need to be offered at a premium because the two types of deposits are not perfect substitutes in terms of liquidity. Moreover, indexed assets may also be more risky because the one-month lag of indexation makes the real return on these deposits vary with the difference between the inflation rate in the month before acquiring the deposit and the inflation rate in the month before it matures. When inflation rates are very volatile, or during turning points from increasing to decreasing inflation, this difference can be substantial and difficult to estimate, as the next sections will show. Even when the existence of a time invariant liquidity premium is taken into account, the match of the two rates of return will not be exact each period because the public and the banks do not know the future values of interest rates and the UF with certainty, and thus in practice expectations must replace the values of future variables in expression (1).

Incorporating the preceding arguments, taking logs of both sides of (1), and assuming that all rates involved are relatively small, the market-efficiency condition can be rewritten as:

$$i_t + E_t i_{t+1} + E_t i_{t+2} = E_t UF_{t+3} + r_t - LP. \tag{2}$$

Future short-term interest rates and the 3-month growth of the UF are expectations formed with the information available at date t, 1/ and LP is a time-invariant liquidity premium on 90-day deposits.

In order to perform formal econometric tests of the efficiency of Chilean financial markets using (2), it is necessary to introduce an assumption regarding the formation of expectations. The tests will analyze jointly market efficiency--in this case allowing for a liquidity premium-- and a particular hypothesis of how expectations are formed. The high degree of organization and development of Chilean financial markets suggests that both the banks and the public are potentially capable of forming an educated guess of future inflation by making extensive use of the information publicly available. Thus, there is in the case of Chile a good basis for supporting the hypothesis that there is efficient arbitrage in financial markets and that expectations are formed rationally--which is not equivalent to perfect foresight.

1/ This paper focuses on market efficiency when expectations are formed on the basis of publicly available information, which in the finance literature is viewed as semi-strong market efficiency since it ignores the role of "inside" information. However, the role of inside information in the market of bank deposits is likely to be limited.

Figure 6

EX POST NOMINAL AND INDEXED INTEREST
(deposits, 30d.—89d and 90d—1y. terms)
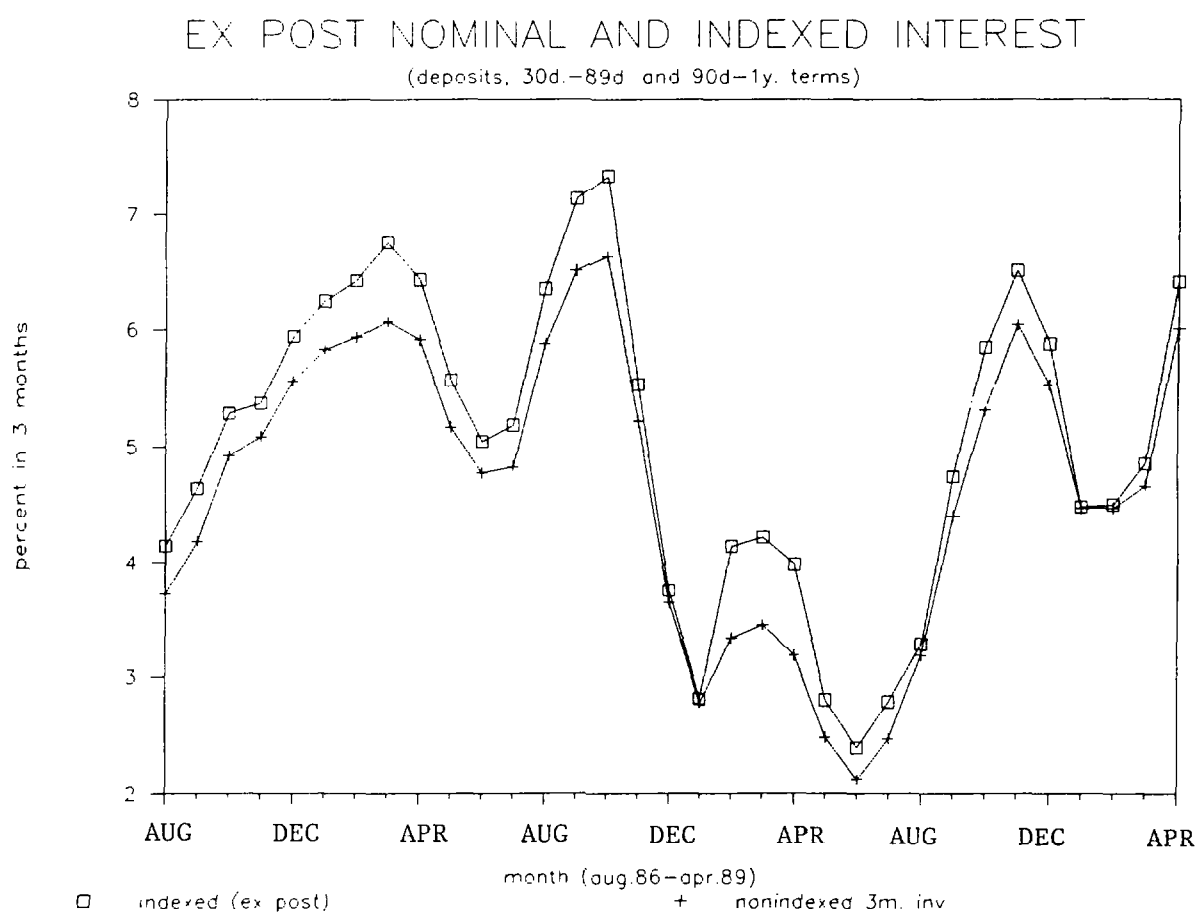
If expectations are rational, forecasting errors are random variables which follow a stochastic process that depends on how far in the future individuals must form expectations on the basis of the information available today. In the case that at period t expectations need to be formed for variables at t+1, the errors follow a white noise process, whereas in cases that require expectations for variables dated t+2 or later, as is the case in this paper, the errors follow a moving average representation. Adding and subtracting the actual values of expected variables to equation (2) results in the following expression:

$$i_t + i_{t+1} + i_{t+2} = {_t}UF_{t+3} + r_t - LP + u_t, \tag{3}$$

$$u_t = e^i{}_{t+1} + e^i{}_{t+2} - e^{uf}{}_{t+3}$$

Where u_t is a random error that includes the forecasting errors with regard to future values of the 30-day non-indexed interest rates ($e^i{}_{t+1}$ and $e^i{}_{t+2}$) and the error in predicting the 90-day growth of the UF ($e^{uf}{}_{t+3}$). Given the one-month lag affecting the adjustments in the UF, if can be shown that u_t should follow a first-order moving average process in order to be consistent with rational expectations. 1/ The moving average error reflects the fact that innovations in monthly interest rates or the UF--i.e., inflation--that occur between date t and date t+3 constitute information not available at t that is relevant for explaining the relative returns of the two investments.

The first test of the _joint hypothesis_ of market efficiency, rational expectations, and a time-invariant liquidity premium is conducted as follows. Expression (3) is rewritten to define the dependent variable as the ex post differential of the effective yields of the two investments in time deposits being considered, which is referred to as DR9030F. If the data supports the hypothesis, DR9030F should follow a stochastic process characterized as a first-order moving average with a constant term:

$$DR9030F = (i_t + i_{t+1} + i_{t+2}) - ({_t}UF_{t+3} + r_t) = -LP + u_t, \tag{4}$$

$$\text{with} \quad u_t = v_t + \theta v_{t-1} \text{ and } v_t \text{ is i.i.d.}$$

Thus, the test consists of identifying the time-series process that characterizes DR9030F in the Chilean data, to see if it satisfies the properties consistent with market efficiency, rational expectations, and a time-invariant liquidity premium on indexed deposits. Note that this test will only support or reject the three hypotheses jointly, without distinguishing one from the others.

1/ Since $e^{UF}_{t+3} = e^{\Pi}_{t+1} + e^{\Pi}_{t+2}$, where e^{Π} is the forecasting error with regard to inflation, it follows that, assuming that i and Π are white noise, $cov(U_t U_{t+1}) = \sigma_i^2 + \sigma_{\Pi}^2$, where σ_i^2 and σ_{Π}^2 are the variances of the forecasting errors related to interest rates and inflation, and $cov(U_t, U_{t+k}) = 0$ for all $k > 1$.

The time series process corresponding to DR9030F is identified following the Box-Jenkins method. The plots of the autocorrelation and partial autocorrelations show that the process is not white noise, with a Q-statistic = 47.7 for 25 lags, but do not provide a clear indication of the nature of the process. The results of estimating an MA(1) process with a constant using Chilean data for the period August 1986-April 1989 are the following: 1/

$$DR9030F = -0.353 + 0.496 \ v_{t-1} + v_t$$
$$\quad\quad\quad (-11.05)^* \quad (2.762)^*$$

$$R^2 adj. = 0.234 \quad\quad D.W. = 1.793 \quad\quad S.E. = 0.183$$

These results provide some evidence in support of the joint hypothesis *mentioned above*. *DR9030F can be represented by an MA(1) process with a constant*, the value of which is very close to the average of DR9030F in the data, -0.35. Both coefficient estimates are statistically significant, and the estimate of θ is consistent with the sample autocorrelation for the first lag estimated at the identification stage ($\theta = 0.5$ implies $\rho_1 = 0.41$, which compares with $\rho_1 = 0.48$ from the identification procedure).

Despite these favorable results, the outcome of this first test must be interpreted with caution. The residuals v_t do not appear to be white noise, and seem to follow a complicated stochastic process in which v_{t-3} is significant for explaining v_t. This pattern of autocorrelation may be indicative of the presence of quarterly seasonality in the data. Moreover, reflecting the ambiguity of the results of the identification procedure, fitting an AR(2) process to the data produces a similar estimate of -LP and statistically significant autoregressive terms. 2/ Thus, in this case the data cannot distinguish clearly between an MA(1) and an AR(2) process.

A second test of the hypothesis under discussion is the following. Consider the MA(1) representation of u_t as correct, and rewrite equation (4) as follows:

$$(i_t \ i_{t+1} + i_{t+2}) = (_tUF_{t+3} + r_t) + MA(1)_t \quad\quad\quad\quad (5)$$

where $MA(1)_t = -LP + \theta v_{t-1} + v_t$

1/ The numbers in brackets in all regression results are "t" statistics; those marked as * are significant at the 5 percent level and those marked as $^+$ are significant at the 10 percent level. The hypothesis of zero autocorrelation of regression residuals was tested using the method of Box and Jenkins. All relevant regression output is included in a technical supplement available upon request.

2/ However, by estimating an ARMA(2,1) process, it can be shown that the restriction that the two autoregressive terms are zero cannot be rejected by the data at the level of 5 percent significance (the corresponding F-statistic is $F(2,27) = 3.363$).

Then, (5) can be estimated using a two-stage least squares procedure. In the first stage, the MA(1) process is estimated, and in the second stage equation (5) is estimated using the forecast values of MA(1), denoted $MA(1)_t$, as an explanatory variable. The first stage is equivalent to the previous test, and the second stage is to estimate the following:

$$(i_t + i_{t+1} + i_{t+2}) = \alpha_1 (_tUF_{t+3}) + \alpha_2 \hat{MA}(1)_t + n_t \qquad (6)$$

where $\hat{MA}(1)_t = -0.353 + 0.496 \, v_{t-1}$ and n_t is i.i.d.

To be consistent with the hypothesis mentioned, the coefficient estimates should be $\alpha_1 = \alpha_2 = 1$. Any other variables that are judged to be publicly available information dated t or earlier must exhibit coefficients that are not statistically significant different from zero, since all these variables are part of the information set used to formulate the expectations. Moreover, the error term n_t must be a serially uncorrelated random variable.

Estimation of (6) for the same sample period as the previous test produces the following results:

$$i_t + i_{t+1} + i_{t+2} = 0.98 (_tUF_{t+3} + r_t) + 0.725 \, \hat{MA}(1)_t + n_t$$
$$\phantom{i_t + i_{t+1} + i_{t+2} =} (49.79)^* (2.587)^*$$

$$R^2 adj. = 0.98 \qquad D.W. = 1.51 \qquad S.E. = 0.178$$

These results support the hypothesis that there is efficient arbitrage in Chilean financial markets, $\alpha_1 \approx 1$, but since $\alpha_2 < 1$ it cannot be argued that the joint hypothesis of market efficiency and rational expectations is also supported by the data. 1/ The regression as a whole has a very high explanatory power and a low standard error, but, as the previous test, it produces residuals that do not seem to follow a white noise process and that appear to be correlated with their third lag.

To provide further evidence on the relative magnitude of α_1 and α_2, (6) was also estimated imposing the restriction $\alpha_1 = \alpha_2$. This regression produces $\alpha_1 = \alpha_2 = 0.997$, as predicted by the model, with a standard error of about 0.006 and $R^2 adj. = 0.98$. An F-test confirmed that the restriction in question cannot be rejected by the data ($F(1,31) = 0.94$). Thus, if the process of the differential in rates of return is modeled as an MA(1) with a constant, the data cannot reject one key restriction imposed by the joint hypothesis of market efficiency and rational expectations, namely $\alpha_1 = \alpha_2 = 1$. Nevertheless, even in the restricted regression the residuals exhibit positive correlation with their third lag.

1/ Other variables dated t or earlier, such as the inflation rate, the exchange rate, the UF and the ex ante yields of indexed and non-indexed time deposits, were introduced to the equation to confirm that they do not convey any significant additional information.

A third test of the efficiency of Chilean financial markets imposes a pattern of quarterly seasonality in the form of a multiplicative seasonal MA term at lag 3, $SMA(3)_t$. The rationale for this, as Figure 6 illustrates, is that indexed and non-indexed interest rates tend to be higher in the second and fourth quarters and lower in the first and third quarters. The estimated time-series process for DR9030F in this case is

$$DR9030F_t = \underset{(-13.64)*}{-0.37} + \underset{(4.84)*}{0.68 v_{t-1}} - \underset{(-4.98)*}{0.88 SMA(3)_t} + v_t$$

$$R^2 adj. = 0.475 \qquad D.W. = 2.034 \qquad S.E. = 0.152$$

Equation (6) is re-estimated using the forecast values for $DR9030F_t$ from the above equation as a proxy for $MA(1)_t$.

$$i_t + i_{t+1} + i_{t+2} = \underset{(67.17)*}{0.99} (_tUF_{t+3} + r_t) + \underset{(4.87)*}{0.99 \hat{MA}(1)_t} + n_t$$

$$R^2 adj. = 0.986 \qquad D.W. = 2.019 \qquad S.E. = 0.149$$

In contrast with the previous results, the introduction of quarterly seasonality eliminates the pattern of correlation in the error terms n_t and y_t. 1/ In the estimate of equation (6), the null hypothesis that $\alpha_1 = \alpha_2 = 1$ cannot be rejected by the data. Thus, if the additional assumption of quarterly seasonality is taken into account, the data clearly supports the joint hypothesis of market efficiency, rational expectations, and a time-invariant liquidity premium on 90-day indexed time deposits.

The results of the tests performed here provide some evidence indicating that efficient arbitrage takes place in Chilean financial markets and that market participants do not make _systematic_ errors in forecasting short-term interest rates or the UF. This evidence supports the view that financial indexation minimizes the risks associated with inflation because no inflation-risk premium is detected in the effective yield paid on non-indexed deposits. In fact, the negative constant term associated with the stochastic process of DR9030F shows that indexed time deposits pay a modest premium of approximately 1.5 percent a year stemming from liquidity preference and imperfect indexation. Thus, indexation facilitates financial operations under inflationary conditions by eliminating the inflation-risk component of interest rates. Given rational expectations, market efficiency and a full Fisher effect, the elimination of financial indexation would only alter interest rates to the extent that inflation-risk premia are present.

1/ The restriction that the seasonal adjustment parameter is zero is clearly rejected by the data at the 1 and 5 percent significance levels $(F_{(1,30)} = 15.21)$.

IV. The Interest Spread and Increases in Inflation

It has been argued here that financial indexation does not induce _systematic_ unjustified increases to interest rates when expectations are formed rationally and efficient arbitrage exists in financial markets because the Fisher effect, in a non-indexed system, would result in similar increases. The tests conducted in the previous section suggest that Chilean financial markets conform well to the joint hypothesis of efficient arbitrage and rational expectations, but do not produce a clear description of the relationship between the returns paid on indexed and non-indexed deposits and the expectations of the future path of inflation. In this section, a series of tests are undertaken to illustrate the extent to which the differential between the premium over UF of an indexed deposit and the nominal interest rate of a non-indexed deposit can be regarded as a precise operational indicator of a future increase in inflation. These tests also have the operational value of helping to establish whether the UF premium can be treated as equivalent to the relevant real interest rate, and thus whether it is proper to use it as an instrument or indicator in the design of monetary policy.

The informational content of the spread between indexed and non-indexed interest rates can be extracted by estimating a functional relationship that follows from Fisher's principle. This approach is a variation of the methodology applied recently to study inflation forecasts based on the term structure of nominal interest rates by Fama (1990) and Mishkin (1990).

The Fisher equations for 30-day non-indexed and 90-day indexed time deposits can be expressed as follows:

$$E_t P_{t,30} = i_{t,30} - R_{t,30},$$ (6)

$$E_t P_{t,90} = (r_{t,90} + E_t UF_{t,90}) - R_{t,90}.$$ (7)

where: (a) E_t denotes a rational expectation conditional on publicly available information available at date t, (b) $P_{t,30}$ and $P_{t,90}$ are the inflation rates for the 30 and 90 days that follow t, (c) $R_{t,30}$ and $R_{t,90}$ are the ex ante real interest rates of each type of deposit, (d) $i_{t,30}$ is the _monthly_ nominal interest rate quoted at date t on a 30-day non-indexed deposit, (e) $r_{t,90}$ is the _quarterly_ premium over UF quoted at date t on a 90-day indexed deposit, and (f) $UF_{t,90}$ is the growth of the UF during the 90 days following t.

Following Mishkin (1990), equations (6) and (7) are combined in an expression that provides a framework useful for extracting the information regarding expectations of future inflation contained in the interest spread. This is done by imposing the conditions that expectations are formed rationally and that ex ante real interest rates fluctuate around constant averages over time. Subtracting (6) from (7) and imposing these two conditions yields the following result:

$$P_{t,90} - UF_{t,90} - P_{t,30} = \alpha_0 + \alpha_1(r_{t,90} - i_{t,30}) + v_t. \tag{8}$$

$$\text{where } v_t = e^{\Pi}_{t,90} - e^{UF}_{t,90} - e^{\Pi}_{t,30} - e^{R}_{t,90} + e^{R}_{t,30}$$

This expression must be interpreted carefully because of the special meaning of the dependent variable on the left-hand side. The dependent variable is the <u>uncovered</u> increase in inflation during the period from 30 to 90 days after t, UNCINFCH. It is considered uncovered because it represents the residual change in inflation after taking into account the protection that indexation gives to 90-day deposits (i.e., UNCINFCH is equal to the difference between the inflation rates minus the correction in the value of the UF).

Expression (8) indicates that, if expectations are rational, the ex ante real interest rates vary around constant means, and equations (6) and (7) hold, UNCINFCH must be equal to the sum of: (a) the average differential in ex ante real interest rates, $\alpha_0 = \bar{R}_{90} - \bar{R}_{30}$, (b) the spread in the quoted returns of indexed and non-indexed deposits, $\alpha_1 = 1$, and (c) a random error, v_t. The error term is a combination of expectational errors pertaining to the 30- and 90-day inflation rates ($e^{\Pi}_{t,30}$ and $e^{\Pi}_{t},90$), the change in the UF ($e^{UF}_{t},90$), and the discrepancy between the period-by-period and mean values of the ex ante real interest rates ($e^{R}_{t,30}$ and $e^{R}_{t},90$). To be consistent with rational expectations, this disturbance must have zero mean and constant variance, and may follow a second-order moving average process because the data correspond to monthly observations and expectations need to be formed for variables up to three months ahead (note that in this case an expectation for inflation in the third month after t is needed, whereas in the market-efficiency tests only inflation expectations up to the second month were required).

The economic interpretation of the movements implicit in equation (8) is the following. For a given value of α_0, a widening of 1 percentage point in the differential between the 90-day premium over UF and the 30-day nominal interest rate indicates that individuals expect inflation in 90 days to increase by 1 percentage point <u>in addition</u> to the expected growth in the UF (about 4 percentage points on an annual basis). Therefore, if the estimate of equation (8) shows that the hypothesis that $\hat{\alpha}_1 \neq 0$ is rejected and the hypothesis that $\hat{\alpha}_1 = 1$ cannot be rejected, the data would indicate that (a) the spread of interest rates is a precise indicator of future increases in uncovered inflation, and (b), the average of ex ante real interest rates is constant over time. This second result would suggest that the UF premium is not a good proxy for the relevant real interest rate because, as Figure 2 illustrates, the UF premium exhibits an increasing trend and does not fluctuate around a time-invariant mean. 1/

1/ This conclusion would not follow if the UF moved exactly with inflation month by month. In this case, the dependent variable in (8) collapses to $-P_{t,30}$ and the UF premium becomes identical to the ex ante real interest rate.

Equation (8) was estimated by the method of Ordinary Least Squares using data from August 1986-January 1990, July 1987-January 1990, and August 1986-December 1987. The latter dates correspond to a period during which the Central Bank provided indicative interest rates for 30-day non-indexed time deposits and consequently the policy regime may have intervened with the Fisherian transmission of market-determined expectations of inflation to interest rates. To allow for quarterly seasonality the equation for the period August 1986-January 1990 was also estimated with a multiplicative seasonal moving average term at the third lag. To test the null hypothesis that $\hat{\alpha}_1 = 1$, two procedures were followed; (a) a standard "t" test and (b) an F test that combined the sum of squared residuals of unrestricted and restricted versions of the model. The results of all estimates are summarized in Table 1 and reported in more detail in a technical supplement available upon request.

With one exception, the results show that the hypothesis that the coefficient $\hat{\alpha}_1$ is significantly different from 0 but insignificantly different from 1 cannot be rejected by the data. Surprisingly, the exception is not the period of indicative interest rates but the period from July 1987 to December 1990. For the sample August 1986-January 1990, the unrestricted estimate for $\hat{\alpha}_1$ is 1.38 with a standard error of 0.26. This implies that the hypothesis that $\hat{\alpha}_1 = 0$ is rejected with less than 1 percent significance, and the hypothesis that $\hat{\alpha}_1 = 1$ cannot be rejected with less than 1 percent significance. Moreover, estimating the model for all the sample periods with the restriction that $\alpha_1 = 1$, produces F statistics according to which the data cannot reject the restriction at 1 percent significance.

Figure 7 depicts the actual and predicted values of UNCINFCH produced by the unrestricted model for the sample August 1986-January 1990. This chart illustrates clearly the predictive power of the regressions based on the spread between indexed and non-indexed interest rates to forecast the evolution of the uncovered increase in inflation. One of the interesting operational implications of this result is that the market-determined interest spread between indexed and non-indexed deposits is an accurate indicator of the public's perception of future changes in inflation. Policy makers have ready access to this interest spread and can use it as an indicator to assess the stance of monetary policy. 1/

Consider the interest spread between the quarterly UF premium and the monthly nominal interest rate depicted in Figure 8. According to the model, a declining spread is an indicator that monetary policy is recognized as

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1/ Note that the spread of interest rates is a useful indicator of the stance of monetary policy, but is not an instrument nor a target. The size of the spread per se does not indicate the extent of the adjustments that are necessary in instruments and targets, it only informs the authorities of the market's perception regarding monetary policy stance.

Table 1. Estimates of Uncovered Inflation-Change Equations 1/

Sample	$\hat{\alpha}_0$	$\hat{\alpha}_1$	SE	R^2adj.	D.W.	t-test $\alpha_1=1$	F-test $\alpha_1=1$
Unrestricted:							
86.08-90.01	-0.75 (-4.45)*	1.38 (5.31)*	0.79	0.59	1.61	1.47	--
86.08-87.12	-0.40 (-0.72)	1.55 (2.31)+	0.79	0.51	1.35	0.82	--
87.07-90.01	-0.74 (-4.25)*	1.89 (6.05)*	0.79	0.66	1.77	2.86*	--
Seasonally adjusted							
86.08-90.01	-0.77 (-4.02)*	1.29 (3.69)+	0.78	0.59	1.67	0.84	--
Restricted:							
86.08-90.01	-0.92 (-7.23)*	1.00	0.82	0.31	1.63	--	3.89#
86.08-87.12	-0.83 (-4.55)*	1.00	0.75	0.43	1.26	--	2.89#
87.07-90.01	-1.02 (-6.53)*	1.00	0.87	0.34	1.62	--	6.62#
Seasonally adjusted							
86.08-90.01	-0.91 (-7.53)*	1.00	0.78	0.38	1.71	--	0.41#

1/ Numbers in brackets are "t" statistics for the null hypothesis that the corresponding coefficient is not significantly different from zero. The asterisk denotes significance at the 1 percent level, the + sign denotes significance at the 5 percent level, and the # sign denotes that the restriction in question cannot be rejected at a level of 1 percent significance. All estimates also include first- and second-order moving average components that are reported in a technical supplement available upon request. The residuals have been identified to be white noise processes using the method of Box and Jenkins, except in the restricted regression for the period 86.08-87.12 in which the residuals exhibit second-order serial autocorrelation.

Figure 7. Uncovered Inflation Change
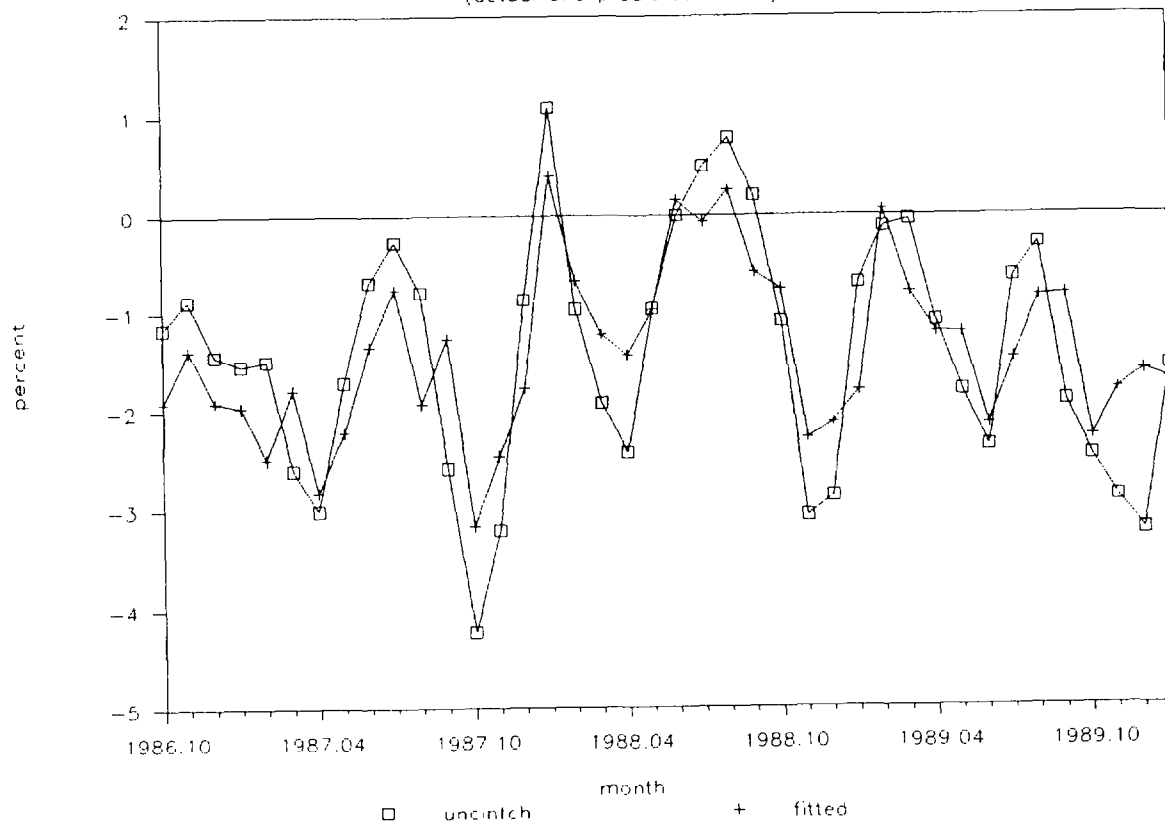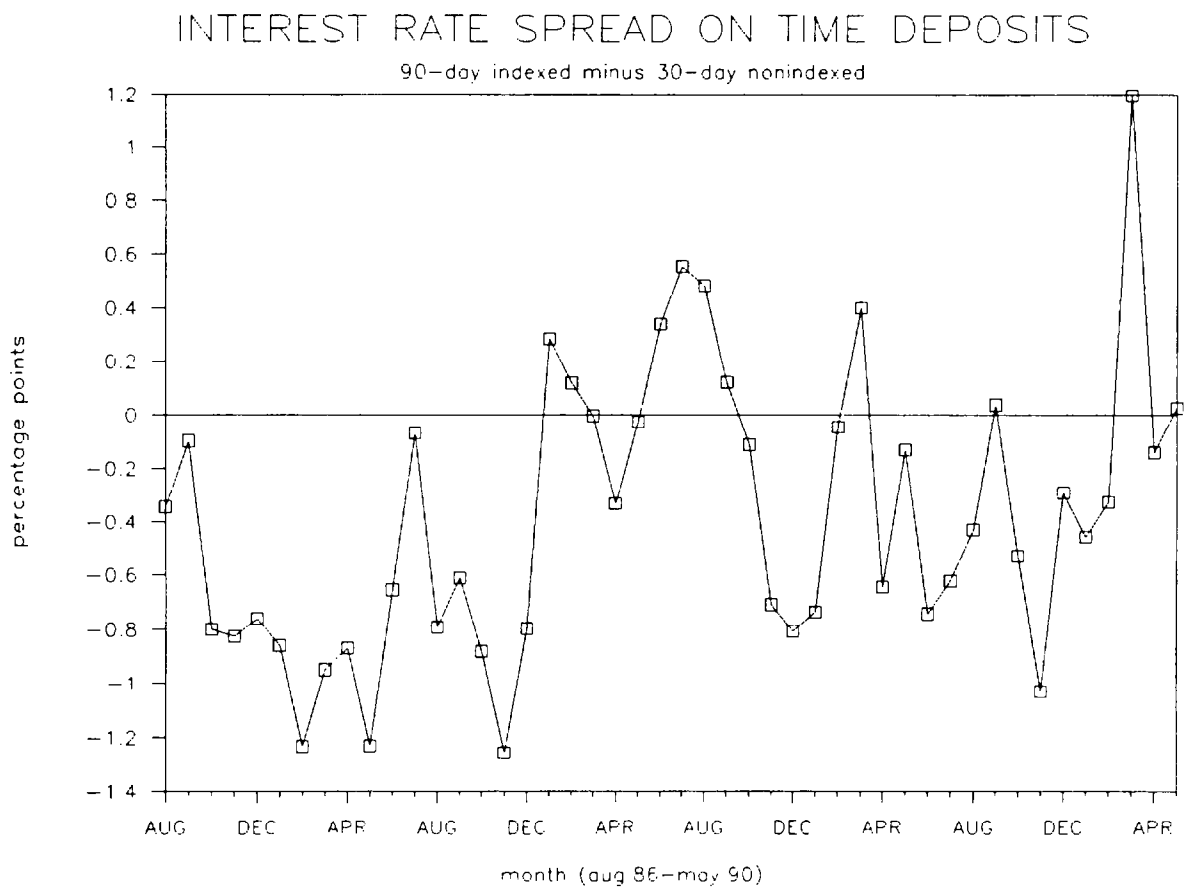(actual and predicted values)

Figure 8

INTEREST RATE SPREAD ON TIME DEPOSITS

90-day indexed minus 30-day nonindexed

month (aug 86-may 90)

tight, whereas an increasing spread indicates the opposite. 1/ During the first and third quarters of 1989 the interest spread widened, and this two periods were also the two peaks of the uncovered acceleration of inflation during that year (see Figure 7). In the first quarter of 1990, the interest spread declined at first, as the Central Bank announced the introduction of an adjustment program, but then it widened to reach 1.2 percent in March (4.9 percent annually). According to the model, the increase in the spread indicated that individuals viewed the adjustment policies either as transitory or insufficient to halt the increasing trend of inflation, possibly reflecting expectations of a fiscal expansion or large inflows of foreign capital attracted by a large favorable differential between domestic and foreign interest rates.

The data also support the hypothesis that ex ante real interest rates fluctuate around time-invariant means. With the exception of the estimate for the August 1986-December 1987 period, in which the estimate of the constant term is not statistically different from zero, the regressions show that the average 90-day ex ante real rate is more than 3/4 of 1 percentage point higher than the average of the similar 30-day rate. As discussed previously, this evidence casts serious doubts on the use of the UF premium as an indicator of the relevant real interest rate because it clearly does not fluctuate around a time-invariant mean.

Equations (6)-(8) also provide an alternative test that can be used to substantiate further the claim that the UF premium is not equivalent to the ex ante real interest rate. These equations imply that, for both rates to be statistically equivalent, the imperfection of the indexation mechanism should not be statistically significant. Thus, estimating equation (8) with a dependent variable that is just the negative of the 30-day-ahead inflation rate should produce similar results. Estimation of this modified equation shows that this hypothesis is rejected. The coefficient $\hat{a}_1$ is significant, but at a value of -0.42, the constant term rises to -1.6 and the first-order autocorrelation coefficient is higher than 1, questioning the stationarity of the residuals.

The UF premium is not the relevant ex ante real interest rate because in calculating the latter agents consider the discrepancy between the inflation of the month before they enter in a credit contract and their expectations of inflation in the last month before it expires. This discrepancy is the residual inflation risk left uncovered by the imperfection of the indexation mechanism. When the inflation rate is stable this discrepancy is minimal and the UF premium reflects the relevant ex ante real rate, but when inflation fluctuates this is no longer a correct

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1/ The issue here is not how tight the Central Bank designs monetary policy, but how individuals in financial markets perceive it. Thus, it does not suffice that the authorities design a theoretically sound anti-inflationary policy; the reputation and credibility they command in financial markets also play a crucial role.

approximation. The fluctuations affecting monthly inflation are due in part to seasonal or random factors, but they also reflect the underlying trend of the inflation rate. What the tests show is that, for Chile, the one-month lag in financial indexation and the volatility of the month-to-month inflation rate cause discrepancies between the UF premium and the ex ante real interest rate that cannot be neglected as accidental. Thus, the results support the view that the spread between indexed and non-indexed interest rates is a better indicator of the stance of monetary policy than the UF premium itself.

V.   Concluding Remarks

     This paper analyzes the Chilean mechanism of financial indexation and explores some aspects of its influence on the operation of the financial system.   The results of a number of empirical tests support the view that indexation facilitates financial intermediation under inflationary conditions and does not automatically produce higher interest rates than a system free of indexation.   In particular, the econometric evidence suggests that there is efficient arbitrage in Chilean financial markets and that market participants do not make systematic mistakes in forecasting future interest rates or future inflation.   The evidence also shows that the spread between indexed and non-indexed interest rates conveys significant information regarding future changes in inflation, and suggests that the average levels of ex ante real interest rates are approximately constant over time.

     The analysis of the joint hypothesis of market efficiency, rational expectations, and a time-invariant liquidity premium provides four significant operational conclusions:

     (1)   Efficient arbitrage is present in Chilean financial markets. Developments in the 90-day UF premium paid on indexed deposits are transmitted to the market of 30-day non-indexed deposits in a manner such that, ex ante, agents expect to make no gain or loss, other than a modest time-invariant liquidity premium, by shifting 3-month investments from non-indexed to indexed time deposits.

     (2)   Inflation changes are consistent with Fisherian transmission and rational expectations. The difference between the 90-day UF premium and the 30-day nominal interest rate is a precise indicator of the expectations of economic agents regarding future changes in inflation (adjusted to account for the protection that imperfect indexation gives to 90-day deposits).

     (3)   Indexation is imperfect. The one-month lag under which indexation is currently undertaken implies that the 90-day UF premium should not be regarded as the real interest rate relevant for economic decisions or for the purposes of designing monetary policy. The spread between indexed and non-indexed interest rates is a better indicator of monetary conditions.

(4) <u>Indexation eliminates the inflation risk from financial
contracts</u>. Because the data suggest that Fisherian transmission takes place
in an environment where expectations are not systematically erroneous and
efficient arbitrage exists, financial indexation minimizes the inflation
risk (which is not detected in 30-day non-indexed deposits) and does not
systematically force a full adjustment of nominal interest rates to
inflation that would not have occurred otherwise.

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