The Chilean Experience in Completing Markets with Financial Indexation

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For a Chilean capital market participant, it may be hard to imagine a world without the indexation unit, the *Unidad de Fomento* (UF). Most market participants would probably agree that the UF played a central role in the creation of a local capital market and also that it has had a positive impact on growth and welfare. The trouble, of course, is proving it, which is precisely what this paper aims to do.

From an investor's perspective, financial indexation may have quite a different role than the one presumably assigned to it by economic authorities. For the latter, indexation may represent an efficient mechanism for signaling to the market a commitment to keeping inflation under control. This, in turn, has to be weighed against the possibility of smoothing taxes by letting inflation dilute the value of the outstanding nominal government debt, although this creates certain time inconsistencies.[1] From this perspective, then, completing the financial market is not directly relevant, even though it may be important for determining the financial costs of government debt. The optimal government debt structure could take into account its implications on welfare, efficiency, and the completeness of the financial markets.

The idea of market completeness comes from Arrow and Debreu, who analyze a case in which there is a finite number of possible future states of the world (namely, peace, war, recession, and prosperity).[2] Completing the market consists in generating patterns of payments in the different states that did not previously exist, such that investors can either hedge against or bet on the occurrence of certain states in a way that could not be done before. In practice, a given financial

1. See, for example, Landerretche, Lefort, and Valdés (in this volume).
2. Arrow (1964); Debreu (1959).

Indexation, Inflation, and Monetary Policy, edited by Fernando Lefort and Klaus Schmidt-Hebbel, Santiago, Chile.

instrument can be said to complete the market if it generates relevant patterns of return that cannot be replicated by the existing securities in the national or international financial markets.[3] In addition, if given markets or instruments are developed as a byproduct of a certain financial innovation, then the innovation has helped to complete the markets.

At the same time, indexation may have the perverse effect of allowing market participants to feel comfortable with certain, seemingly reasonable levels of inflation, which may eventually make it harder for economic policymakers to reduce inflation. Perhaps private discomfort with inflation facilitates the implementation of policies to reduce inflation, but in any case, aside from sending letters to the newspapers, the role of the private sector in reducing endemic inflation rates is not clear.

I argue that indexation in Chile (together with several other structural reforms that have taken place) has helped to complete and develop the financial markets at least in the following senses: it has allowed the existence of medium- and long-term bond (and loan) markets that otherwise would not exist; long-term UF indexed bonds create relevant patterns of returns that are not available either internationally or locally via short-term nominal or indexed bonds or dollar-denominated bonds; and long-term UF indexed bonds generate relevant patterns in that they are useful for hedging against adverse changes in capital good prices. I further argue that had it not been for the rules that made the Chilean indexed unit mandatory for many financial transactions, as well as for the UF-denominated government (Central Bank) debt, the fixed-income market would have developed toward shorter-term, dollar-denominated securities, as the international evidence from the other developing countries suggests. This, in turn, would have had a significant impact on the potential bankruptcy costs of the Chilean economy.

1. Capital Markets and Inflation

The problem of how to develop a capital market under high and volatile inflation rates has been a subject of analysis for quite some time.[4] In this context, Chile is an interesting case study.

3. It has to be relevant in the sense that, in equilibrium, the pattern would not be diversified away. For instance, in a capital asset pricing model (CAPM), only one risky mutual fund is needed, and no particular premium would be paid for new patterns.

4. See, for example, Aspe Arnella, Dornbusch, and Obstfeld (1983).

1.1 A Brief History

Before 1972, upper limits on interest rates and credit rationing coexisted. Starting in 1974, nominal and real (UF-based) interest rates became progressively liberalized and quantitative restrictions on credit began to disappear. In 1974 a new tax law introduced monetary correction mechanisms, with the idea of neutralizing the impact of inflation on the balance sheets and also on the tax obligations by firms and individuals. Nevertheless, as documented in Valdés (1988), the monitoring of asset and liability structures of financial intermediaries probably failed, first with the SINAP (national system of savings and loans), then with the so-called *financieras*, and later with other episodes.[5]

This early experience with the liberalization of financial markets ended with the devaluation of the local currency and the well-studied debt crisis of 1982, with most of the financial sector back in the hands of the Sate (see, for example, Mizala, 1991, and the references therein). This crisis may be at least partly attributed to poor practices in the risk management of the bank's assets, corresponding to a mismatching problem.[6] Dollar-denominated debt predominated over other kinds of debt because of its apparently lower cost at the time, but it usually did not have dollar-denominated assets as a counterpart. It is reasonable to expect that this lack of matching increases expected bankruptcy costs after a devaluation.[7]

In any case, indexation clearly is not a sufficient condition for creating a successful, stable capital market. Nevertheless, it does seem useful and probably even necessary in a context of moderately high and volatile inflation rates, especially considering that these variables usually are linked to other unstable macroeconomic indicators.

The Chilean experience suggests that the following steps are necessary for a capital market to develop in an inflationary context: end financial repression by deregulating institutions and liberalizing interest rates; create an indexed unit and allow for indexed financial instruments;[8] reform the tax code to achieve inflation neutrality; and

5. See Valdés (1988) for a good description of the liberalization process and several bankruptcy cases.

6. See Mendoza (1991).

7. The debt crisis might have had a smaller impact on the real economy if banks had issued indexed debt instead of dollar-denominated debt. There are two simple reasons for this. First, UF-based loans seemed more expensive, such that total debt levels presumably would have been smaller. Second, the inflation-adjusted value of the exchange rate increased 60 percent between June and December of 1982 and 53 percent toward the end of 1983. Thus indexed levels would have been much lower.

8. The *Unidad de Fomento* (UF) was introduced in Chile in 1967, although daily adjustments only began in 1977. For example, see Mendoza (1991).

create regulatory institutions to monitor, among other things, the matching of the asset and liability structure of financial intermediaries. The first three conclusions are present, for example, in De Pablo, Mancera, and Henrique (1983).[9] The last conclusion arises from the Chilean experience and also from the application of well-known principles in asset and liability management.

1.2 A Market for Indexed Securities

An important question that needs to be answered is the following. What are the necessary conditions for ensuring the success of a market of indexed financial instruments? This section opens the discussion on this issue, while section 2.4 (below) uses empirical evidence for Chile to illustrate what is meant by success.

The widespread acceptance for the UF as the de facto local currency unit in most financial transactions is probably attributable to four factors. First, the unit has credibility, in that it will not be manipulated by the authorities and is based on the Chilean consumer price index (CPI), which is computed by an independent entity, the National Institute of Statistics (INE).[10] Second, the laws themselves accept the UF as a valid alternative currency unit. For example, most loans and time deposits are legally required to be indexed; in the case of life insurance companies, assets and liabilities are measured in UFs. Third, there is a deep, liquid market for Central Bank indexed bonds. This provides a riskless real interest rate for many different maturities, which serves as a reference for private transactions. Finally, Chile's tax regulations are consistent with a generalized indexation of the economy. An additional benefit is that the UF significantly reduces the cost of recontracting and allows price adjustments to occur almost instantaneously in an inflationary environment.

It is likely that these conditions are necessary and sufficient for ensuring the success of an indexed bond market. Points two, three, and four deserve special attention. First, if the laws do not explicitly consider the index as a valid currency unit, it is less likely that private contracts will generally use it. For example, if life insurance companies do not issue indexed contracts, then buying indexed assets may not be suitable for linking loans to the CPI, if companies cannot raise funds in

9. See also CEP (1992, pp. 112-13).

10. By contrast, the *dólar acuerdo* has no credibility. The Central Bank has outstanding debt denominated in that unit, whose value is supposedly determined by a crawling peg rule. In at least three opportunities, however, the Central Bank has revalued the *dólar acuerdo* or changed the rule, automatically reducing the market value of the outstanding debt.

the same unit. Second, trading indexed government bonds is also important, since it reduces the uncertainty surrounding the expected costs and benefits of buying or selling indexed securities. The costs of creating a new market and informing investors may be large enough to inhibit the spontaneous creation of indexed securities by private investors.[11] Finally, tax considerations are also important. If unexpected inflation is neutral in terms of tax consequences, it is likely that more issuers and investors will be interested in such instruments. Since the issue at hand is the market for bonds with a fixed real income, the tax advantages of debt are important, too. In Chile between 1974 and 1984, the use of debt carried a considerable tax advantage that was eliminated with the 1984 tax reform.[12] In combination with other factors, this would probably lead to lower debt levels (indexed or otherwise) in Chile than in other countries.

In January 1997 the United States Treasury issued Treasury inflation-protected securities (TIPS), which provide an interesting case study. Soon after the issue of these ten-years bonds, the Federal Home Loan Bank and the Tennessee Valley Authority announced that they would do the same.[13] Given the current 3.3 percent rate of inflation and compared with the 6.4 percent interest rate on the equivalent nominal bonds, the resulting 3.45 percent real interest rate was debatably large. This may be due to the illiquidity of the new instrument, as well as to uncertainty over the status of the current CPI index, which is said to overstate inflation.[14] Shortly after the introduction of this new security, the pension fund manager TIAA-CREF created a new inflation-protected account that is considered to be a long-term, low- to medium-volatility alternative. Nevertheless, the tax treatment of this security may also partly explain the relatively large yield. Cohen, Hassett, and Hubbard (1997) argue that inflation continues to be relevant for the determination of the user cost of capital. The use of debts still has a tax advantage, but in the particular case of indexed bonds, both the real component and the nominal adjustment to the value of the bond (the nominal capital gain) are taxed. This means that if the inflation rate becomes high enough, the cash flows paid by the bonds could be insufficient to pay the tax liability they create.[15]

11. Campbell and Shiller (1996) also present the money illusion and balkanization arguments.

12. This may be an additional explanation for the debt crisis. See Hernández and Walker (1993) (or see Walker and Hernández [1992] for an English version of the same paper).

13. See, for example, www.morevalue.com/themes/i-bond2.html.

14. For a simple discussion see the Financial Pipeline website (www.finpipe.com/tips.html).

15. This and other potential problem are noticed by Campbell and Shiller (1996).

In this discussion, the four elements considered necessary for a successful indexed market are present, including the credibility of the unit; its validity as an alternative currency unit for certain financial products; tax considerations; and a central authority taking the first step to create a new, liquid instrument. The private sector must now continue to develop the market.

Other important reforms that have directly or indirectly contributed to deepening the Chilean financial markets include the pension fund reform and privatizations. Pension funds originally invested only in indexed, fixed-income securities, and they still invest a large fraction of their portfolios in that way. Privatized firms have also frequently used the capital markets to finance their operations. In the end, it is not possible to isolate the effects of the UF on the development of the local capital markets.

2. Indexation and the Long-Term Fixed-Income Markets

This section presents arguments justifying the idea that generalized indexation contributes to the existence of a long-term market in countries with a history of high, volatile inflation rates.

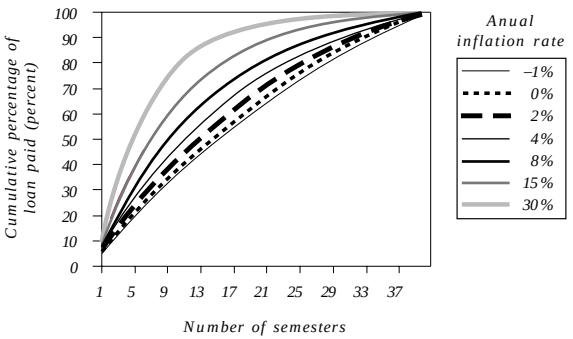
2.1 Inflation and the Shortening of Effective Maturity

Higher interest rates imply a shortening of the effective maturity (or duration) of a fixed-income security. Naturally, for a given real interest rate, higher expected inflation rates imply that a larger fraction of the value of a given fixed-income (nominal) security has to be paid at the beginning of its life.

Figure 1 shows the percentage of the total present value of a twenty-year annuity bond that is paid during the first and following semesters. For example, with a 30 percent annual inflation rate, 80 percent of the real value of the loan is paid after the tenth semester. With a 0 percent inflation rate, the same 80 percent is paid after twenty-seven semesters. Another way to look at this is through the Macaulay duration corresponding to the bond's price elasticity to changes in its discount rate. The response of a pure discount bond to the inflation rate, for a fixed real interest level, can be used as a point of reference. Increasing the inflation rate from 0 percent to 15 percent reduces the duration of the bond from about eight and a half

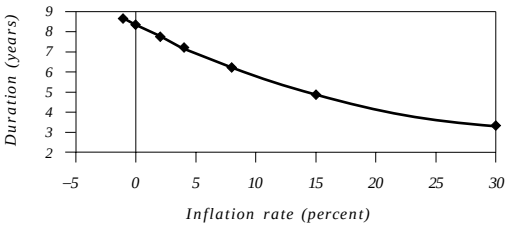
years to about five years. With 30 percent inflation, the number drops to slightly above three years. Therefore, high levels of expected inflation concentrate the inflation-adjusted (real) payments in the first few years of the life of the bond, and thus little incentives remain for extending the maturity of the bonds from the perspective of either borrowers or lenders. For example, under the same assumptions, extending the life of a loan from ten to fifteen years increases its present value by 32 percent under zero inflation, but by only 10 percent under a 15 percent inflation rate.

Figure 1. Inflation and the Total Present Value of a Twenty-Year Annuity Bond[a]



Source: Author's calculations.
a. Equal payments; forty semesters; various inflation rates; 6 percent real rate.

Figure 2. Inflation and the Effective Duration of a Twenty-Year Annuity Bond[a]



Source: Author's calculations.
a. Equal payments; forty semesters; various inflation rates; 6 percent real rate.

The problem, of course, is that under high inflation, nominal payments that are far off have little real value. Keeping the real value of payments relatively constant would require increasing nominal payments. This is exactly what indexation does (in addition to its more important feature of providing protection for unexpected changes in the inflation rate), and the above arguments clearly make a case for the practice. Without some kind of indexation, high inflation rates make long-term markets disappear.

2.2 The Nature of the Inflation Risk Premium in Nominal Rates

Campbell and Shiller (1996) estimate the inflation risk premium for a five-year U.S. pure discount bond to fall in the neighborhood of 50 to 100 basis points. Their estimation methodologies include sample averages and the covariance between consumption growth and stock index returns (based on the capital asset pricing model, or CAPM, and the C-CAPM). They also cite evidence for the United Kingdom indicating an average premium of only 0.5 percent.

The actual risk premium could be even lower if the nature of the inflation risk premium resembled that of a sleeping monster.[16] In this case, the normal covariance and other sample statistics would not reflect the true risk premium, unless the number and magnitude of the high inflation episodes in the sample coincide with what was expected, on average, by the markets participants.[17]

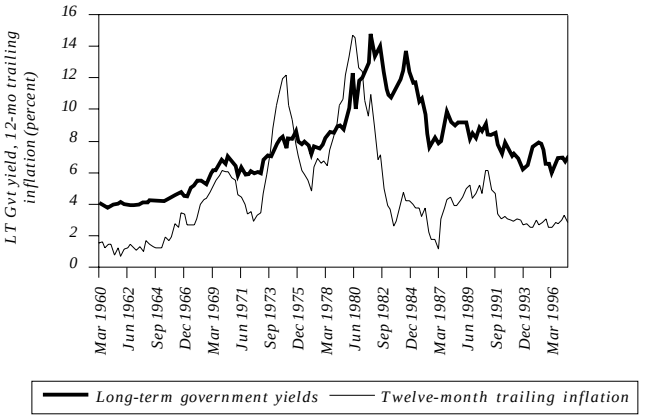
Figure 3 shows long-term U.S. government yields and trailing twelve-month inflation rates. Judging from valley to valley, four high inflation episodes seem to have occurred. A comparison of the left and right extremes of the graph indicates that real yields are higher toward the end, giving nearly a 4 percent real rate of return as opposed to about 2 percent at the beginning of the periods. Comparing that with the 3.5 percent of the TIPS rate gives a 0.5 percent premium, assuming that the term structure for real rates is flat.[18]

16. Haugen (1995) explains that if the higher expected return on value stocks is due to risk, then the risk must correspond to a sleeping monster.

17. This so-called peso problem argument has also been used to explain the equity premium puzzle (Goetzmann and Jorion, 1997). It is the kind of risk reflected in the increase in the value of out-of-the-money put options after the stock market crash of 1987 (Bates, 1997).

18. See Barro (1995).

Figure 3. Inflation and Long-Term U.S. Government Yields



Source: Ibbotson Associates.

In the case of a country like Chile, where the inflation episodes have been significantly more acute, it is only possible to speculate on how large the premiums on long-term nominal bonds would have to be in order to induce investors to buy them. Mendoza (1991) finds evidence of a liquidity premium (a higher return) for ninety-day UF-denominated deposits over nominal thirty-day deposits. This is like a negative inflation premium. These are very short-term instruments, however, and the conclusions cannot be extended to longer-term securities. The large historical levels and the high volatility of the inflation rate together should imply that the inflation premium would be larger than in the United States. Nevertheless, the exercise presented in the appendix shows that large inflation volatility might have counter-intuitive implications. Given a credible inflation target, a higher historical volatility would imply (ceteris paribus) lower nominal rates on long-term bonds by a convexity effect: the present value is a convex function of its discount rate. For a given long-term expected value, therefore, higher volatility in the inflation rates implies lower nominal rates. This effect may be more than offset by a higher required risk premium stemming precisely from the high volatility. Nevertheless, the point is that using the Fisher equation to estimate the inflation risk premium may lead to underestimating it. It may thus be difficult to estimate the inflation premium because of its sleeping monster nature and the impact of its volatility on the implementation of the Fisher equation.

To estimate what the long-term nominal rates would look like in Chile, I start by assuming twice the U.S. inflation risk premium.

The rate for the Central Bank's twenty-year adjustable bond (the PRC 20, or Pagaré Reajustable del Banco Central) is set at the level prevailing at the end of July 1997 (6.5 percent), and the long-term expected inflation rate is assumed to be 4 percent. Using the Vasicek model, this gives a nominal yield for the equivalent (annuity) nominal bond of between 11 and 12 percent (using inflation risk premiums of 1 and 2 percent, respectively) and a duration of seven years (about one year less than that of the corresponding UF bond).

2.3 Implications of not Having an Indexed Unit of Account

In the particular case of Chile, a forced elimination of the UF would likely have large negative social costs—apart from welfare redistribution effects—given that most financial transactions use the UF as a reference and that most financial instruments are expressed in this unit. Any manipulation of the UF is likely to have a considerable negative impact, because when a widely accepted unit loses its credibility, it casts doubt on the true value of a very large fraction of the financial assets held by investors. Affiliates of the pension fund system would be especially affected.

In the case of other countries with a history of high, volatile inflation rates, I hypothesize that the lack of a widely accepted indexed monetary unit would have two implications. First, the capital markets would begin to rely on a different inflation protection unit such as a foreign currency—probably the U.S. dollar, given its widespread acceptance.[19] Second, the maturities of most financial instruments (in local nominal currency or denominated in dollars) would be relatively short.

The reasons to expect a relatively short-term market in local nominal currency, which were discussed above, have to do with the shortening of the effective maturities of the fixed-income nominal securities. On the other hand, the purchase or sale of dollar-denominated instruments usually entails important risks. From an investor's perspective, the principal risk of investing in a foreign currency-denominated asset is an unexpected appreciation of the local currency. This happened, for example, in 1994, when the UF appreciated 12.5 percent against the dollar, which affected the few Chilean pension funds with investments abroad. Given the arbitrage that exists between short-term UF- and

19. In addition, the inflation tax would become smaller because the demand for local money balances would decrease.

peso-denominated deposits (Mendoza, 1991), this means that the latter also had an additional real return of approximately 12.5 percent above their counterpart in dollars. It is perhaps because of these risks and the relatively high local interest rates that a very small percentage of institutional investments are denominated in dollars. Investors should consider the trade-off between this currency risk and interest rate risks. If only foreign currency-denominated bonds were available for longer term investing, it could be convenient to invest a certain fraction of the portfolio in such instruments.

From the perspective of a productive firm, issuing dollar-denominated debt has different degrees of risk, depending on the nature of the firm's activities. A firm in the productive tradables sector should probably issue long-term dollar-denominated debt to match the currency denomination of assets and liabilities and reduce bankruptcy risks. Bankruptcy risk is here understood as a second moment risk that has to do with the residual variance of net income, which depends on the covariance between income and expense flows. It needs to be measured ex ante, before the trend of the exchange rate is known, for example. In this sense, firms in the nontradables sector would increase their bankruptcy risk by issuing dollar-denominated debt. If this is the only way to obtain relatively long-term financing, firms will face a trade-off between the possibilities of matching the currency and maturity structures of assets and liabilities. Compared to the alternative of issuing long-term indexed debt, firms will probably end up with a larger-than-optimal fraction of dollar-denominated debt and a shorter-than-optimal maturity for it. Thus while there is room for some foreign currency-denominated debt, the maturities will be generally shorter than with matching debt given the inevitable degree of mismatching in the asset and liability structure.

Taken together, these two effects imply that a long-term fixed-income market would probably be less developed than in an indexed market. By the same token, under high inflation rates, if a foreign currency replaces the local currency as the preferred denomination for local securities, the economy is likely to face higher potential bankruptcy costs than in the case of a generalized use of indexed debt. Firms in the tradables sector should be similar with or without indexing their debt structure, whereas firms in the nontradables sector will increase their potential for bankruptcy by issuing dollar-denominated debt instead of indexed debt.

Table 1 presents evidence for Colombia, Mexico, and Venezuela with regard to which securities are more frequently traded. As expected, most of the fixed-income securities that are traded are short-term, but little evidence was available for dollar-denominated bonds.

Table 1. Volumes Traded in Mexico, Venezuela, and Colombia

Billions of U.S. dollars

	Mexico[a]				*Venezuela*[b]	*Colombia*[c]
Type of instrument	*1993*	*1994*	*1995*	*1996*	*1996*	*1996*
Equity	83.37	81.35	28.33	41.31	1.42	1.50
Fixed-income securities	30.95	10.63	5.68	2.66	...	...
Money market	4,184.42	5,262.55	598.86	869.90	...	...
Brady bonds	...	...	...	...	1.95	1.95
Long-term bonds	...	...	...	...	0.21[d]	13.45
Short-term securities	...	...	...	...	...	20.73
Total	4,298.73	5,354.52	632.87	913.88	3.58	37.63

Source: For Mexico, Larraín Vial; for Venezuela and Colombia, Santander Investment.
a. Bolsa Mexicana de Valores.
b. Bolsa de Valores de Caracas; most transactions are over the counter.
c. Number of U.S. dollar transactions in local markets.
d. Bolivar-denominated.

The relative composition of short- and long-term bond trading volumes is heavily biased toward the short term in all cases, notably more than in the case of Chile (see table 2). Nonetheless, a large fraction of what appears as long-term fixed-income securities in local currency actually corresponds to floating-rate notes. This is the case for almost all long-term fixed-income securities in Mexico, for example. Thus these would also be short term. The relative sizes with respect to the Chilean market are also interesting. The Mexican economy is roughly six times the Chilean one, but the so-called fixed-income category is even smaller than the Chilean mortgage bond subsector.

2.4 The Chilean Fixed-Income Market

Table 2 shows the trading volume of the Santiago stock exchange, which corresponds to the principal trading center in the country. In 1996, the total amount traded was roughly three times the Chilean gross domestic product (GDP), and in this sense it is relatively large. The largest fraction of the total amount traded in 1996 corresponds to financial intermediation (53 percent of the total); this category actually corresponds to a market that provides short-term liquidity, in which very short-term securities such as time deposits are traded. The longer-term fixed-income market is smaller, but it still represents a large volume relative to GDP. Such instruments totaled US$79 billion, of which nearly US$59 billion correspond to securities issued by the Central Bank and the government. The bonds issued by the private sector represent US$20 billion, more than half of which corresponds to mortgage bonds. Mortgage bonds are thus by far the most important privately issued fixed-income security.

Table 2. Volumes Traded on the Santiago Stock Exchange

Billions of U.S. dollars[a]

Instrument	*1994*	*1995*	*1996*
A. Dollars (bills and checks)	5.87	11.33	12.48
B. Government, state-owned firm, and Central Bank bonds			
Bono Reconocimiento (BR)	0.90	1.06	1.11
Pagarés Compra Cartera (PCC)	1.96	1.30	0.24
Pagarés Capítulo XVIII-XIX (PCD)	2.24	2.91	3.24
Pagarés Dólar Preferencial (PDP)	3.42	2.09	0.08
Pagarés Reajustables del Banco Central con Cupones (PRC)	35.36	59.71	54.23
Pagarés Reajustables Tesorería (PRT)	0.03	0.00	0.00
Pagarés Tasa Flotante (PTF)	0.17	0.02	0.00
Pagaré Portador Banco Central (PPBC)	0.28	0.30	0.01
Bonds issued by state-owned firms	0.00	0.00	0.00
Bonos Cora (COR)	0.00	0.00	0.00
Subtotal	44.36	67.39	58.90
C. Private fixed-income bonds			
Mortgage bonds	5.61	11.29	12.94
Leasing bonds	0.76	0.98	2.59
Bank bonds	2.93	2.42	2.63
Bonds issued by nonfinancial firms	0.95	1.39	2.32
Subtotal	10.25	16.07	20.48
Subtotal fixed-income bonds (B + C)	54.61	83.45	79.38
D. Short-term financial intermediation			
Nonindexed IOUs	16.22	21.20	28.00
Indexed IOUs	22.64	40.52	83.32
Subtotal	38.86	61.72	111.33
E. Stocks	6.18	11.37	8.47
F. Investment fund shares	0.09	0.33	0.08
Total	105.61	168.20	211.74

Source: Bolsa de Comercio de Santiago, *Memoria Anual*, 1994-96.
a. Numbers adjusted to December 1996 using the Chilean CPI and then transformed into dollars at the exchange rate 424.75 pesos to the U.S. dollar.

Table 3 decomposes the volumes traded in 1996. The UF (and other very similar units) is the most important denomination for both short- and long-term securities. The dollar-denominated short-term securities that are traded are not really financial instruments; these corresponds more properly to a foreign exchange market. The vast majority of the securities issued by the private and public sectors are denominated in indexed units.

Table 3. Estimated Decomposition of Transactions on the Santiago Stock Exchange, 1996

Billions of U.S. dollars

Type of instrument	*Short Term*	*Long Term*	*Total*
Peso-denominated debt	28.00	0.00	28.00
Private sector	28.00[a]	0.00	28.00
Public sector	0.00	0.00	0.00
Dollar-denominated debt	12.48	3.54	16.02
Private sector	12.48[b]	0.30[c]	12.78
Public sector	...	3.24[d]	3.24
Indexed debt	83.32	75.84	159.16
Private sector	83.32[e]	20.18[f]	103.50
Public sector	0.00	55.66[g]	55.66
Total	123.81	79.38	203.19

Source: Superintendencia de Valores y Seguros.
a. Corresponds to nonindexed IOUs in table 7 (section D).
b. Corresponds to dollars (bills and checks) in table 7 (section A).
c. Assumes that 13 percent of the amount of traded bonds issued by nonfinancial firms (estimated at US$2.3 billion) corresponds to U.S. dollars (the same proportion of their outstanding debt).
d. Corresponds to Pagarés Capítulo XVIII-XIX (PCD) in table 7.
e. Corresponds to indexed IOUs in table 7 (section D).
f. Subtotal of private fixed-income bonds (table 7) minus private sector dollar-denominated debt.
g. Subtotal of government, state-owned firm, and Central Bank bonds (table 7) minus public sector dollar denominated debt.

Dollar-denominated bonds are rather scarce. As of December 1996, the firms that had outstanding debt in dollars actually did belong to the tradables sector.[20] The one exception was CTC, the largest local telephone company, but in this case a large fraction of its costs are dollar denominated. Of its total outstanding debt (estimated at US$564 million), 36 percent was dollar denominated.[21] Other recent dollar-denominated bond issues, not registered with the securities commission, have been sold abroad, but they correspond to firms that do business overseas.

Table 4 shows the asset holdings of the principal institutional investors in Chile. After the bank loans, the major holdings again correspond to Central Bank and government debt (US$20.5 billion) and mortgage bonds (US$8 billion). Looking at the totals, the first three columns are almost entirely indexed and long term.

20. These are Soquimich (mining); Celarauco (pulp); Cocar (coal); CTC (telephone); Viña Santa Rita (wine); and Industrias Tricolor (paints).

21. Debt estimates sourced from the *Boletín Mensual* (December 1996) published by the Superintendencia de Valores y Seguros (SVS).

Table 4. Asset Classes Held by Major Institutional Investors, 1996

Millions of U.S. dollars

Investor	*Central Bank and government bonds*	*Mortgage bonds*	*Nonfinancial bonds*	*Deposits and bank bonds*	*Stocks*	*Investment fund shares*	*Foreign investments*	*Other*	*Total*
Pension funds	11,591	4,919	1,285	1,591	7,159	834	149	0	27,527
Life insurance companies	2,605	2,957[a]	n.a.	n.a.	577	n.a.	n.a.	1,053[b]	7,192
Mutual funds	604	212	65	1,721	198	0	0	11	2,810
Short-term fixed-income	484	31	1	1,347	0	0	0	3[c]	1,866
Long-term fixed-income	97	169	63	329	0	0	0	1[c]	658
Equity	24	13	1	45	198	0	n.a.	7[c]	287
Banks	5,785	0	0	0	0	0	1,2	38,585[d]	44,371
Total	20,584	8,088	1,350	3,312	7,934	834	149	39,649	81,900

Source: Authors calculations based on data from Superintendencia de Valores y Seguros de Chile (SVS), *Boletín Mensual*, several issues; Superintendencia de Bancos e Instituciones Financieras de Chile (SBIF); Superintendencia de Administradoras de Fondos de Pensiones de Chile (SAFP); Central Bank of Chile.

a. Assumes that all privately issued bonds held are mortgage bonds; also includes bonds issued by banks.

b. Corresponds to other real estate investments. Includes *mutuos hipotecarios*, another type of mortgage bond.

c. Cash plus others.

d. Excludes mortgage loans; includes all other loans and cash, principally *colocaciones efectivas*.

It is difficult to decompose deposits and bank bonds, but an analysis of the composition of the pension funds' assets indicates that 93 percent of it is indexed, 27 percent is truly long term (bank bonds), and 8 percent is indexed deposits with a maturity of over one year. Finally, the bank loans can be decomposed as 15 percent U.S. dollar denominated, 37 percent peso denominated, and 48 percent indexed. Thus out of the US$82 billion represented in the table, US$51.6 billion (63 percent) is indexed.

This analysis indicates that the overall evidence shows a successful indexed market. Most productive and financial firms have chosen UF-denominated debt. For the purposes of matching assets and liabilities, therefore, the UF dominates other feasible alternatives such as dollar-denominated debt, which gives credibility to the hypothesis that without the UF, the overall bankruptcy risks of the economy would increase. The relatively large mortgage bond market can also be interpreted as evidence of success. In this case, it implies lower expected distress costs for individuals and firms that have purchased real estate property with indexed loans, compared with the alternatives of either short-term nominal or long-term dollar-denominated debt.

2.5 Possible Links between Markets

Tables 2, 3, and 4 show that the most important long-term bond issues are mortgages. Most of the outstanding stock issued is in the hands of the pension funds and the life insurance companies. The longer maturity of these instruments gives these investors the possibility of matching their assets and (defined or undefined) liabilities. Such instruments have thus been useful for the development of these two industries. The funds raised in this manner are essentially used in the construction sector, fostering development in the medium- to high-income residential sector, in particular.

The lack of indexed bonds issued by nonfinancial firms could be used as an argument against their attractiveness or even their usefulness from a social welfare perspective. I argue, however, that other factors explain the relatively low volumes issued.

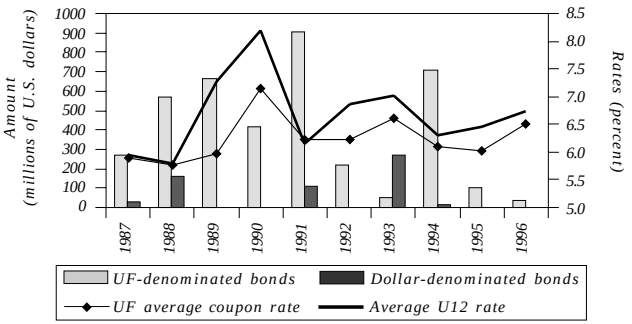
Figure 4 shows the bond issues registered with the Chilean securities commission (the Superintendencia de Valores y Seguros, or SVS). Registration represents the purpose of issuing and selling a bond, but it is possible for a bond issue to fail. The amounts listed represent the aggregate face value of debt, such that the ex post proceeds from bond sales may be different. The figure shows a downward trend (with the exception of 1994, when the failed Pangue issue made up 25 percent of the total). The figure also indicates an inverse relation between the interest rate level in a particular year and the amount registered.

In addition, the year with the highest dollar issues was 1993, when UF-based interest rates were high. This leads to the hypothesis that one of the reasons for the small amount of bonds issued by nonfinancial firms is that, on average, UF-based interest rates have been high. The Central Bank has kept local interest rates high by means of a special reserve requirement on foreign capital flows into Chile, which has segmented the fixed-income market from the rest of the world.

A simple exercise illustrates the extent to which local UF rates are higher than their equilibrium levels:

U.S. real interest rate (TIPS):	3.5 percent
Country dollar risk premium:[22]	1.1 percent
Purchasing power parity (PPP) rule followed by the Central Bank for the *dólar acuerdo* (expected depreciation of the UF):	–4 percent
UF/U.S. dollar currency risk premium:	X
Theoretical rate:	X + 0.6 percent
PRC 10 rate (22 July 1997):	6.7 percent

Figure 4. Nonfinancial-Firm Bond Issues Registered with the Chilean Securities Commission[a]



Source: Superintendencia de Valores y Seguros (SVS), *Boletín Mensual*, various issues.
a. Numbers in UF changed into dollars at the December 1996 rate of UF/US$ = 31.27. Avgerage U12 rate corresponds to a market-determined interest rate offered by the Banco del Estado mortgage bonds.

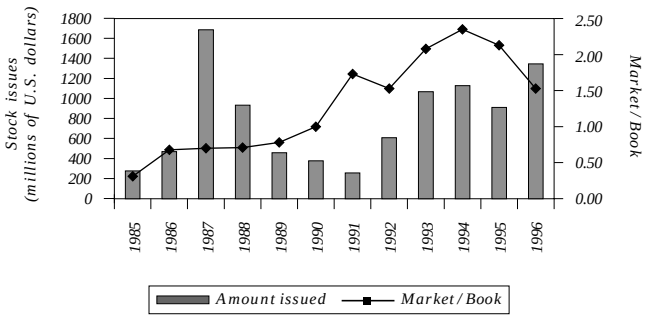
22. Estimated by CB Capitales as the difference between the dollar rates obtained by local companies abroad and the corresponding U.S. Treasury Rate. *Informe Económico* 6, May 1997. For Mexico, Domowitz, Glen, and Madhavan (1996) find an equivalent premium of 2.0 to 2.7 percent.

This exercise shows a very large spread that helps explain why issuing UF-denominated bonds may not be attractive. The currency risk premium would have to be extremely large to make the current rate an equilibrium one.

A second reason why bond issues are scarce in Chile relative to other countries is the Chilean tax structure, which is virtually neutral with respect to the incentives for the use of debt or equity.[23]

Third, although the fixed-income market is segmented, the stock market is likely to be integrated with the rest of the world because of the foreign investors that operate in Chile and the massive use of American depository receipts (ADRs) by the largest firms. Figure 5 shows the intentions of issuing stock, valued at subscription prices (which are likely to differ from the final prices obtained), as well as the market-to-book ratio for the aggregate stock market. Excluding 1987 and 1988 (years in which privatizations were significant), the figure shows an upward trend. The market-to-book ratios increased considerably (tripling since 1990) as a result of the alignment process of the local stock market with the rest of the world.[24] Relative to presumable equilibrium levels, then, debt financing may be expensive in comparison with equity financing. This may have tilted the financial structure toward the use of equity.

Figure 5. Subscription Price and Market (Book) Value of Stock Issues[a]



Source: Bolsa de Comercio de Santiago, Reseña 1996.
a. Exchange rate used: 424.75 pesos to the dollar.

23. See Hernández and Walker (1993) or Walker and Hernández [1992] (English version).

24. Walker (1998) estimates a 6 percent drop in the real discount rate for stocks after 1991.

Finally, the early bond issues may have contributed to the development of the stock market as well. The pecking-order theory outlined in Myers (1984) suggests that information asymmetry and its associated costs leads to the establishment of a sequence of preferred financing sources: first, retained earnings, followed by debt (presumably supplier's credit, then banks, and finally the public) and then new equity. The sequence can be interpreted either as a list of preferred financing sources (given a certain level of information asymmetry between a firm and its stakeholders) or as a chronological sequence (as a function of the accumulation of information by investors about firms' activities). Figures 4 and 5 show evidence that is roughly consistent with the latter vision. Figure 4 shows relatively large public issues of debt until 1991. Hernández and Walker (1993) conclude that during the same period the use of bank debt was significantly reduced. This is also consistent with a new step in the pecking-order theory, in the sense that as potential investors become informed about the nature of traded firms and their businesses, issuing traded securities becomes less costly since the information asymmetry is smaller. The new bond issues required firms to provide orderly information to the securities commission and to the official risk rating committee. Issuing firms later used the same institutional arrangements to get approval for selling new stock issues to the pension funds.

The long-term indexed bond market has thus been important for the development of the entire capital market.

3. The Unique Return Patterns of Indexed Bonds

The idea of completing a market with financial indexation from the perspective of a local investor is rather intuitive: in the absence of indexation, unexpected inflation risks are essentially nondiversifiable, but this risk is totally eliminated with the aid of indexation. For example, long-term investors who hold indexed annuity bonds for the purposes of their pension are essentially holding a riskless security. At the same time, a firm whose income and expense streams are tied to the price index would view moderate levels of indexed debt as riskless. Indexation can therefore serve as a welfare-improving device that completes the market.

To go a step further, if all security returns are measured in terms of indexed units (as is usually done in Chile), then a riskless asset can be defined as one with zero variance measured in this unit. In this context,

an indexed bond issued by the government would be riskless by definition (for a matched investment horizon). Therefore, analyzing whether there are other assets besides indexed bonds whose combinations provide a riskless portfolio amounts to finding two perfectly negatively correlated assets. It is hard to imagine two of such assets. Any attempt to identify the degree to which indexed bonds differ from other local assets (for example, how successfully they can be replicated) makes little sense from this perspective. No combination of stocks, cash, and real estate, for example, can be expected to provide a riskless indexed return. The return patterns of indexed bonds are thus analyzed by themselves.

Figure 6 and table 5 both present results for Chilean indexed bonds. The indexes are the following:

• INPRC10. The PRC 10 is a Central Bank UF-denominated bond with semiannual constant coupons over ten years. The index assumes a simple trading strategy that consists in buying a newly issued PRC 10 at the end of each month, using the proceeds from the sale of the previous one. The interest rate used for the calculations corresponds to the yield of the bond on the last day of each month. In the early years, before the existence of the PRC, the equivalent PDP series was used. The calculation is based on data provided by AFP Habitat and the Bolsa de Comercio de Santiago.

• INU12. This index corresponds to a twelve-year mortgage bond issued by the Banco del Estado de Chile. The bond is based on a different indexation mechanism, which may make it behave slightly differently from UF-indexed instruments.[25] It is calculated using the same methodology and the same data sources as the INPRC10.

• INUF90. This index corresponds to the ninety-day UF-denominated deposit rate offered by prime banks to large pension funds. The methodology and sources are the same as for the INPRC10.

• CB YIELD. The CB Yield corresponds to a fixed-income, UF-based, long-term government bond index calculated by CB Capitales. Data are provided by CB Capitales.

The U12 and the CB Yield are used only for control purposes, given that the longest series correspond to the other two indexes. The correlations between INPRC10 returns and the returns on the INU12 and CB Yield are quite high, and in this sense the PRC 10 may be representative. It is also interesting to note that in the common period, the

25. The mechanism used is the average value index (the Índice de Valor Promedio, or IVP), which is similar to a lagged UF.

observed returns are very similar among the longer-term indexes as well as with the short term deposit, although there would seem to be a premium of between 6 and 10 basis points per month in the PRC 10 returns. Not surprisingly, the short-term security has the lowest volatility, followed by the CB Yield (a portfolio), PRC 10, and U12. Since the U12 has a longer duration, these results are to be expected. The small differences among the different volatilities and correlations suggest that there is little room for diversification in the fixed-income markets. This, in addition to the similarity of the observed returns, gives credibility to the idea of a well-arbitraged market.

Figure 6 supports the results in the table, showing a very similar behavior for the long-term indexes, while the behavior of the short-term index is obviously different and, in particular, significantly smoother, given its short maturity. It is precisely the volatility of the longer-term indexes that gives protection to the long-term investors, jointly with their long-term negative serial correlation, which is apparent in the graph.[26] This is due to the effects of a mean-reverting changing yield through time. Short- and long-term UF investing thus provides very different patterns of returns that are not equivalent from the perspective of a local investor.

Table 5. Representative Fixed-Income Indexes

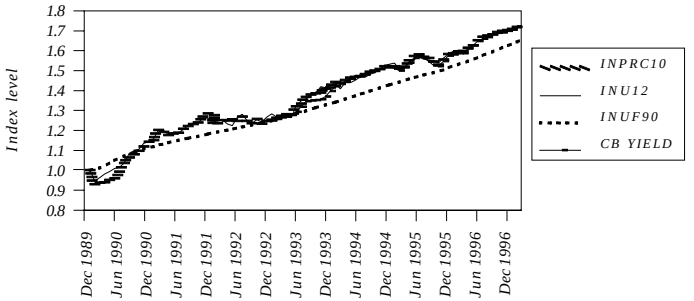
Percent

	Index[a]			
UF-based statistic	*INPRC10*	*INU12*	*INUF90*	*CB YIELD*
Period covered	Jan 1990 to Mar 1997	Jan 1990 to Mar 1996	Jan 1990 to Mar 1997	Jan 1993 to Feb 1997
Average monthly return	0.63	0.63	0.57	0.63
Monthly standard deviation	1.47	1.59	0.18	0.78
Common period (Jan 1993 to Mar 1996)				
Average monthly return	0.64	0.59	0.54	0.62
Monthly standard deviation	0.90	1.28	0.07	0.86
Correlations				
INPRC10	1.00	0.64	0.52	0.78
INU12	...	1.00	0.15	0.43
INUF90	...	...	1.00	0.47

Source: Author's calculations, based on data provided by AFP Habitat, the Bolsa de Comercio de Santiago, and CB Capitales.
a. Indexes defined in text.

26. For overlapping annual PRC 10 returns, the one-year serial correlation is –0.42. For nonoverlapping yearly returns, it is –0.82 (with only 6 data points).

Figure 6. Cumulative Wealth of UF-Based Indexes[a]



Source: Author's calculations.
a. See text for definition of indexes.

4. The Unique Return Patterns of Indexed Bonds: An International Perspective

The idea of completing the market with indexed bonds is analyzed here from the perspective of an investor who looks to world markets for alternatives that are similar to indexed Chilean fixed-income securities. The results show that replicating portfolios of foreign securities generally will not do a very good job. These findings can be useful in several ways:

• For the Chilean Central Bank, which has to invest in foreign assets and which maintains UF-denominated short- and long-term liabilities. It is interesting to consider the kind of portfolio that minimizes the tracking variance with respect to the Central Bank's liabilities, that is, the kind of portfolio that minimizes the variability of the difference between asset and liability returns.

• For Chilean investors who wish to invest abroad. In the case of long-term local investors, a riskless investment opportunity is represented by a long-term UF denominated bond; in the case of short-term local investors, the riskless asset would be a UF short-term instrument. In both cases, the results indicate the foreign portfolio that most closely resembles the local riskless asset. These results also indicate why pension funds and insurance companies have invested so little in foreign securities;

• For government authorities, who need to better understand why foreign investors are interested in investing in local fixed-income securities despite the reserve requirements.

The analysis is developed based on software and data from Ibbotson Associates.[27] It treats two fixed-income, UF-based wealth indexes as if they were two separate fund managers. I conduct a performance attribution analysis of the indexes (see Sharpe, 1992) and also analyze the out-of-sample rolling portfolios that would have most closely resembled the indexes. The algorithm implements a Markowitz-style optimization model, searching for the nonnegative portfolio weights that minimize both the tracking variance, var $(r_I - r_R)$, where I and R represent the replicated index and the replicating portfolio, respectively, for the entire period and also the series of weights that would minimize it on a thirty-six-month moving-average basis. The latter is used to calculate out-of-sample replicating portfolio returns.

To find foreign replicating portfolios, INPRC10 and INUF90 were transformed into dollars, at the observed exchange rate and the corresponding value in pesos for the UF.[28]

All the international data used were provided by Ibbotson Associates. The data indexes chosen are the Salomon Brothers (SB) three-month U.S. Treasury bill index; the intermediate-term U.S. government bond index; the long-term U.S. government bond index; the long-term U.S. corporate bond index; the Salomon Brothers (SB) broad investment-grade (BIG) bond index; the Standard and Poor's 500 index; the Morgan Stanley (MS) capital international EAFE index; the Morgan Stanley (MS) capital international Latin America free index; and the International Finance Corporation (IFC) emerging composite index. The criterion employed was to seek world coverage with bond and stock portfolios, giving additional emphasis to the U.S. indexes.

Figure 7 shows the cumulative dollar return for the indexes and their overall replicating portfolios. Only the in-sample results are shown (for example, when a single set of portfolio weights is used for the entire period) because the out-of-sample results were similar. The replicating portfolio barely obtains half of the wealth accumulated by the local indexes, as a result of the high local interest rates and the UF-dollar appreciation.

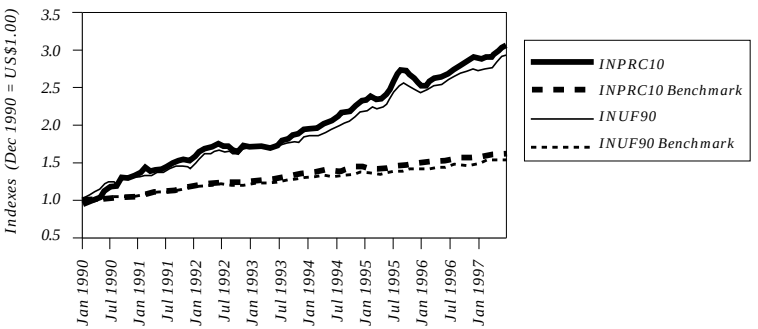
Table 6 lists the asset class weights that turned out to be different from zero, and it also presents the parameters of a simple one-variable linear regression that correlates the index returns with their corresponding replicating portfolios. The portfolio weights are heavily

27. Used by permission. The software is called ENCORR ATTRIBUTION.
28. Data provided by the Central Bank of Chile.

concentrated in short-term U.S. Treasury bills (or T-bills), because if no single asset class has a significant correlation with the indexes, then the tracking variance is minimized with the smallest variance asset. Nonetheless, the replicating portfolios of the two indexes display certain differences. The longer-term index includes long-term U.S. government bonds (whereas the short-term index does not) and also has larger percentages in emerging markets. The regression statistics indicate that the out-of-sample methodology provides insignificant results, except for the constant (alpha). This contrasts with the overall period results, which appear statistically significant despite their low explanatory power. This implies that the optimal portfolio weights may not be stable through time. The serial correlation of the rolling portfolio implies that it may be possible to use this information to better calculate portfolio weights.

Both UF-based indexes thus provide patterns of return that are not available in the international markets. This is true in the following two senses. First, the large alphas indicate that with respect to their replicating portfolios, the UF-based indexes provided additional dollar returns of between 0.7 and 1.0 percent per month. Second, the low correlations indicate that the alternatives behave very differently through time and do not entail the hedging properties that may be required by a local investor.

Figure 7. Dollar-Based Indexes and their Replicating Portfolios[a]



Source: Author's calculations.
a. See text for definition of indexes.

Table 6. Average Composition of Replicating Portfolios, January 1990 to March 1997[a]

	Overall		*Rolling*	
Data index	*INPRC10*	*INUF90*	*INPRC10*	*INUF90*
SB three-month T-bill	78.4300	90.7500	...	...
Long-term U.S. government	8.0900	0.0000	...	...
IFC emerging composite	12.2300	7.3200	...	...
MS Latin America free	1.2500	1.9200	...	...
Summary statistic				
Alpha	0.0072	0.0069	0.0104	0.0103
Alpha *t* statistic	2.4035	2.3864	3.3677	3.7981
Beta	1.0737	1.1254	0.1628	0.0269
Beta *t* statistic	3.5094	2.9070	0.6166	0.0886
R^2	0.1266	0.0904	0.0077	0.0002
F statistic	12.3159	8.4507	0.3802	0.0078
No. observations	87	87	51	51
Serial correlation	0.0991	0.1069	0.2682	0.3140

Source: Author's calculations, based on Ibboston Associates data and software.
a. Data indexes and replicating portfolios defined in text.

Other lessons that can be drawn from this exercise are that the Central Bank should consider, for hedging purposes, including long-term U.S. government bonds and a small proportion of emerging market equity in its portfolio. Finally, investing in foreign fixed-income seems to make little sense for a Chilean investor whose investment horizons are represented by either index, given that local indexed bonds outperform them.

5. Relevance of the Return Patterns Provided by UF Bonds

The results of the previous section indicate that UF-denominated short- and long-term bonds provide patterns of returns that are not available in the international markets. This section assesses whether these patterns are relevant and if so, in what sense.

The analysis includes three different perspectives. The state-variable perspective addresses the idea that the short- and long-term UF-based indexes may represent relevant states of nature. From the perspective of an optimal leverage composition (or hedging against changes in capital asset prices), the issue is whether firms that belong to the nontradables sector would find it convenient to use more

UF-denominated debt. Finally, the third perspective encompasses whether UF-denominated bonds provide useful protection against adverse changes in nontradable goods prices.

5.1 States of Nature

If short- and long-term UF-denominated bonds are indeed useful indicators of the state of the economy, news about them should have a significant impact on the prices of financial instruments. In particular, investors might want to either hedge against or bet on the movements of these variables, and this risk should be priced. Therefore, if the returns of these bonds are correlated with those of the stock market, for example, significant relationships should emerge.[29]

To test this simple idea, I performed a regression analysis with the four industry stock market indexes of the Bolsa Electrónica de Santiago. These are value-weighted indexes that represent buy-and-hold strategies. The four sectors represented are electricity, services, manufacturing, and natural resources. The returns on these indexes are first expressed in dollars and calculated in excess of the ninety-day U.S. T-bill returns. This procedure is also carried out for the explanatory variables, namely, the excess dollar return of the short- and long-term UF-based indexes and of the long-term U.S. government bond index.[30] The next section explains the reason for working with excess returns; here, it is interesting to note that the resulting numbers are almost unit-free, since the variation of the dollar exchange rate is implicitly subtracted on both sides.

Tables 7 and 8 show the results of this exercise. A seemingly unrelated regression (SUR) analysis was performed, including equations for the short- and long-term index excess returns. Table 7 shows the results of estimating an autoregressive equation for the short-term index return, while table 8 shows the results for the long-term bond and stock indexes.

In table 7 the lags were set ex post at three to minimize the number of degrees of freedom lost in the SUR analysis for the rest of the equations, given that higher lags were not significant. Results show a relatively weak positive AR(1) behavior.

29. Strictly speaking, the first step in testing this is to estimate the sensitivity of different asset prices to these state variables and then to verify whether this risk is priced in a cross-section.

30. Same sources as before.

Table 7. Influence of UF-Based Indexes on Stock Returns: The State Variable[a]

Explanatory variable	*EINUF90*	
Constant	0.0061	(2.7731)
EINUF90 (t – 1)	0.2650	(2.0925)
EINUF90 (t – 2)	–0.0500	(–0.3823)
EINUF90 (t – 3)	–0.1350	(–1.1896)
Summary statistic		
No. observations	60	
d. f.	56	
Adjusted R^2	0.0339	
SSR	0.0126	
DW	1.9677	

Source: Author's calculations.
a. Dependent variable is the ninety-day UF-based index excess returns (measured in dollar excess returns above the ninety-day T-bill monthly return). Estimation model is a seemingly unrelated regression (SUR); *t* statistics in parentheses.

Table 8. Influence of UF-Based Indexes on Stock Returns: Stock, UF, and U.S. Dollar Portfolio Returns[a]

Explanatory variable	*EINPRC10*	*ERELECT*	*ERSERVI*	*ERINDUS*	*ERNATUR*
EINUF90	1.1571	–0.3356	–1.0352	–0.4501	–1.6159
	(17.6062)	(–0.2564)	(–0.7610)	(–0.3409)	(–1.1868)
EINPRC10	…	2.2766	2.4900	1.5870	2.7715
	…	(2.2227)	(2.3385)	(1.5356)	(2.6006)
EUSLTGVT	0.0490	–0.0838	0.7331	0.7990	0.0379
	(1.1169)	(–0.2384)	(2.0065)	(2.2534)	(0.1038)
Summary statistic					
No. observations	60	60	60	60	60
d.f.	58	57	57	57	57
Adjusted R^2	0.8222	0.2447	0.2400	0.1909	0.1916
SSR	0.0042	0.2636	0.2845	0.2692	0.2854
DW[b]	1.9681	1.8903	1.7390	1.7716	1.7715
Hypothesis					
UF coefficients > U.S. dollar (*p* values)	…	0.0089	0.0952	0.2516	0.2524
Equal UF coefficients (*p* values)					
0.0973	…	x	…	x	…
0.1376	…	x	…	…	x
0.4076	…	…	x	x	…
0.5880	…	…	x	…	x

Source: Author's calculations.
a. All dependent and explanatory variables are measured in dollar excess returns above the ninety-day T-bill monthly return. EINUF90 corresponds to the ninety-day UF-based index excess returns; EINPRC10 corresponds to the ten-year UF-denominated bond excess returns; EUSLTGVT corresponds to the long-term government bond excess returns; ERELECT, ERSERVI, ERINDUS, ERNATUR correspond to the four industry indexes calculated by Bolsa Electrónica and respectively represent the electrical, services, manufacturing, and natural resources sectors. Estimation model is a seemingly unrelated regression (SUR); *t* statistics in parentheses.
b. The DW statistics do not change if we include a constant in the equations.

Table 8 starts with an analysis of the long-term UF-based index in the first column of numbers. This is a very well behaved equation in which the only significant explanatory variable is the excess return on the short-term UF-denominated bond. In the other equations, the coefficient on the short-term bond is negative and insignificant, and in three out of the four equations the coefficient on the long-term bond is very significant. The joint hypothesis that the coefficients on the UF-denominated bonds are zero at any significance level can thus be rejected.

The analysis indicates that UF-denominated bonds are useful indicators of the state of the economy. This is especially true in the case of the long-term bond, even though it is greatly influenced by the short-term rate.

5.2 Optimal Debt Composition or Hedging against Capital Asset Price Changes

All the regressions in table 8 exclude a constant and are expressed as returns in excess of the T-bill returns, because one minus the sum of the regression coefficients represents what should be invested in the T-bill. To see this, assume three assets (*A*, *B*, and *C*) and suppose that the aim is to find the unrestricted portfolio composed of *B* and *C* that best replicates *A*. If we run the regression

$$r_A - r_B = \mathrm{b}\left(r_C - r_B\right) + \nu \ ,$$

then estimated b will represent the fraction of the portfolio invested in *C* and 1 – b the fraction invested in *B*. The regression analysis finds the portfolio weights that minimize the tracking variance.

Consequently, the coefficients of the regressions without constants can be interpreted as the portfolio weights of the short-term UF-denominated bond, the long-term UF-denominated bond, the long-term U.S. government bond and the T-bill (computed as one minus the sum of the other coefficients).

The results obtained have two alternative (but complementary) interpretations. First, they could represent hedging portfolios made up of the low-risk, fixed-income portfolios that most closely resemble the returns of the industry portfolio. The idea is to identify the portfolio that investors would choose if they could not invest directly in a given industry. Which portfolio, for example, allows us to hedge best against adverse price changes in housing (the nontradables sector)? The

second interpretation is that of the optimal leverage composition, in which the evolution of the industry portfolios represents those of the firms that compose them. The portfolios would reflect the market's assessment of changes in the value of assets. In this case it makes sense to look for the composition of the total liability (represented by government bonds)—in terms of maturity and currency denomination—that most closely follows the market value of assets, because this minimizes bankruptcy risks.[31]

The hypothesis that can be tested (and that is consistent with both of the above perspectives) is that the nontradables sectors (electricity and services) should have a higher optimal percentage of the total composition (either as a hedging portfolio or as a liability) in UF-denominated bonds. The opposite should be true for the tradables sector (manufacturing and natural resources). The test should also verify whether the former is greater than the latter, as expected. In this case, since the variables involve the market value of equity rather than of assets, results are likely to be biased against the hypothesis. For example, if a firm already has an optimal debt composition, the value of equity would be less affected by adverse changes in the exchange or interest rates.

The results in table 8 can now be reinterpreted. First, the replicating portfolio of the long-term indexed bond consists of a long position in the short-term UF-denominated bond (1.16), a long but insignificant position in the long-term U.S. government bond (0.05), and a short position in the T-bill (–0.21). This means that historically the UF-denominated bond has provided a pattern of returns that is similar to buying a short-term indexed bond with dollar-denominated debt.

The last four columns in table 8 show the results for the stock portfolios. In general, these are well-behaved regressions, and the results are in line with what can be expected considering the usual explanatory power for stock portfolio returns based on a few explanatory variables. Moreover, results are generally significant, although the coefficients could be biased if the omitted variables are correlated with the regressors. Nonetheless, the portfolio perspective given above is still valid.

To interpret the results for the stock portfolios, the central procedure is to test whether the total amount in UF-denominated bonds (the sum of the first two coefficients) is greater than the amount

31. Government bonds are considered representative because from the perspective of an issuing firm, the bond issued is free of default risk.

in dollar-denominated bonds. In other words, it is sufficient to test whether the sum of the first two coefficients is greater than 0.5. The role of separate coefficients for the short- and long-term bonds (both UF-denominated and dollar-denominated) is to allow for the adjustment of the portfolio duration. Results indicate that for the electrical and services portfolios (in the nontradables sector), the UF coefficients are indeed larger than the dollar coefficients at significance levels of 1 percent and 10 percent, respectively. For manufacturing and natural resources (in the tradables sector), they are not. This is consistent with what is to be expected. At the same time, only the electrical sector gives some indication of having coefficients that are larger than those of the industries in the tradables sector.

The evidence is thus mixed, and it only partially supports the hypothesis that the optimal composition is biased toward the indexed unit.

5.3 Indexed Bonds and Goods Prices

Table 9 presents the results of performing simple bivariate Granger causality tests between tradable and nontradable goods price returns and the short- and long-term indexed bond returns. The idea is to verify to what extent investing in these assets would provide protection to an investor who wishes to hedge against adverse changes in goods prices. This requires a measurement unit for returns and price changes, and since the U.S. dollar has had a significant downward trend, I decided to measure everything in units of the tradable good. Therefore, the price returns actually correspond to the change in the relative prices of the tradable and nontradable goods. The index returns are also measured in terms of the tradable good.

Table 9. Bivariate Granger Causality Tests[a]

Causality test	*Adjusted R^2*	*Observed significance for AR(1) test*[b]	*Lagged variable*[c]	*Sum of coefficients*	*t statistic*
NT causes UF90	0.1652	0.4787	CPI-NT	1.0951	1.3917
UF90 causes NT	0.0694	0.7515	INUF90	–1.0385	–0.7721
NT causes PRC10[d]	0.2612	0.1644	CPI-NT	0.5501	0.7264
PRC10 causes NT[d]	0.2552	0.0881	INPRC10	0.0034	0.0186

Source: Author's calculations, based on data from the Chilean Instituto Nacional de Estadística (INE).
a. Variables measured in terms of tradable goods units. Sample period is 1992:1 to 1997:3. NT means nontradable; CPI-NT corresponds to the consumer price index of the nontradables sector; INUF90 corresponds to the ninety-day indexed bond returns; INPRC10 corresponds to the ten-year indexed bond returns.
b. Test suggested by Godfrey (1978) and Breusch (1978).
c. Tested twelve lags in each case.
d. Modeled with an AR(1) error

Results show that the correlation between lagged price returns and bond returns are positive, but not significant. There is thus no direct evidence that UF-based investing alone provides a good hedge against increases in the relative prices of nontradable goods. More importantly, indexed bond returns do not feed back into prices, which helps to mitigate the eventual concern of the economic authorities that financial indexation perpetuates inflation.

6. Conclusions and Final Comments

This paper has provided sufficient evidence to prove that financial indexation has been an important factor in the development of the Chilean capital market. This is likely to have had a positive impact on welfare and growth through better resource allocation. The paper analyzed the issue from several perspectives to justify the conclusion.

The Chilean experience with the liberalization of financial markets leads to the conclusion that in addition to liberalizing interest rates and credit restrictions and establishing an inflation-neutral tax system, the UF constitutes a central piece of the technology developed for protecting capital market participants from inflation. This technology includes the credibility of the unit, compatible laws, and the precedent established by the central authorities in issuing indexed bonds.

Without an inflation-protection unit, high expected inflation rates and nominal financial instruments imply that the effective maturity of a long-term nominal bond is short. The implications of not having an index unit are that longer-term debt is likely to be issued in a foreign currency (such as the U.S. dollar) and that the overall size and average maturity of the fixed-income markets are likely to be reduced. This, in turn, implies a larger degree of mismatching in firms' asset-liability structures, which increases the expected bankruptcy costs.

The paper describes the Chilean fixed-income market and its generalized indexation as successful. An estimated 63 percent (US$82 billion) of the assets held by institutional investors, including banks, pension funds, life insurance companies, and mutual funds, are indexed. Excluding banks from the sample increases the number to 80 percent. Excluding equity investment as well further increases the percentage to 99 percent.

The paper also identifies links with other markets, especially the equity market, concluding that the development of a fixed-income

indexed market was a necessary step toward the development of the equity market. Similar arguments apply in the financial sector with regard to the development of mortgages, pension funds, and life insurance companies. In the real sector, the development of the construction sector through the market for mortgages was probably one of the greatest benefits of indexation. On the other hand, nonfinancial firms have issued small amounts of debt, partly as a result of the distortion between the required returns on debt and equity.

It is not possible to successfully replicate the short- and long-term indexed bond return patterns in international markets, and in this sense they are unique. This uniqueness is relevant for local investors, considering the following evidence. First, short- and long-term indexed bonds represent states of nature that significantly impact asset prices. Second, different debt structures (hedge portfolios) would be optimal for firms in the tradables and nontradables sectors, with the latter being tilted toward UF-denominated securities. These results also indicate that the Central Bank's optimal asset composition should include long-term U.S. government bonds and a small fraction of emerging market equity. Finally, from the perspective of local investors, investing in foreign fixed-income securities seems to make little sense, which may explain why this process has been so slow.

The economic authorities have probably played an important role in the development of the local capital market. In addition to establishing the set of regulations, the issuance of indexed bonds with diverse maturities has provided an important stimulus. The liquidity and benchmarking that these bonds provide are necessary signals for the private sector. In this sense, other government initiatives, such as issuing nominal and dollar-denominated long-term bonds in addition to indexed bonds, would probably help to continue completing the financial markets. For example, long-term nominal bonds could have a social role not only in terms of clarifying private sector expectations about future inflation rates, but also in terms of modifying or creating certain forms of industrial organization. With these instruments providing clear reference rates and with minor legal changes, the market for nominal funds is likely to experience increased competition, which could lower nominal interest rates on consumption loans, for example.

APPENDIX

The Convexity Effect

Consider the Vasicek (1977) model for the term structure of interest rates. It assumes that the changes in the nominal interest rates follow a mean-reverting diffusion process with constant parameters of the following type:

$$dr = a(b - r)dt + \sigma dz ,$$

where a is the "pull", b the level toward which the rates revert, σ the volatility parameter, and dz the Wiener process. This equation has a closed form solution that depends on the above parameters and also on the current level of the short rates.

To study the impact of the volatility of the inflation rate, the real U.S. rates are assumed to be constant, and the current and equilibrium rates are assumed to correspond to the TIPS rate plus a 3 percent long term inflation rate (which gives a log nominal rate of 6.396 percent). We estimate the parameters a and σ from a simple regression of changes in the annual inflation rate against its lagged value from 1960 on. This yields the corresponding estimates of 0.26 and 2.15 percent, respectively. Calculating the Vasicek formula with these parameters generates a downward-sloping nominal yield curve. Using the Fisher equation to estimate the expected inflation rate (that is assumed constant) would therefore underestimate it by 17 basis points in the ten-year bond and 25 basis points in the twenty-year bond. For Chile, using a current and long-term real rate of 6 percent, a constant expected inflation rate of 4 percent, a parameter a equal to 0.201,[32] and twice the volatility of the United States (4 percent), the ten- and twenty-year nominal discount bonds appear to have interest rates that are 78 basis points and 130 basis points below the value given by the Fisher equation. In this case, the inflation risk works in a way that is opposite to what can be expected. Increasing the inflation volatilities reduces the resulting nominal rates. The present value is a convex function of its discount rate. Therefore, for a given long-term expected value, higher volatility in the inflation rates implies lower nominal rates.

32. Corresponds to the coefficient of the error correction model in Rojas, Rosende, and Vergara (1995, table V.10).

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