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CHILE

Selected Issues

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Approved by the Western Hemisphere Department

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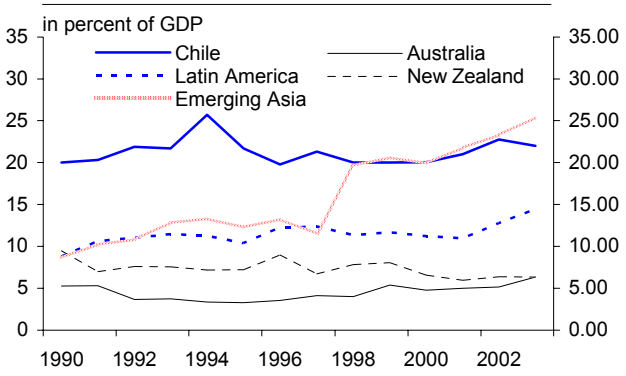
I. Chile's Holdings of Foreign Reserves[1]

A. Introduction

1. ***Since 1990, Chile's foreign reserves have been very stable as a percent of GDP, and were equivalent to 22 percent of GDP at end-2003.*** (Figure 1). This level of reserves is significantly above the Latin America average, and three times higher than in Australia and New Zealand, two countries which also implement rules-based macroeconomic policies with a flexible exchange rate regime and in which commodities are an important component of the economy. Chile's level of reserve holdings is about the same as in emerging market Asian economies. This chapter first reviews the benefits and costs of reserves, with emphasis on standard methodologies for assessing reserve adequacy. Given that the economic literature still lacks a firm guidance to assessing the optimal level of reserves, the chapter reports an empirical methodology that analyzes simultaneously key explanatory variables behind a country's level of reserves. Finally, this chapter previews mechanisms that could supplement a country's liquidity needs in times of stress.

Figure 1. International Comparisons: Reserve Holdings, 1990-2003



B. The Rationale for Holding Reserves

Assessing adequacy

2. ***One of the main purposes for building foreign reserves is to help smooth out the impact of external shocks.*** Temporary shocks to the balance of payments can either be financed or managed through domestic adjustment which could induce large output swings. While reserves allow countries to smooth out the path of adjustment, it is difficult to assess their appropriate level. Several measures associated with imports, short-term debt, and potential capital outflows have been proposed to assess their adequacy.

3. ***Measured as a percentage of annual imports, Chile's reserve ratio is high.*** Traditionally, concerns about shocks to the balance of payments have focused on the external current account balance. This emphasis led to the practice of tracking trade deficits as a predominant source of vulnerability, and closely monitoring the reserves-to-imports ratio.[2] At the equivalent of about nine months of imports, Chile's reserve-to-import ratio is well above

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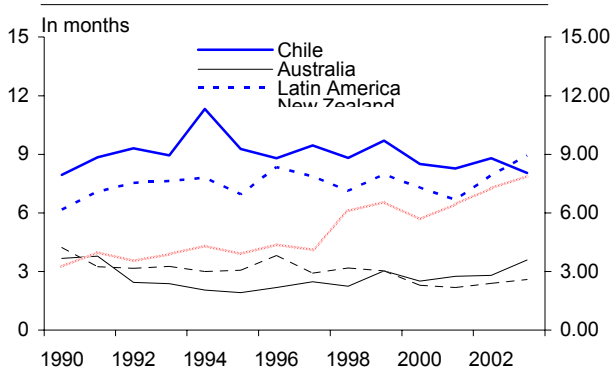
[1] Prepared by Marco A. Espinosa-Vega (Ext. 3-8589) and Mercedes Vera-Martin (Ext. 3-1117). We thank our discussant Claudio Soto (Central Bank of Chile), as well as Nancy Marion and Hali Edison for valuable comments and suggestions.

[2] This indicator is often used to assess reserve adequacy in countries dependent on commodity trade and with a relatively close capital account.

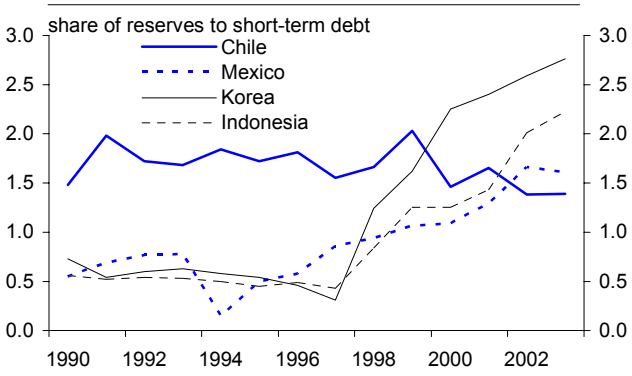
the frequently used guideline of a reserve cover of three-to-four months of imports. It is at about the same level as in emerging market Asian countries, and more than twice as high as in Australia and New Zealand (Figure 2).

Figure 2. International Comparisons: Reserves to Imports, 1990-2003



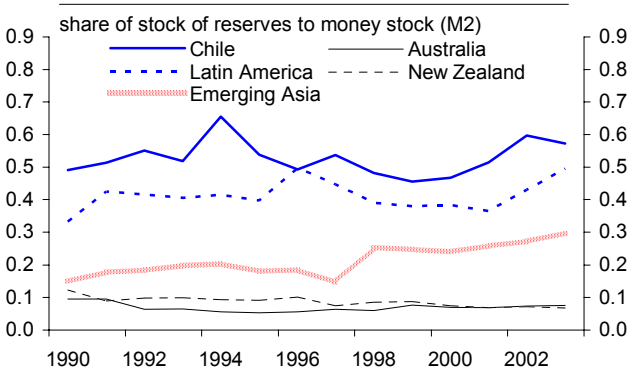
4. ***As a percent of short-term debt, Chile's reserves ratio is also high.***[3] The 1994 Mexican crisis and the 1997–98 Asian crises highlighted the problems associated with sudden stops in capital financing. Unable to continue to tap capital markets to finance their current account deficits, countries were faced with sharp current account contractions and resulting costly adjustments. By some accounts, these crises originated in excessive reliance on external short-term debt, and emphasis was placed on measuring reserves as a proportion of a country's short term external debt. Pablo Guidotti and Alan Greenspan suggested that the reserves to short-term debt ratio (measured on a remaining maturity basis) should be of at least one, in order to allow a country to be able to operate for a full year without external borrowing. Chile's ratio of short-term debt to reserves has consistently exceeded this benchmark (Figure 3).

Figure 3. International Comparisons: Reserves to Short-term Debt 1990-2003



5. ***The possibility of bank run-induced crises calls for a complementary indicator to measure the appropriate reserves level.*** As initially suggested by Calvo and Mendoza in 1996, confidence crises can translate into runs on bank deposits with a corresponding drop in the level of reserves and destabilizing balance sheet effects arising from sharp exchange rate movements. To capture the vulnerability associated with a sudden reversal of confidence and capital flight, the ratio of

Figure 4. International Comparisons: Reserves to M2, 1990-2003



[3] For a detailed presentation of these indicators, see "Debt and Reserve-Related Indicators of External Vulnerability"—International Monetary Fund (2000).

reserves to broad money has been commonly used in recent years. Chile's gross reserves cover about 57 percent of broad money. This ratio is comparatively higher than in emerging Asian economies. It is close to the average in Latin America. The high degree of dollarization in some Latin American economies has induced some central banks to keep a high reserves ratio to act as lender of last resort (Figure 4). In Chile, the banking system is not dollarized; foreign currency sight deposits account for only 7½ percent of total liquid deposits. However, under the narrow banking concept, the central bank provides full guarantee on sight deposits and term deposits of less than 30 days (as well as on deposits with term-to-maturity of less than 10 days). This function may reinforce the need for the central bank to hold reserves.

6. ***Chile's reserves are currently above a composite minimum benchmark which takes into consideration short-term debt and risks of capital flight.*** Following the methodology suggested by De Beaufort and Kapteyn (2001), reserve adequacy in Chile has been assessed against a minimum benchmark that combines short-term external debt on a residual maturity basis, reserves to broad money, and a country risk index. The increase in the estimated adequate level of reserves, according to this methodology, is due to the increase in short-term external debt in recent years. However, since 1999 Chile's reserves have been above the estimated adequacy upper bound (15 percent in 2003, Table A).

Table A. Estimated Adequate and Actual Reserves
(in billions of U.S. dollars)

	Adequate Reserves	Actual Reserves
1999	7.6 - 8.1	14.6
2000	10.7 - 11.1	15.0
2001	10.3 - 10.6	14.4
2002	11.9 - 12.1	15.3
2003	13.4 - 13.7	15.8

Sources: IMF WEO database, BIS, and Economist Intelligence Unit.

7. ***Central banks also hold international reserves to help manage exchange rate volatility.*** Even countries with free float exchange rate regimes at times intervene in the foreign exchange market, to correct perceived sporadic exchange rate volatility. For instance, recently, the central bank of New Zealand obtained authorization to accumulate additional reserves to guarantee successful intervention in the exchange rate market in case it showed excessive volatility. Also, although the Bank of Canada has not intervened in the exchange rate market since 1998, its policy is to intervene in foreign exchange markets only in cases of "extreme currency movements that could seriously threaten the sustainable long-term growth of the economy." Similarly in Chile, where the floating exchange rate regime has been in place since late 1999, the central bank reserves the right of intervening under exceptional circumstances. When the bank has intervened, it has done so by pre-announcing the maximum length of time of the intervention and the maximum amounts reserved for that purpose. The last official intervention in the foreign exchange market took place in 2002.

Reserves as means of reducing the probability of a crisis

8. ***Considerable analysis has been conducted at the Fund on the role of foreign reserves in preventing external crises.*** As noted earlier, low ratios of reserves to short-term debt were a key factor behind the Asian financial crises. In their study of the Mexican 1994, Asian 1997, and Russian 1998 crises, Bussière and Mulder (1999) found that different transformations and scaling of reserves variables were significant and robust in explaining

the depth of the crises during these episodes. The adequacy of reserves for crisis prevention also became part of a more comprehensive effort to identify leading indicators of currency and financial crises, which resulted in the Early Warning Systems (EWS).

9. ***EWS models indicate that, given Chile's comfortable reserves holdings, the probability of a currency or financial crisis is currently very low.*** The Fund's internal Developing Country Studies Division (DCSD) EWS model[4] shows that, following a moderate increase at end-2000, the probability of a crisis in Chile within a two-year horizon has steadily declined significantly and is currently low, at 13 percent (Figure 5). Among the explanatory variables, neither the level of real effective exchange rate nor the current account deficit, the two main factors contributing to the increase in probability in 1998, are a source of concern. Furthermore, the stability in the country's level of reserves has contributed to Chile's resilience to shocks. The crisis signal model (based on Kaminsky, Lizondo, and Reinhart, 1998), and the Goldman-Sachs framework for predicting financial crises (GS-Watch, 1998) also indicate that the probability of a crisis in Chile is currently low, at 11½ percent and 7 percent, respectively. Across models, Chile compares favorably with emerging market OECD member countries, as its crisis probability averaged 10 percent in 2003, the second lowest among the countries in the sample.

10. ***Although EWS models may be informative tools, it is important to acknowledge their limitations.*** They do not fully take into account cross-country institutional and macro framework differences. For example, unlike a number of Latin American countries, Chile is a country whose institutional strength and macro discipline (see for instance Kalter, et al. (2004)) has allowed it to structure its public debt in a way as to reduce currency and roll over risks, thus increasing its resilience to external shocks. Such cross-country differences, unfortunately, are not well captured by the EWS models.

Assessing the costs of holding reserves

11. ***Under an opportunity-cost approach, the annual average cost of holding reserves is estimated between 0.3 and 0.5 percent of GDP in Chile.*** Under this approach, the opportunity cost for 2002–2004 is computed as the difference between the return on foreign reserves and the interest paid by the Central Bank of Chile on its dollar-denominated domestic debt. The return on reserves is estimated assuming that the central bank's investment portfolio consists of a combination of three years U.S. Treasury bonds and three months Treasury bills. The calculation does not take into account valuation gains or losses of international reserve holdings due to movements in the exchange rate. Aguirre, et al. (2004) estimate the current annual cost of holding reserves at about 0.2 percent of GDP. In this study, Aguirre, et al. compute the cost of holding reserves as the product of the sovereign spread by the average level of reserves holdings.

C. Toward a Definition of the Optimal Level of Reserves

12. ***Although providing useful guidelines, the above-mentioned rules of thumb on the reserves level lack theoretical underpinning and present several shortcomings.*** They are

[4] For more details, see Berg, Borensztein, Milesi-Ferretti, and Patillo (1999).

indicative of an adequate level of reserves, but do not provide any guidance on the optimal level of reserves. They usually consider only one source of vulnerability at a time when assessing reserve adequacy, and ignore countries' idiosyncratic features that could serve to dampen or exacerbate the need for adjustment in the event of a shock. In addition, they do not make a distinction in policies or institutions across countries.[5] Finally, these indicators do not consider the cost of holding reserves explicitly.

13. ***Recent empirical literature based on the buffer stock model has tried to assess the level of reserves by suggesting some potentially key explanatory variables (Box 1).*** These variables include economic size, current and capital account vulnerabilities, exchange rate flexibility, and the carrying cost of reserves. Of course, settling down on what variables best serve as proxies for these categories of explanatory variables is still an active area of research. The relationship between these variables and reserves is as follows:

- ***Economic size*****:** international transactions increase with economic size, and therefore reserves are expected to increase with real GDP per capita and population.

- ***Balance of payments vulnerability*****:** the more open an economy, the more vulnerable it becomes to sudden stops and, therefore, the higher the desired level of reserves.

- ***Exchange rate flexibility*****:** the greater the flexibility in the exchange rate regime, the lower the need to support the currency and the more likely the exchange rate will serve as a shock absorber, thus reducing the need to accumulate reserves.

- ***Carrying cost of reserves*****:** higher costs of holding reserves should induce lower holdings of reserves.

14. ***Based on the buffer stock model, we have estimated reserve holdings for a panel of emerging economies.*** This estimation is based on panel data from 1980–2002 for twenty emerging economies, including Chile (Tables 1–3). The holdings of reserves are postulated to be a linear function of a combination of variables such as economic size, capital and current account vulnerability, opportunity cost of holding reserves, exchange rate flexibility, and country risk premium. Our estimation confirm that the size of the economy, as measured by GDP per capita and population, is positively correlated with the level of reserves. Regarding current account variables, imports as a share of GDP and export volatility have a positive impact on a country's holdings of reserves. Foreign reserves are also positively related to the variables associated with the capital account vulnerability such

[5] For example, the reserves-to-broad money ratio aims at capturing vulnerability to deposit outflows. However, this ratio does not capture well cross-country differences on the regulatory strengths of the banking systems.

as the log of imports to GDP. Exchange rate volatility, as expected, is negatively associated with the level of reserves. As in previous studies (e.g., Aizenman and Marion, and Edison),the carrying cost of reserves is not statistically significant. Finally, country-specific risk variables that summarize political, financial, and economic risks, are found to be statistically significant and positively correlated with reserve holdings, indicating that countries with lower risks hold less reserves.[6]

Box 1. Empirical Literature on the Optimal Level of Reserves

The foundation for this empirical literature is the buffer stock model. Heller (1966), and Frenkel and Jovanovic [F-J] (1981) are examples of theoretical frameworks that have tried to identify the elements underpinning the optimal level of a country's holdings of international reserves. These papers are based on a buffer stock model in which the government seeks to minimize the cost of restocking reserves when these follow a Wiener process (a continuous time random walk). The second paper included an empirical test of this theory. The empirical test postulated the level of reserves as a function of the volatility of reserves and the opportunity cost of holding reserves.

Flood and Marion [F-M] (2001) replicate the F-J test, but introduce a series of refinements to the original set up. First, they note the difficulties in assuming a Wiener process to describe the behavior of reserves and they also caution against the measurement of reserve volatility used in F. J. Flood and Marion suggest measuring reserves volatility by relying on the shadow exchange rate, defined as the exchange rate that would be determined in the foreign exchange market if foreign exchange reserves were exhausted and the exchange rate were allowed to float freely. In addition, F-M re-estimate the buffer stock model with the new measure of volatility. They conclude that, although their estimation results are a good fit for the actual level of reserves held by the countries they analyze, a significant part of cross-country variation in reserves holdings is due to the introduction of country-fixed effects. In turn, F-M suggests some extensions to the standard buffer stock model.

Aizenman and Marion (2003a) seek to move away from the reserves restocking adjustment cost to identify variables that help explain reserve accumulation as a way to minimize costly domestic adjustments. Aizenman and Marion (2003b) introduce a measure of corruption in their cross-country analysis of reserves holdings, and found that it acted as a tax on the return of reserves, reducing the optimal level of reserves.

This empirical literature has seen a number of extensions in recent years. Edison (2003) and Aguirre, et al. (2004) advance this empirical literature on two fronts, by: (i) introducing a number of variables that could better match the key categories of explanatory variables proposed by Aizenman and Marion; and (ii) studying alternative subset of countries for different periods of time. For example, in Aguirre, et al., the proxy for vulnerability in the balance of payments is not short-term debt but a ratio of FDI to GDP. Also, instead of computing proxies for the net cost of carrying reserves, Aguirre, et al. consider only the interest earned on reserves. They also find that the ratio of FDI to GDP helps explain reserves, but that the terms of trade do not appear significant as an indicator of balance of payment vulnerability. They also confirm that countries with floating exchange rate regimes have lower levels of reserves than countries with pegged exchange rate regimes.

15. ***The regression analysis results suggest a lower level of reserve holdings for Chile than its present level.*** The estimation accounts for only 70-78 percent of the variation of actual reserves holdings in our sample and, thus, our estimation results should be interpreted with caution. They suggest that the predicted reserves for Chile are below actual reserve

[6] For robustness purposes, year dummies were introduced in the empirical analysis to account for the joint process of globalization and capital/current account liberalization in the emerging market economies during the period surveyed. However, estimation results are then very similar to the ones reported here, and the significance of the explanatory variables does not change.

holdings. A possible explanation may be that this empirical literature fails to include other equally important considerations in the estimation, such as precautionary motives for reserve holdings.[7] Chile belongs to a region that has repeatedly experienced financial and economic crises. Although Chile has shown that it is significantly less prone to contagion, its geographical location may justify a higher level of reserve holdings than otherwise.

16. ***Precautionary motives, or the need to smooth out consumption, could account for higher reserves holdings in Chile and in emerging market economies in general.*** Aizenman and Marion (2003) suggest a theoretical reconsideration of factors that emphasize the precautionary motives of holding reserves. They propose models that highlight the need for a government to smooth out consumption in the face of shocks when the government suffers from loss aversion (defined as the propensity to assign higher value to output losses than to output gains). One important contribution of their theoretical analysis is the search for underlying frictions (such as political motives, or aversion to IMF programs) which would lead countries to accumulate large foreign reserves. Some of these frictions would cause countries to over-emphasize precautionary motives in their reserves holdings.

D. Alternative Mechanisms to Reserves Accumulation

17. ***While reserve accumulation remains a country's main buffer against external shocks, there also exist other mechanisms***. In the previous section, two separate approaches—reserve adequacy ratios and the inventory model approach—have indicated that reserves in Chile are broadly adequate. However, relying exclusively on international reserves accumulation may not always provide the optimal level of liquidity. Specifically, given that reserves help guard against unforeseen needs of foreign exchange liquidity that otherwise would require a significant economic adjustment, they can be seen as self-insurance against shocks. A combination of reserves and alternative financial instruments, including private contingent credit lines and swap arrangements, could help reduce the costs of this insurance.

18. ***Private contingent credit lines (PCCLs) are a possible complement reserve accumulation.***[8] Contingent credit lines, which are voluntary market mechanisms supplied by a pool of private banks, provide access to liquidity in times of stress. Such facilities are complementary to a country's official reserves, and may reduce their carrying costs. Given that they are negotiated and priced in periods of relative tranquility, PCCLs provide an insurance against liquidity shocks that can disrupt ordinary market financing. Mexico and Argentina are two countries that have made use of PCCLs (Box 2).[9]

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[7] For other important explanations for these models under prediction of the level of reserves for some economies, see Edison (2003).

[8] The IMF established a similar facility, the Contingent Credit Line (CCL) in 1999, which was abandoned in 2003.

[9] Indonesia also established a series of US$500 million credit lines with large group of banks during 1994–97. The lines were drawn in late 1997 and early 1998, and subsequently restructured into medium- and long-term obligations.

Box 2. County Experience with PCCLs

In November 1997, Mexico negotiated a PCCL of around US$2.5 billion in the form of a syndicated loan from 33 international banks, making use of the funds in October 1998 as external conditions became adverse. The facility was designed as a 12-month credit. The terms of the loan were applicable according to a rating-linked pricing grid, and resulted in a spread of 50 basis points over Libor for a six-month drawdown, 75 basis points for a 12-month withdrawal, and 100 basis points for an 18-month drawdown. The loan was zero risk-rated until the credit was drawn. According the private sector comments, the size of the commitment took much of the country limits at a time where many banks were eager to lend to the private sector. In October 1998, under the pressure of soaring borrowing costs in the bond markets and a sharp decline in oil revenues, Mexico opted to withdraw funds from the contingency line. The outstanding credit was later swapped for tradable securities in March 1999.

At end-2001, Argentina negotiated a contingent repurchase (Repo) facility with a group of fourteen international banks intended to provide liquidity insurance to the financial system. The objective was to reduce the risks arising from a liquidity shock due to events in international capital markets. The PCCL gave the right to the central bank to sell specified Argentine international bonds (mostly Par and Discount bonds, and some Global 2008) subject to a repurchase clause. The size of the facility was originally US$6.4 billion, but it was subsequently reduced to US$4.7 billion. In November 1998, the World Bank and the Inter-American Development Bank approved an enhancement of US$1 billion, to meet margin needs arising from the decline in the prices of bonds used as collateral. The facility was activated for an amount of US$1.8 billion in September 2001 in response to a sharp decline in deposits associated with the deepening economic crisis. The amount outstanding was reduced to US$1.4 billion in December 2001, due to the fall in market prices of the bonds. The facility has been repaid in full.

19. ***The limited ability of banks to hedge their country exposures may be an important obstacle to a broader use of PCCLs.*** The market for PCCLs is currently not very deep. Banks may be reluctant to provide contingent financing because it would increase their exposure to a country after economic conditions have deteriorated and access to spontaneous new financing has been lost. Banks may hedge exposure by taking short positions in internationally-traded securities, which would tend to affect secondary market yields or by undertaking transactions that offset the balance of payment effect of the PCCL. In the end, banks may be reluctant to provide new net financing during periods of stress.

20. ***Countries can also arrange bilateral swap arrangements to provide liquidity in times of need, but the effectiveness of these mechanisms has not yet been tested.*** Under swap arrangements, member central banks are allowed to swap their currencies for major currencies during a short period of time and for an amount predefined at time of the contract. All facilities are activated by mutual agreement, enabling the creditor to set further conditions for disbursement. A country with liquidity needs can borrow foreign currency from another country and use the funds to buy its own currency. The general facility usually carries an interest of LIBOR plus a pre-determined spread. The swift availability of liquidity is designed to help limit currency speculation and counter investors' herding behavior. However, it is too soon to draw conclusions about their effectiveness as swaps are relatively new and it is unclear how swap arrangements would operate in the presence of common regional external shocks.

E. Concluding Remarks

21. ***General equilibrium models of reserve holdings are in their early stages of development, which explains the difficulties in analyzing the optimal level of reserves.*** As an alternative to study the optimal level of a country's foreign reserves, economists have relied on empirical applications of the buffer stock model. However, these applications have not yet been able to identify all the key benefits countries ascribe to the holding of foreign reserves. The main findings of this chapter are as follows:

- Under a series of rules of thumb used in the literature, reserves in Chile seem at or above the levels that these common benchmarks suggest would be adequate.

- The estimation results of a buffer stock model under predict Chile's actual holdings of reserves.

- The reserves level contributes to explain Chile's low probability of a crisis, as estimated under the EWS models. The probability of a crisis in Chile compares favorably with emerging market OECD countries.

- While reserve accumulation remains the main buffer against external shocks, other mechanisms could provide additional liquidity. In this regard, contingent credit lines and bilateral swap arrangements can provide additional insurance. However, there are still important barriers to widespread use of these alternative forms of insurance.

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Table 1. List of Countries Included in the Regression Models

Latin America	**Emerging Asia**	**Emerging Europe**	**Africa**
Argentina	China	Hungary	South Africa
Brazil	India	Poland	
Chile	Indonesia	Russia	
Colombia	Korea	Turkey	
Mexico	Thailand	Czech Republic	
Peru	Philippines		
Venezuela	Malaysia		

Table 2: Variables Used in the Regressions

Variable	Description	Source
Dependent Variable:		
lrrmg	Log of real reserves (scaled in millions US$)	IFS
Explanatory Variables:		
Size:		
lpop	Log of population.	WEO
lgpc	Log of real per capita income.	WEO
Current Account Vulnerability:		
limy	Log of import to GDP in percent.	WEO
lseex:	Log of export volatility (defined as the standard deviation of real export receipts).	WEO
Capital Account Vulnerability:		
fdi	Foreign Direct Investment in US$.	WEO
lrfdi	Log of real fdi.	
lfdigdp	Log of the ratio of fdi to ngdp.	
lkaopen	Log of capital openness, ratio of sum of capital flows to gdp.	
lrdebt	Log of real BIS short-term debt.	BIS Debt Series
lrmgdebt	Log of the ratio of reserves to BIS short-term debt.	
Exchange Rate Volatility:		
volxcsq	Exchange rate volatility squared (defined as the standard deviation of monthly changes in the exchange rate against the U.S. dollar).	WEO
vol_xc	Exchange rate volatility calculated using the standard deviations.	WEO
Opportunity Cost:		
ratedif	Nominal interest rate differential with the US interest rate.	IFS
lrltdiff	Real interest rate differential with the US real interest rate.	IFS
Other:		
cri	Composite of international country risk index including political, financial, and economic risk	PRS Group

Table 3. Optimal Level of Reserves: Multivariate Analysis with Country Fixed Effects, 1980–2002

Dependent variable: Real reserves (in logs)

	lrrmg (1)	lrrmg (2)	lrrmg (3)	lrrmg (5)	lrrmg (6)	lrrmg (7)	lrrmg (9)	lrrmg (10)	lrrmg (11)	lrrmg (13)
lgpc	0.855**	0,894**	0.986**	0.658**	0.982**	1.034**	0.660**	1.051**	1.239**	0.794**
	(3.84)	(4.91)	(4.98)	(2.85)	(5.46)	(5.27)	(2.85)	(5.79)	(6.26)	(3.33)
lpop	1.549**	1.886**	1.284**	2.395**	2.017**	1.341**	2.475**	2.285**	1.829**	3.164**
	(3.54)	(4.95)	(3.13)	(6.38)	(5.30)	(3.27)	(6.66)	(6.09)	(4.46)	(8.86)
limy	0.517**	0.485**	0.706**	0.682**	0.493**	0.729**	0.681**			
	(3.55)	(3.80)	(4.71)	(5.05)	(3.83)	(4.87)	(5.04)			
lseex	0.073	0.164*	0.111	0.101				0.171*	0.144	0.100
	(0.98)	(2.41)	(1.54)	(1.37)				(2.45)	(1.94)	(1.31)
vol_xc	-0.007**	-0.010*	-0.007	-0.012*	-0.012*	-0.008	-0.013**	-0.009	-0.008	-0.011*
	(1.04)	(2.15)	(1.06)	(2.46)	(2.55)	(1.18)	(2.68)	(1.91)	(1.11)	(2.15)
lrfdi	0.074*	0.085**			0.082**			0.106**		
	(2.31)	(2.80)			(2.67)			(3.46)		
lkaopen	0.080		0.157**			0.155**			0.231**	
	(1.71)		(3.37)			(3.32)			(5.08)	
lrdebt	0.100			0.098			0.121			0.142*
	(1.59)			(1.54)			(1.97)			(2.16)
cri	0.020**	0.020**	0,022**	0.024**	0.020**	0.022**	0.024**	0.020**	0.021**	0.026**
	(5.95)	(6.22)	(6.44)	(7.05)	(6.13)	(6.44)	(7.13)	(6.22)	(5.96)	(7.48)
ratediff	0	0	0	0	0	0	0	0	0	0
	(1.20)	(1.02)	(1.39)	(0.77)	(0.99)	(1.39)	(0.73)	(1.22)	(1.64)	(1.05)
flexible	0	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
Constant	-34.182**	-38.678**	-29.044**	-48.301**	-41.95**	-30.682**	-50.324**	-45.514**	-38,071**	-61,745**
	(4.61)	(6.00)	(4.33)	(7.81)	(6.60)	(4.62)	(8.36)	(7.18)	(5.70)	(10.63)
Observations (with 19 countries)	271	300	289	322	300	289	322	300	289	322
R-squared	0.75	0.75	0.73	0.71	0.74	0.72	0.71	0.73	0.70	0.68

Absolute value of t-statistics in parentheses

Note: ** and * indicate significance levels at the 5 and 10 percent, respectively.

II. HEDGING FOREIGN EXCHANGE RISK IN CHILE[1]

1. A market for foreign exchange hedging instruments can help domestic corporations better manage currency mismatches between assets and liabilities and enhance risk allocation. More efficient risk transfer, better investment decisions, and lower exchange rate volatility justify adopting policy measures that foster growth of the currency derivatives market. Derivatives markets also help to reduce agency problems that affect investment decisions by firms, and empirical studies suggest that the volatility of the underlying assets declines substantially following the introduction of options (Conrad, 1989; Detemple and Jorion, 1990).[2] This paper describes the instruments available for hedging foreign exchange risk, the demand and supply of foreign exchange hedging in the onshore market, and assesses foreign exchange exposure in different industrial sectors using factor analysis.

A. The Foreign Exchange Derivatives Market Instruments

Forward Contracts

2. ***Forward contracts are available onshore and offshore.*** In the onshore market, contracts can be written for Chilean pesos and *Unidades de Fomento* against the U.S. dollar, though the former are generally preferred. Nine out of ten contracts are non-deliverable (Moguillansky, 2002). In the offshore market, forward contracts are non-deliverable and written only for Chilean pesos. Some market analysts indicate that domestic corporations find more advantageous to hedge their exposure in the onshore market while the offshore market is used mainly by leveraged foreign investors. The daily volume is estimated to be in the range of US$100 million dollars and the average face value of a forward contract is US$5 million, according to private sector sources.[3]

3. ***The maturity breakdown of forward contracts in the onshore market is similar to that observed in Australia and New Zealand.*** In Chile, 21 percent of contracts are conducted for maturities of one week and less, 78 percent for maturities between seven days and one year, and 1 percent for maturities of one year and above. The corresponding figures for Australia are 61 percent, 31 percent, and 8 percent, and for New Zealand, 41 percent, 58 percent, and 1 percent (Table 1). Because a majority of contracts have very short maturities, hedging in the forward market may not contribute much to reduce cash flow volatility. This situation, however, is similar to that in Australia and New Zealand (Figure 1).

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[1] Prepared by Jorge A. Chan-Lau (Ext. 3-4271).

[2] During periods of extreme volatility, derivatives markets could amplify market instability, as explained in Dodd (2001).

[3] Anidjar (2002), *Estrategia* (Feb. 16, 2004), and Romo, Castro, and Abdel-Mootal (2002). Central bank figures indicate a higher daily turnover of $625 million in 2001 (Bank for International Settlements, 2001).

Table 1. Maturity Breakdown on Onshore Forward Contracts

Forward contract maturities

	1 week or less	Over 1 week and less than 1 year	Over 1 year
Chile	21	78	1
Australia	61	31	8
New Zealand	41	58	1

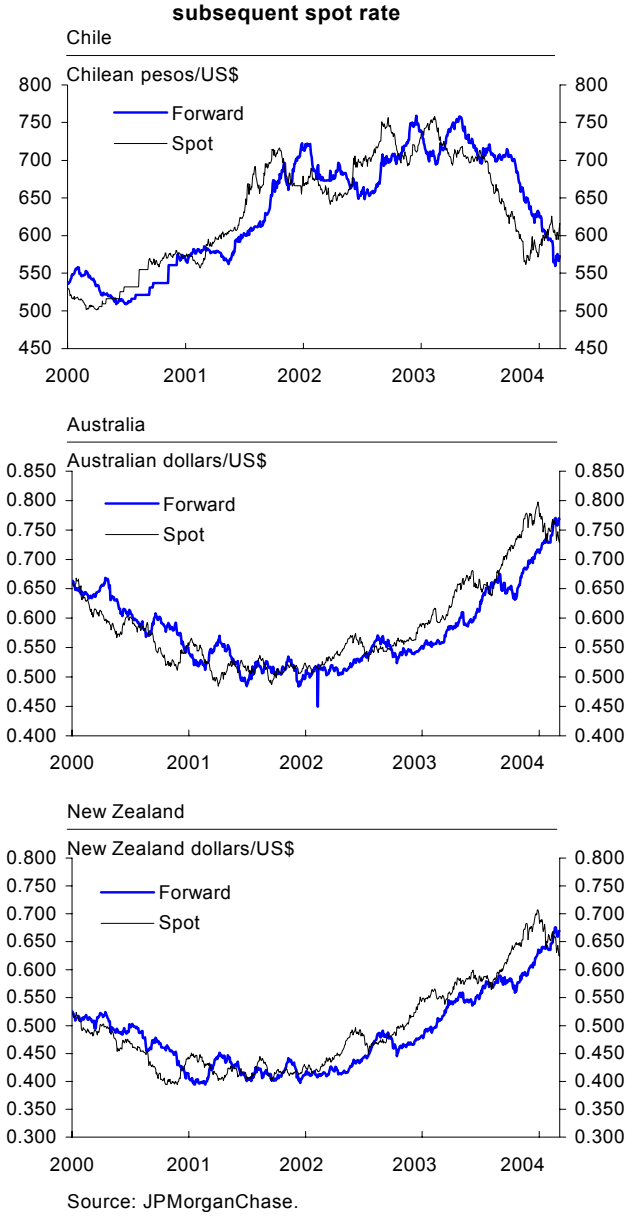
Source: BIS (2002).

4. ***The onshore forward market is quite liquid for contracts with maturities of three months or less.*** Market participants indicate that the forward market for contracts with maturities of one year or less is a two-way market: the demand for foreign currency hedging by corporations with short dollar positions is mostly met by the supply of hedging from institutions with long dollar positions such as exporters and pension funds.

5. ***The cost of using forwards, as measured by the bid-ask spread as a percent of the forward rate, is low compared to emerging market countries.*** In Chile, the bid-ask spread is eight basis points for one-month contracts. Compared to emerging market countries, the bid-ask spread in Chile is half of that observed in Brazil (15 basis points), similar to the spread in South Korea (eight basis points), but still higher than in small industrialized countries like New Zealand (four basis points) and Australia (two basis points) (Mendelson and Glaessner, 2004, and Alarcon, Selaive, and Villena, 2004).

6. ***The opportunity cost of hedging with forward contracts is comparable to costs in Australia and New Zealand.*** The opportunity costs of hedging with forward contracts can be measured as the

Figure 1. 3-month forward rates and subsequent spot rate



Source: JPMorganChase.

foreign exchange gains foregone by locking in the exchange rate in advance rather than holding an unhedged position. The higher the opportunity cost, the lower the incentives to hedge foreign exchange risk. Opportunity costs in Chile, measured as the difference in percent between the realized spot rate at the time the contract matures and the forward rate at the inception of the contract, are slightly lower than in Australia and New Zealand (Table 2). For the period April 2001 to April 2004, the average opportunity cost in Chile was similar to that in Australia and lower than in New Zealand. With respect to the maximum gain foregone by entering a forward contract, Chile also fared better than the other two countries during the time period reviewed.

Table 2. Opportunity Cost of Hedging with 3-Month Forward Contracts
(Measured as percent of forward rate at inception)

	Chilean Peso (CLP)	Australian Dollar (AUD)	New Zealand Dollar (NZD)
Average	4.68	4.76	5.69
Maximum	13.20	16.11	15.99
Minimum	0.00	0.00	0.01
Volatility	2.90	3.78	4.11

Source: JPMorgan Chase and staff calculations

7. ***Forward contracts in Chile, though, have additional costs that can work against their widespread use by corporate end-users.*** Corporate end-users that enter a forward contract with a bank may be required to post collateral with the bank because of counterparty risk. On average, the collateral requirement is equal to 5 percent of the nominal value of the contract for maturities less than 30 days, 7 percent to 10 percent for maturities of 30-180 days, and 15 percent for maturities of 180-360 days (Diario Estrategia, 2004). Even if corporations meet the credit ratings requirements of the bank underwriting the forward contract, the approval of a credit line is required. The credit line is costly since it ties up the bank's economic capital. The cost of the credit line is passed on to the end-user as less favorable forward rates.

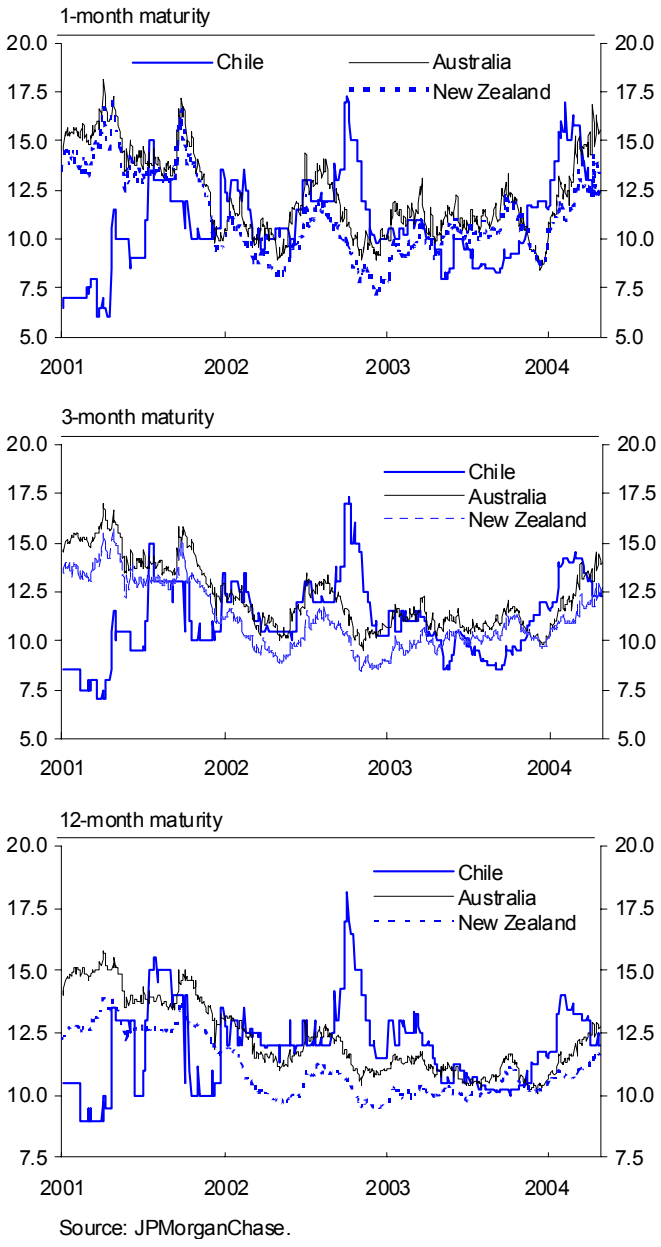
8. ***These additional costs, which are tied up to the credit rating of the corporate end-user, may contribute to the observed relatively low hedge ratios in the corporate sector***. The collateral requirement and the use of credit lines may explain why only 40 percent of foreign exchange liabilities were hedged using forwards (Mendelson and Glaessner, 2004), a figure well below those observed in other small industrialized countries. For example, results from a special survey in 1999 showed that in New Zealand financial contracts were used to hedge 64 percent of foreign currency denominated liabilities.

Currency Options

9. ***Plain vanilla currency options on U.S. dollar–Chilean peso are available offshore at prices similar to those quoted for U.S. dollar–Australian dollar and U.S. dollar–New Zealand dollar options.*** A simple way to measure the costs of using currency options for

hedging is to use the implied volatility of at-the-money forward contracts.[4] Table 3 indicates similar average implied volatility for currency options written on the Chilean peso, the Australian dollar, and the New Zealand dollar vis-à-vis the U.S. dollar during the period September 2000–April 2004 (Figure 2). While there are no figures about volumes traded in the offshore market, liquidity is lower for Chilean peso options than for Australia and New Zealand dollar options, as shown by less frequent changes in implied volatilities for the former currency option (Figure 2). Indeed, options on the Australian dollar were the seventh most traded currency option contracts in the world, with a daily average traded volume of US$40 billion in outstanding notional amount in 2001 (BIS, 2002).

Figure 2. Implied volatilities of offshore, over-the-counter currency options



Source: JPMorganChase.

10. ***The premium volatility of offshore U.S. dollar-Chilean peso options is higher that the volatility of U.S. dollar-Australian dollar and U.S. dollar- New Zealand options.*** Figure 3 shows the option premium quotes for U.S. dollar call options vis-à-vis the Chilean Peso as well as vis-à-vis the Australian and New Zealand dollars for the period May 2003–April 2004. The premium is lower for the Australian dollar, especially for the six-month maturity contract, arguably reflecting higher liquidity in this market. The cost of hedging U.S. dollars using offshore currency options is similar for Chile and New Zealand. Table 3 summarizes the descriptive statistics of the U.S. call contracts for each currency. While there are no substantial price

[4] Pricing convention in the over-the-counter market specifies the price of an option in terms of volatility, which must be replaced in the Garman-Kolhagen (1983) formula to obtain the option premium. At-the-money forward option contracts specify the forward rate at the maturity date as the strike price.

differences across currencies, the premium volatility for options on the U.S. dollar vis-à-vis the Chilean peso is twice as high as the premium volatility for these options vis-à-vis the Australian and New Zealand dollar.

Table 3. Over-the-Counter Currency Options: Implied Volatilities in Offshore Market

	1-month contract			3-month contract			12-month contract		
	CLP	AUD	NZD	CLP	AUD	NZD	CLP	AUD	NZD
Average	10.67	11.45	12.65	10.67	11.45	12.65	12.00	11.21	12.44
Maximum	17.33	17.34	19.11	17.33	17.34	19.11	18.17	13.91	15.83
Minimum	6.00	7.09	8.45	6.00	7.09	8.45	9.00	9.43	10.10
Standard Deviation	2.23	2.22	2.41	2.23	2.22	2.41	1.60	1.19	1.48

Source: JP Morgan Chase and staff calculations.

11. ***The growth of the over-the-counter market in currency options onshore has been constrained by regulation.*** Regulations prevent banks from offering option contracts. In order to circumvent this constraint, option contracts are offered through affiliates or "*sociedades de inversión.*" Corporate demand for these contracts remains low for two reasons, according to some market analysts. First, in contrast to a forward contract, the option premium has to be paid upfront. Corporate users viewed this payment as a cost rather than the price of insuring against adverse exchange rate movements. Second, there is the perception that currency options may be not offer all legal protection because banks cannot offer them directly to their clients. As a result, the option market is very thin, with a daily average volume of $2.5 million. The customer base in this market is comprised by large corporations.

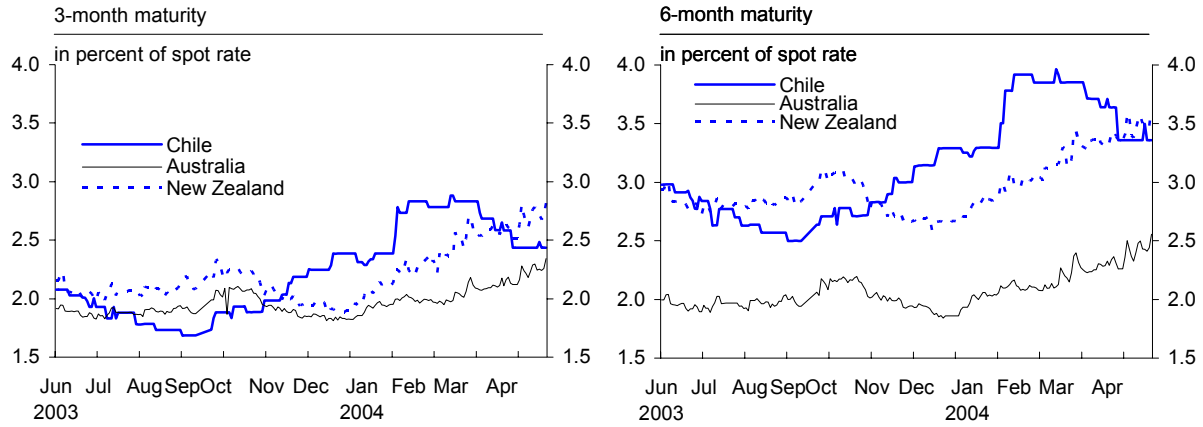
Table 4. Offshore Option Premium, in Percent of Spot Rate

	3 month maturity			6 month maturity		
	Chilean Peso	Australian Dollar	New Zealand Dollar	Chilean Peso	Australian Dollar	New Zealand Dollar
Average	2.20	1.98	2.22	3.11	2.08	2.98
Maximum	2.88	2.42	2.89	3.97	2.68	3.67
Minimum	1.68	1.81	1.88	2.50	1.84	2.59
Volatility	0.38	0.13	0.24	0.45	0.17	0.25

Source: JPMorgan Chase and staff calculations.

12. ***Currency options in the onshore market are expensive compared with offshore currency options.*** Option premia in the onshore over-the-counter market, which are quoted as a percentage of the spot rate, currently stand at 3 percent for the three-month contract, and 4 percent for the six-month contract (*Diario Estrategia,* Feb. 16, 2004). Compared to offshore options, domestic currency options are expensive since the average premium during the period April 2003–2004 was 2.2 percent for the three-month contract and 3.1 percent for the six-month contract (Table 4 and Figure 3).

Figure 3. Offshore Option Premium: Chile, Australia, and New Zealand (vs. U.S. dollar) calls



Sources: JPMorganChase and staff calculations.

B. Demand and Supply

13. ***Foreign exchange derivatives in Chile are traded mainly in the over-the-counter market, and banks play a major role as market makers***.[5] Domestic banks and financial institutions can write a variety of derivatives instruments, and are responsible for matching corporate end-users and institutional investors' needs to cover exchange rate risk.[6] Commercial banks are allowed to take positions on foreign futures contracts on foreign currency and interest rates, and on exchange-traded options on foreign currency and interest rate futures. Thus, commercial banks that act as market makers in the local market can hedge their net positions offshore if needed.

14. ***The demand for foreign exchange hedging arises mainly from large corporations.*** As in other countries, large corporations have the resources and skills to implement foreign exchange hedging programs and participate actively in the foreign exchange derivatives market. Small- and medium-sized enterprises seldom hedge their foreign exchange exposures, in part because of a lack of knowledge about the benefits of hedging using financial instruments. Currently, local banks are organizing seminars to educate end-users in the small and medium enterprise sector about the benefits of foreign exchange hedging.

15. ***Financial institutions hedge a higher share of their currency exposure than non-financial institutions.*** While banks hedge 90 to 100 percent of their exposure, corporations

[5] The regulation of foreign exchange derivatives in Chile follows the guidelines contained in the Law of Banks and Financial Institutions, and in the Law of Capital Markets. In addition, these contracts must satisfy the Central Bank regulations related to exchange rate markets and financial institutions.

[6] These instruments include futures, forwards, swaps, and combinations of these instruments on the domestic currency, inflation-linked indexes, interest rates, and foreign currency and interest rates. See Fernandez (2001) for a comprehensive analysis and description.

only hedge 40 percent (IMF and World Bank, 2004). This is not surprising since the exposure of financial institutions is associated mostly to transactions on nominal contracts and a limited number of risk factors, which are easy to measure. Also, staff in financial institutions is more familiar with risk management techniques. In contrast, the exposure of non-financial corporations is difficult to assess since it is not only related to financial assets and liabilities but also to operating decisions.

16. ***Pension funds are the main providers of foreign exchange hedging to corporate end-users.*** As of end-December 2003, pension funds held 24 percent of their assets, or US$11.9 billion, in foreign assets, most of them denominated in U.S. dollars (Table 5). Minimum coverage requirements for the foreign assets held by pension funds make these funds the natural providers of foreign currency hedging to corporate end-users (they have an incentive to take the foreign currency paying leg of a derivatives transaction). Furthermore, pension managers hedge more than what is required by regulations because of optimal portfolio management considerations. Given that pension funds need to hedge a large proportion of their large foreign asset holdings (equivalent to 14 percent of GDP), the hedging needs of corporate and end-users can be met with relative ease. Indeed, by end-December 2003, institutional investors had an outstanding dollar-paying position of US$7.7 billion compared to the outstanding dollar-buying position of US$2.9 billion of corporations (Alarcón, Selaive, and Villena, 2004).

Table 5. Pension Fund Foreign Assets and Their Potential Supply of Foreign Exchange Hedging

Type of Fund 1/	Foreign assets, in millions USD	Minimum foreign exchange coverage, in percent	Minimum supply of foreign exchange hedging, in millions USD
Total	11,867		9,801
A	1,318	63	831
B	2,739	78	2,136
C	172	82	141
D	6,437	87	5,600
E	1,202	91	1,094

Sources: Asociacion AFP and staff calculations.

1/ The maximum and minimum equity investment limits as percent of assets under management for Type A funds are 80 and 40 percent, for Type B funds, 60 and 25 percent, for type C funds, 40 and 15 percent, and for type D funds, 20 and 5 percent. Type E funds are not allowed to invest in equities.

17. ***Exporters are also important providers of foreign exchange hedging to corporate end-users.*** Central bank data show that foreign-currency paying positions of corporate end-users, mainly exporters, amounted to US$4.8 billion or close to 28 percent of the total amount of foreign-currency paying positions in the domestic derivatives market, in 2003 (Alarcón, Selaive, and Villena, 2004). However, some big exporters such as Codelco, prefer to conduct transactions in the spot market rather than the forward market because earnings volatility is not considered a major concern for their financial operations.

18. ***The supply of foreign exchange hedging, however, is concentrated on derivatives contracts with short maturities.*** As in other countries, like Australia and New Zealand, short-term maturity forward contracts constitute the largest share of the market. Pension funds and exporters take foreign currency paying positions in derivatives contracts with maturities of three months or less, according to some market analysts. Furthermore, these analysts also note that pension fund managers do not cover their long foreign currency positions fully since carrying unhedged dollar positions during periods of dollar appreciation is profitable.

19. ***Banks, therefore, are the main suppliers of foreign exchange hedging for maturities of one year and above.*** Banks hedge the foreign exchange exposure arising from these long-term forward contracts with dollar and dollar-linked bonds issued by the Central Bank. Some market analysts estimate that the outstanding amount of forward contracts with maturities above one year exceeds banks' holdings of dollar and dollar linked instruments by 50 percent, implying that banks carry an unhedged position in Chilean pesos. Banks' exposure, though, is rather small given that these contracts only account for 1 percent of the forward market.[7]

C. Foreign exchange exposure in Chile

20. ***Systemic risk from currency mismatches in corporate balance-sheets appears relatively low compared with other countries.*** Caballero, Kowan, and Kearns (2004) report that the mean and median share of foreign currency liabilities in Chile are approximately 28 percent and 5 percent of total corporate liabilities, respectively, compared with over 50 percent and 60 percent in Argentina, Peru, and Uruguay. These authors also note that foreign exchange liabilities appear concentrated mainly in the tradable sector, a sector that may be able to withstand adverse exchange rate movements better than other industrial sectors. Central Bank figures also indicate that 84 percent of the total external debt of the non-financial private sector—amounting to US$24.9 billion, or 34 percent of GDP at end-2003—is tilted towards medium and long-term maturities which reduces corporate sector vulnerabilities to adverse exchange rate movements. Findings by Dominguez and Tesar (2001) using factor analysis suggest that foreign exchange exposure is important for about 13 percent of publicly listed firms. At the industry level, the exposure affects 17 percent of all industries. Foreign exchange exposure in the Chilean corporate sector is significantly lower than in other countries (Table 6).

[7] Back of the envelope calculations using figures reported by Alarcón, Selaive, and Villena (2004) and the opportunity costs detailed below suggest that the banks' exposure arising from unhedged long-maturity forward contracts amounts only to US$50–60 million, or barely 0.1 percent of total assets in the financial system.

Table 6. Firm and Industry Level Exposure, Chile and Other Countries

	Firm level exposure, in percent	Industry level exposure, in percent
Chile	13.6	17.4
France	18.9	17.1
Germany	20.6	64.7
Italy	26.3	32.3
Japan	31.1	59.5
Netherlands	26.3	40.0
Thailand	21.3	25.0
United Kingdom	18.8	46.2

Source: Dominguez and Tesar (2001).

21. ***Although factor analysis suggests that the financial sector has been the sector most exposed to foreign exchange risk, it appears well positioned to withstand adverse exchange rate movements.***[8] Table 7 shows the sensitivity of equity returns in different industrial sectors to exchange rate changes after controlling for movements in the overall stock market (see Box 1 for a detailed description of the methodology and caveats). Because equity returns are proxies for expected future earnings, a higher coefficient associated to the exchange rate changes indicates higher exposure. Clearly, the financial sector has been the most exposed, both before and after the abandonment of the floating band in September 1999. In particular, the exposure of the financial sector has increased by almost 30 percent since 2000.[9] Interestingly, the exposure has increased although data compiled by the Financial Sector Assessment Program (FSAP) suggests that banks in Chile hedge between 90 to 100 percent of their net position (Mendelson and Glaessner, 2004). Banks, however, appear resilient to market risk arising from adverse exchange rate movements.

[8] See Box 1 for a detailed explanation of the empirical method and the data used in the analysis. A more complete assessment of foreign exchange risk across sectors could be achieved using balance-sheet data, as proposed by the Australian Bureau of Statistics. Ongoing work by the Central Bank using this approach would complement the analysis presented here.

[9] It should be noted, though, that there could be an omitted variable problem: domestic interest rates. Banks are sensible to fluctuations in the interest rates and the exchange rate responds to interest rate differential. A reduction of domestic interest rates could improve financial returns, due to duration mismatches, while depreciating the peso exchange rate.

Table 7. Foreign Exchange Risk Exposure

	Consumer Discretionary	Consumer Staples	Financials	Health Care
Sample period: January 1995–December 1999				
Constant	-2.367	0.495	0.907	0.194
	-1.291	*0.608*	*0.717*	*0.152*
Exchange rate changes, monthly	**0.289**	**0.105**	**0.286**	0.054
	2.345	*1.804*	*3.229*	*0.570*
Total stock market returns, monthly	**0.596**	**0.672**	**0.657**	**0.808**
	15.392	*36.709*	*23.502*	*27.107*
Adjusted R-squared	0.959	0.973	0.959	0.965
F-statistic	9820	15331	9884	11653
Sample period: January 1995–December 1999				
Constant	1.355	-0.144	0.858	2.111
	0.919	*-0.128*	*0.715*	*1.577*
Exchange rate changes, monthly	**-0.195**	**0.174**	**0.387**	2.020
	-1.611	*2.186*	*4.169*	*-0.586*
Total stock market returns, monthly	**0.998**	**0.879**	**0.537**	**0.853**
	25.044	*33.549*	*17.429*	*21.961*
Adjusted R-squared	0.974	0.985	0.966	0.966
F-statistic	14234	24400	10541	10549
Sample period: January 1995–April 2004				
Constant	-0.490	0.276	0.849	1.090
	-0.387	*0.368*	*0.989*	*1.163*
Exchange rate changes, monthly	0.008	**0.124**	**0.349**	-0.016
	0.091	*2.508*	*5.447*	*-0.212*
Total stock market returns, monthly	**0.802**	**0.775**	**0.595**	**0.832**
	28.525	*48.577*	*28.638*	*34.213*
Adjusted R-squared	0.969	0.982	0.963	0.966
F-statistic	24856	43409	20756	22939

Source: Morgan Stanley Capital Indices and staff calculations. Bold fonts indicate coefficient is statistically significant at the 10 percent level at least; t-statistics in italics.

Table 7. Foreign Exchange Risk Exposure (cont.)

	Industrials	Materials	Telecommunications	Utilities
Sample period: January 1995–December 1999				
Constant	-0.601	-1.171	1.528	-0.061
	-0.494	*-1.490*	*1.287*	*-0.140*
Exchange rate changes, monthly	**0.133**	-0.037	**-0.210**	0.006
	1.701	*-0.733*	*-2.808*	*0.177*
Total stock market returns, monthly	**0.210**	**0.814**	**1.145**	**1.175**
	8.538	*51.484*	*48.899*	*117.898*
Adjusted R-squared	0.953	0.987	0.981	0.995
F-statistic	8637	32047	21568	89824
Sample period: January 1995–December 1999				
Constant	2.634	0.724	-0.710	-0.057
	0.801	*0.496*	*-0.413*	*-0.059*
Exchange rate changes, monthly	0.018	0.066	-0.136	-0.149
	0.078	*1.044*	*-1.427*	*-2.836*
Total stock market returns, monthly	0.090	**0.763**	**1.356**	**1.124**
	1.144	*36.389*	*43.098*	*64.955*
Adjusted R-squared	0.933	0.988	0.982	0.990
F-statistic	5201	30580	20087	37319
Sample period: January 1995–April 2004				
Constant	0.868	-0.321	0.564	-0.107
	0.510	*-0.398*	*0.555*	*-0.204*
Exchange rate changes, monthly	0.083	0.023	**-0.190**	**-0.072**
	0.661	*0.564*	*-3.127*	*-2.348*
Total stock market returns, monthly	**0.151**	**0.787**	**1.251**	**1.151**
	3.763	*60.491*	*63.990*	*116.809*
Adjusted R-squared	0.937	0.988	0.981	0.99241
F-statistic	11856	65183	41472	104517

Source: Morgan Stanley Capital Indices and staff calculations. Bold fonts indicate coefficient is statistically significant at the 10 percent level at least; t-statistics in italics.

Box 1. Assessing Foreign Exchange Exposure using Factor Analysis

The foreign exchange exposure of a particular firm or industrial sector can be assessed approximately using factor analysis (Jorion, 1990). The method consists of regressing the stock market return of the particular industry or firm analyzed on exchange rate changes while controlling for overall stock market movements. The econometric model specification used in the analysis is:

$$R_{i,t} = a_0 + a_1 R_{s,t} + a_2 R_{m,t} + \varepsilon_{i,t}, \quad (1)$$

where $R_{i,t}$ is the stock market return of firm or industry i in period t, $R_{s,t}$ the rate of change of the Chilean peso exchange rate vis-à-vis the U.S. dollar, $R_{m,t}$ is the rate of the return of the Chilean stock market, and $\varepsilon_{i,t}$ is an independent and identically distributed error. The coefficient associated to changes of the exchange rate, a_1, measures the foreign exchange exposure of firm or industry i, or equivalently, the elasticity of its stock returns to changes in exchange rates.

Two caveats about factor analysis should be born in mind. First, as noted by Adler and Dumas (1984), factor analysis is equivalent to a statistical decomposition of stock market returns and does not necessarily imply a causal relationship between returns and exchange rate changes. Second, the empirical method cannot explain how changes on firms' operating procedures affect their exchange rate exposure. If the coefficient a_1 is not different from zero, it does not necessarily imply negligible foreign exchange exposure. For instance, the firm may be hedging actively its foreign exchange exposure using derivatives or other operational techniques. Therefore, the firm offsets any impact exchange rate movements have on its stock market return.

The analysis includes the following sectors: consumer discretionary goods, consumer staples, financials, health care, industrials, materials, telecommunications, and utilities. Morgan Stanley Capital Indices (MSCI) for each sector and the overall market are used to calculate monthly stock market returns. The sample period analyzed is January 1995 to April 2004. Equation (1) was estimated for the full sample period as well as for two subperiods, January 1995 to December 1999, and January 2000–April 2004 using Ordinary Least Squares and correcting for serial correlation of the error term. Dividing the sample in two subsamples helps assessing changes in foreign exchange exposure that may be attributed to increased management of exchange rate risk at the sectoral level. It also allows examining the impact on foreign exchange rate exposure of the abandonment of the floating band in September 1999.

D. Conclusions

22. ***Foreign exchange exposure in Chile is lower than in other countries in the region, such as Argentina, Peru, and Uruguay, and some small industrialized countries such as the Netherlands.*** The most exposed sector is the financial sector. However, this may not be a major source of systemic risk since the banking sector is well-covered. Furthermore, a recent assessment of financial sector in Chile suggests that banks could withstand relatively severe exchange and interest rate shocks.

23. ***Managing currency exchange risk has been facilitated by a well-functioning forward market.*** There exists a two-way market, with pension funds and exporters taking foreign-currency paying positions and domestic corporate end-users taking foreign-currency buying positions. Currently, the foreign exchange hedging needs of domestic users are met fully by pension funds and exporters. This situation is likely to continue to prevail as the pension fund industry continues to grow. Liquidity in the forward market, as measured by

bid-ask spreads, is higher than in most emerging markets, and deemed satisfactory by market participants.

24. ***Counterparty credit risk and a lack of sophistication prevent small- and medium-sized enterprises from accessing the forward market.*** Banks require collateral from clients who do not meet internal credit rating requirements. Also, underwriting a forward contract requires first extending a credit line to the end-user. The costs associated to collateral and credit lines are passed on to the end-user as less favorable forward rates. Finally, corporate treasurers in small- and medium-sized enterprises often lack the needed training to manage currency risk actively.

25. ***Growth in the currency options market has been constrained by regulations but authorities are planning to address this problem.*** Allowing banks and pension funds to underwrite currency options could help foster the development of this market. Currency options are valuable tools for hedging foreign exchange risk since their non-linear payoffs cannot be replicated with forward contracts. Also, establishing a liquid market of plain-vanilla currency options is a necessary step to introduce more complex financial instruments. The authorities are fully aware of this problem and is included in their discussion agenda.

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III. CHILE'S EXPERIENCE WITH INFLATION-LINKED BONDS[1]

1. ***The Chilean experience with indexation is often associated with the successful development of long-term fixed-income markets.*** Several studies have pointed to the various benefits of the indexation of debt in terms of market completion, in particular in the context of the transition from a high-inflation to a low-inflation environment.[2] In fact, Chile's CPI inflation-based measure of account, *Unidad de Fomento* (UF), has constituted a central piece of the technology developed for protecting capital market participants from high inflation, providing investors with a unique set of bond return patterns and allowing borrowers to extend the duration of their liabilities.

2. ***In this regard, the monetary authorities in Chile have played a key role in the development of the inflation-indexed debt market.*** Until recently, most financial market and monetary policy instruments in Chile were denominated in UF. The central bank had extensively issued debt in UF, creating pricing benchmarks at various maturities facilitating the issuance of domestic corporate bonds in UF. However, with the shift to a nominal monetary policy target in 2001, the central bank has gradually moved to reduce the prevalence of indexation in financial markets and promote the development of a peso bond market.

3. ***With the shift to a nominal monetary policy target, important questions have been raised regarding the structure of the liabilities of the central bank and its implications for the local capital market.*** Given competing efforts to promote a liquid market of peso-denominated central bank paper, a natural policy issue pertains to the value of maintaining a well-functioning market for UF-denominated securities. In addition, in the current low inflation environment and with inflation expectations well-anchored around the middle of the inflation target bank, the role of the UF has become less evident. While a broader set of financial markets has obvious benefits, the development of these markets is costly and involves trade-offs related to economies of scale in liquidity and transaction costs.[3]

4. ***This chapter reviews the role of the central bank's debt program in the context of the current low inflation environment.*** The analysis provides, first, a review of the recent development of the global market for inflation-linked securities in low-inflation economies and compares the degree of integration of the Chilean UF market with international markets. The analysis then points to one of the ancillary merits of maintaining a well-functioning UF bond market, in particular with regard to the real yield curve's ability to predict future economic activity. Finally, the study reviews the implications of the shift toward a nominal monetary policy target and the changing structure of central bank debt for the development of the corporate bond market and integration with international markets.

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[1] Prepared by Rodolfo Luzio (Ext. 3-8327).

[2] See Landerretche, Lefort, and Valdés (2002); and Walker (2002).

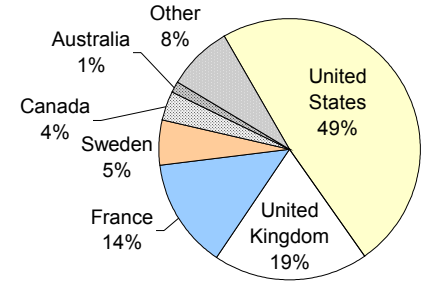
[3] The trade-off between broadening financial markets and the risk of fragmenting market liquidity is an issue that has received significant attention in countries with falling or low debt stocks, such as Australia or Canada. See, for instance, Bank of Canada (2003).

A. The Global Market of Inflation-Linked Bonds and the Chilean Market

5. ***In the past decade, sovereign issuances of inflation-linked (IL) bonds have experienced a remarkable growth.*** Following the lead of the United Kingdom (1981) and Australia (1985), new markets were established in Canada (1991), Sweden (1994), the United States (1997), France (1998), South Africa (2000), and most recently in Greece (2003), Italy (2003), and Japan (2004). Over the past three years, the issuance of IL bonds quadrupled bringing the total global market capitalization of sovereign IL bonds close to US$ 500 billion by end 2003, nearly five times its size in 1996. The United States and the United Kingdom accounted for 68 percent of the market by end 2003, with a large presence in the medium- and long- range of the market (Figure 1). Because many major countries have relatively immature markets and will continue to expand their market for IL instruments toward a higher target, IL bonds are expected to grow at a rapid pace in coming years.[4]

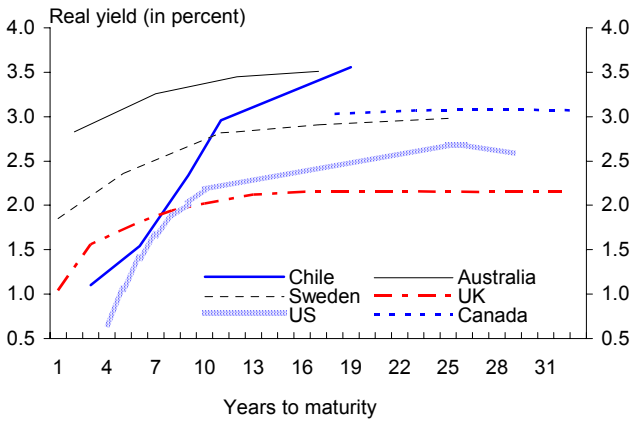
6. ***The increase in global supply and number of sovereign issuers has caused IL bonds to evolve into a global asset class***. The rapid expansion of these instruments has met a growing appetite by investors seeking to enhance scope for diversification. IL bonds provide a type of asset that reduces the risks associated with inflation allowing investors to lock in a real rate of return.[5] The demand of IL bonds has been largely driven by institutional investors, such as pension funds and insurance companies. The strategic demand for IL bonds is expected to continue growing as pension funds and other long-term funds increasingly use IL bonds as a long-term inflation hedge to shield their exposure to the long term nature of their liabilities, often also linked to inflation. In addition, the correlation of IL

Figure 1a. Sovereign Inflation-Linked Bond Markets



Source: Barclay's Capital.

Figure 1b. Yield Curves of Sovereign Inflation-Linked Bond Markets



[4] Most recently, the U.S. Treasury announced an aggressive expansion of its IL bond program with expected net new issuance of about US$60–70 billion a year in the next couple of years, about a third of the current total market capitalization.

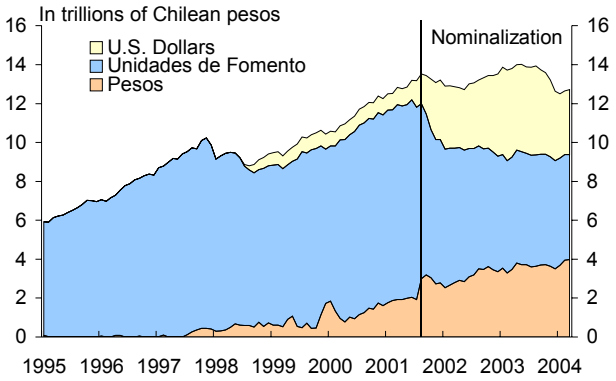
[5] See Bridgewater (2002) for an efficient frontier analysis showing the degree to which IL bonds merit inclusion and that they tend to displace nominal bonds with a typical portfolio. Bodie (1990) shows how the introduction of IL bonds can improve portfolio efficiency, and why these instruments are the only hedge against long-run inflation risk.

bond returns with those of conventional bonds and equities have been low or negative in most markets, making it possible for investors to improve the efficiency of their portfolios.

7. ***In contrast to the rapid expansion of global sovereign IL bond markets, UF-denominated debt issued by the Central Bank of Chile has seen a sustained decline in recent years.*** Until 2000, the majority of the central bank paper was denominated in UF, with peso-denominated and dollar-indexed instruments representing less than 20 percent of the total (Figure 2).[6] With the shift to the nominalization of the monetary policy target, the central bank also adjusted its debt program to allow a sharp increase in nominal debt, with most of the increase reflecting the replacement of UF short term bills. In addition, the limited pre-announced periods of foreign exchange intervention in 2001 and 2002 contributed to higher issuance of dollar-linked debt. As a result, the share of UF-denominated paper fell to less than 45 percent by end 2003, with the stock of UF-denominated paper dropping to 60 percent of its capitalization in 2000.

Figure 2. Central Bank Paper by Currency, 1995-2004

Stock of paper (evaluated at end of period exchange rates)



Source: Central Bank of Chile.

8. ***The drop in the stock of UF-denominated debt also reflected a change in the type of instruments supplied to the market.*** In 2002, the central bank announced a new debt program for medium- and long-term instruments, with a view to standardizing and increasing the efficiency of the UF market.[7] The supply of the UF-linked promissory notes (PRCs), which had been issued for more than two decades, was discontinued and replaced with a more standardized UF-denominated bond program offering defined and sizeable bullets with 5-year and 10-year maturities (BCUs). In addition, the central government started issuing domestically 20-year UF-denominated securities in November 2003.

9. ***As in other countries, institutional investors in Chile have been the main drivers of demand for UF-denominated paper.*** The demand for UF bonds in Chile has been largely concentrated among pension funds and insurance companies, which held more than half of the outstanding stock. Despite increased liberalization of investment rules of these funds, strategic demand for UF-denominated instruments by the pension funds and insurance

[6] This is in stark contrast to most other sovereign IL bond markets, which, despite their rapid growth, still represent a small share of the total sovereign debt markets.

[7] Another important innovation included the stripping of coupons allowing the development of zero-coupon instruments.

companies is likely to continue given the expected growth of these funds over the medium term and their continuous need to hedge their long-term inflation exposures.[8]

Some features of inflation-linked bonds

10. ***Although the structure and mechanics of IL bonds are similar across countries, differences do occur in some aspects of the bonds.*** The similarity in the structure of IL bonds, which reflects the fact that the real rate of return of these instruments must be known and fixed in advance, facilitates investors' understanding and pricing of these instruments across markets. This feature makes this type of bonds the only instrument for which income flows are fully adjusted for changes in the cost of living. However, differences do exist across markets: [9]

- ***Deflation protection*:** Australia, France, and the United States offer a floor protection at par for the principal, whereas Chile and other markets do not.

- ***Inflation lag*:** All bond programs are linked to inflation with a lag, allowing time for the compilation of inflation statistics. In Chile, the adjustment lag is one month with the UF allowing a lagged daily interpolation of the monthly inflation. In comparison, in Canada, France, and the United States, this lag is three months, and in the United Kingdom eight months.

- ***Inflation index*:** As in Canada, the United Kingdom, and the United States, Chile uses a non-seasonally-adjusted headline CPI for inflation adjustment, while France uses a CPI excluding tobacco prices.

- ***Taxation*:** Coupon income and principal appreciation are taxed as interest for most of the major issuing countries. However, in Chile, like in the United Kingdom, interests are taxed after adjusting for inflation. In France, principal appreciation is taxed as interest on an actuarial, smoothed basis.

- ***Coupon frequency*:** Like in Canada, the United Kingdom, and the United States, IL bonds in Chile pay coupons on a semi-annual basis, while Australia and France do so on a quarterly and annual basis, respectively.

Linkages across IL bond markets

11. ***The growth of sovereign IL bonds has led to increased linkages between markets.*** Numerous studies have analyzed the extent to which short-term real interest rates are related across countries to evaluate the degree of financial integration. Cumby and Mishkin (1986) find that short-term real interest rates in several European countries and Canada are associated with U.S. real rate movements. However, Throop (1994) shows that the short-run

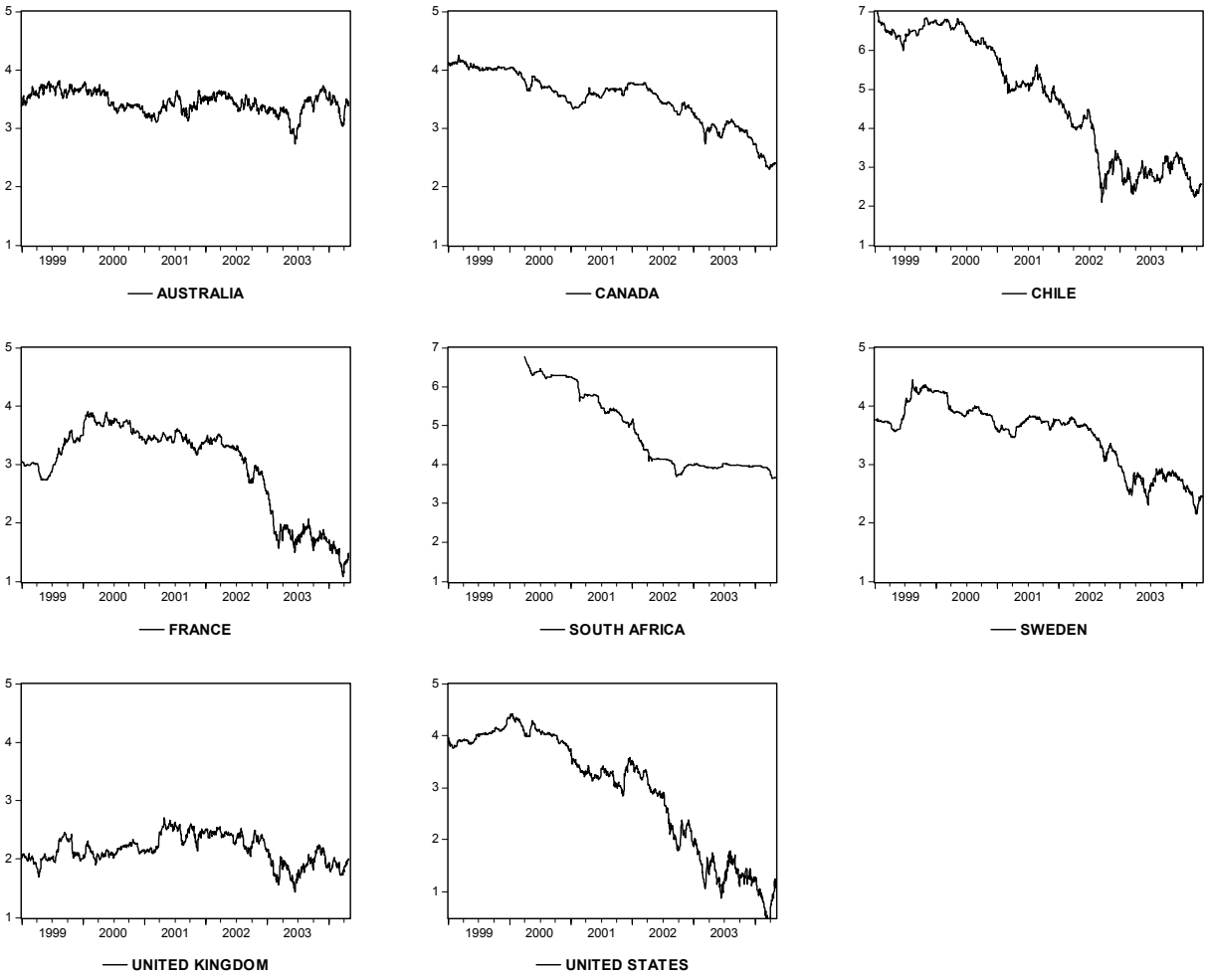
[8] Pension payments are tied to the UF and the minimum pension guarantee is also linked to the UF.

[9] The econometric analysis below does not take into account the pricing implications of these minor structural differences.

responses between short- and long-term real rates are weak despite growing financial integration among industrial countries. In principle, international financial integration would not completely work to equalize real interest rates, as exchange rate expectations and time-varying risk premia may prevent convergence of real rates. Nonetheless, assuming constant ex-ante real exchange rates, higher integration would lead to higher co-movement of real rates in the long run.

12. ***The current analysis uses real yields from IL bonds with long maturities to assess the extent to which the Chilean UF bond market interacts with global IL bond markets.*** The data used includes weekly yields on IL bonds with maturities ranging from 8 to 18 years collected for Australia, Canada, Chile, France, South Africa, Sweden, the United Kingdom and the United States for the period from January 1, 1999 to April 30, 2004 (Figure 3).[10]

Figure 3. International Inflation-Linked Bond Yields



Sources: Barclays Capital and RiskAmerica.

[10] Risk America.com kindly provided the UF yield data for Chile. The data for other countries was obtained from Barclays Capital.

Since 1999, long-term IL bond yields have followed a downward trend in all the countries in the sample. The downward adjustment in yields reflected largely the global slowdown starting in 2000 and the concomitant easing of monetary policy. In fact, yields for all countries appear to follow unit root processes in the sample period. The analysis uses first differences of yields to assess the extent to which these series are integrated.

13. ***Granger-causality tests for yields across markets indicate precedence and information content of some markets.*** Table 1 summarizes the results from pairwise Granger-causality tests for all countries. A key finding is that IL yields in Australia, Canada, France, and Sweden are Granger-caused by three or more markets. In contrast, Chile, South Africa, the United Kingdom, and the United States do no seem to be influenced by other markets. An important difference among these countries, however, is that the United States and the United Kingdom do Granger-cause other markets. The United States in fact Granger-causes all other markets, except for Chile and South Africa. The little forecast value of the Chilean and South African yields on other yields underscores the relatively minor interaction of these markets with other markets. A VAR analysis using the system of yields across markets is also consistent with these findings.

Table 1. Pairwise Granger Causality Tests of IL Bond Yields Across Markets

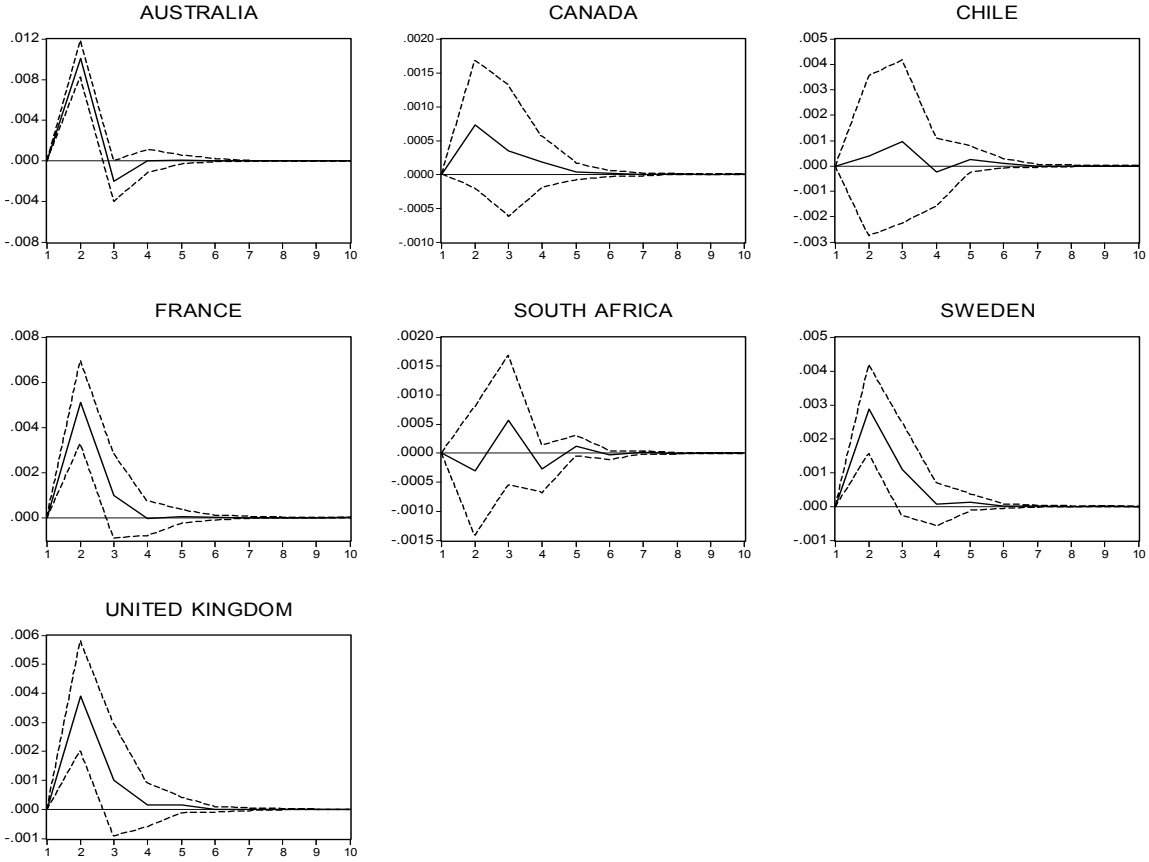
	Australia	Canada	Chile	France	South Africa	Sweden	United Kingdom	United States
	F-statistic	F-statistic	F-statistic	F-statistic	F-statistic	F-statistic	F-statistic	F-statistic
Australia		0.2	0.8	1.8	2.6 *	2.3 *	0.0	0.8
Canada	51.5 **		2.9 *	4.9 **	0.3	23.0 **	1.4	0.0
Chile	0.8	0.2		1.5	0.7	2.4 *	0.2	0.7
France	43.5 **	5.4 **	1.2		1.0	35.7 **	1.1	3.2 **
South Africa	3.4 **	0.8	0.7	1.7		0.0	0.5	1.0
Sweden	11.6 **	4.5 **	1.6	3.5 **	0.6		0.4	0.4
United Kingdom	36.0 **	3.2 **	0.6	1.2	0.0	13.4 **		0.6
United States	147.6 **	6.1 **	1.2	24.4 **	1.0	41.0 **	9.7 **	

Sources: Barclays Capital, RiskAmerica, and staff estimates

Note: (**) denotes significance at the 5 percent, and (*) at the 10 percent. Sample period Jan. 95–Mar. 04. Significance implies rejection of the null hypothesis meaning that row i does Granger Cause column j.

14. ***Impulse responses to U.S. IL bond innovations illustrate the dominant role of U.S. yields*** (Figure 4). Positive one-percent-deviation innovations of U.S. rates induce a positive response on most markets. For Australia, France, Sweden, and the United Kingdom, the innovation effect is significant even though the effect is short-lived. Surprisingly, the effect is less pronounced for the case of Canada despite the proximity of the Canadian and U.S. markets. Consistent with the previous evidence, innovations of U.S. yields are found to have little effect on Chilean and South African yields. Innovations of other markets do not appear to have any significant effect on these two markets either. Similar results are found after controlling for exchange rate movements and adjusting for country risk premia. This evidence would suggest that the Chilean and South African yields would appear to be less integrated to global IL bond markets. Still, market yields could also reflect, more fundamentally, differences in Chile's economic and financial structure and on sources of economic fluctuations relative to those of typical advanced countries.

Figure 4. Impulse Responses to U.S. Yield Innovations



Source: Fund staff estimates.

B. The Chilean Real Yield Curve as a Predictor of Output Growth

15. ***The nominal yield curve has been shown to contain information about real economic activity.*** It is well documented that the behavior of the nominal yield curve changes across the business cycle.[11] The intuition follows from the fact that the premia on long bonds are countercyclical because of investors' dislike for risk in bad times, while short-term yields are procyclical because of the stimulative monetary policy stance. In fact, the spread between nominal long-term and short-term government bond rates appears frequently in the literature as a significant regressor in equations that predict measures of future economic activity, with the predictive relationships robust over time and across different countries. The existence of a real yield curve in Chile provides thus a useful case to assess market expectations about future economic activity.[12]

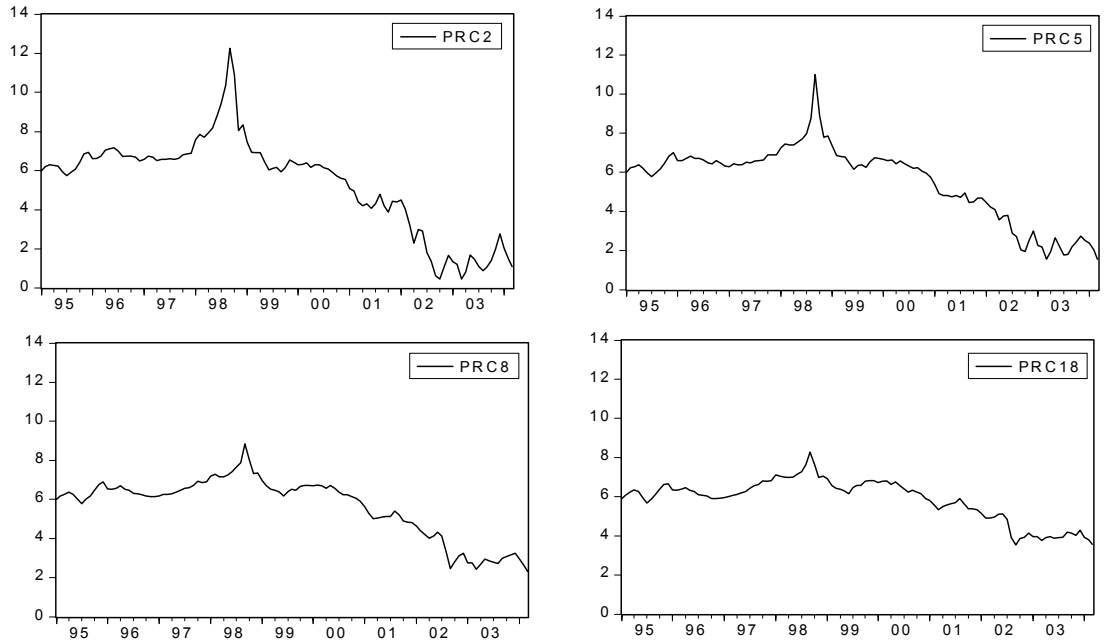
[11] See, for example, Estrella and Mishkin (1997) and Hamilton and Kim (2002).

[12] The theoretical basis for the empirical evidence of the predictive power of the yield curve refers mostly to real yields rather than nominal yields. For instance, Plosser and Rouwenhorts (1994) use real business cycle models to explain the relationship between the term structure and real activity.

Data and basic model

16. ***The study uses yield data from UF-denominated debt (PRCs) issued by the Central Bank of Chile with constant maturities ranging from 1–20 years spanning from January 1995 to March 2004***. Real yields at various maturities, as measured from the yields of UF-linked central bank instruments with constant maturity, followed a common pattern since 1995 (Figure 5). From 1995 through early 1998, they remained within the six to eight percent range. In the fall of 1998, however, yields rose sharply as the central bank increased short-term rates to over nine percent to fend off pressure on the exchange rate. After 1999, yields at all maturities have experienced a gradual decline, with volatility in real yields rising sharply, especially in the short range, after September 2001 when the central bank moved to a nominal target rate.

Figure 5. Yields of UF-linked Bond (PRCs)
In percent

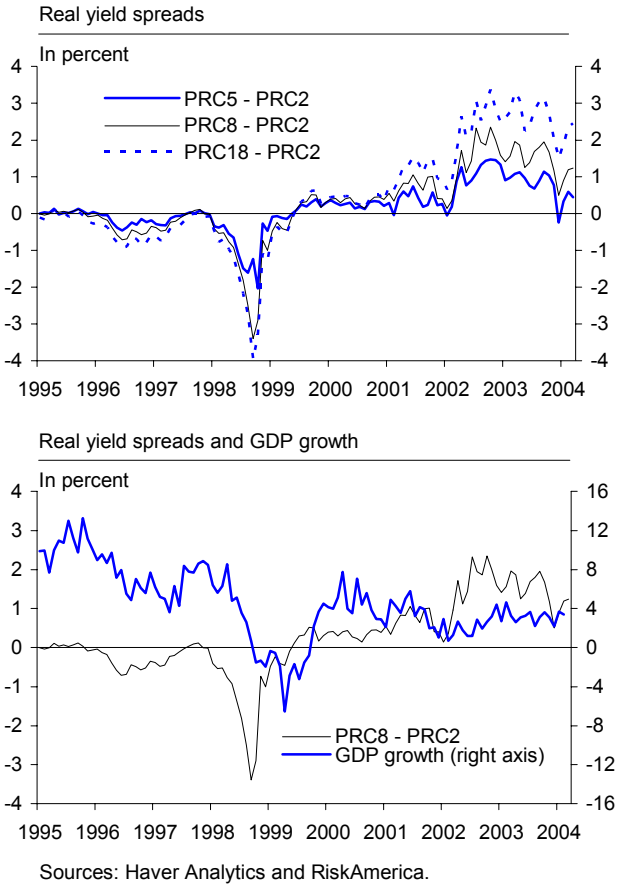


Source: RiskAmerica.

17. ***Real yield spreads have followed a path consistent with the course of economic activity in Chile*** (Figure 6). From 1995 to 1998, the economy maintained its rapid growth pace observed since the mid-1980s. The spread between short-term and long-term UF-denominated interest rates was close to zero reflecting high short-term rates as a result of the prudent monetary policy stance. In fact, the real yield curve remained slightly inverted throughout the period with investors' demanding little long-term risk premia. After the monetary tightening in late 1998, real yield spreads fell sharply. The slowdown in economic activity and subsequent recovery in 1999 and 2000 followed the upturn in yield spreads. By the end of 2002, the slope of the curve had steepened significantly as monetary policy became increasingly loose and economic activity regained traction. In recent years, real

yields on long-term bonds have hovered at around three to four percent and those on short-term yields at about one to two percent. The slope of the yield curve has been more volatile since 2001, reflecting the higher volatility of short-term real yields associated with higher inflation volatility.[13]

Figure 6. Real Yield Spreads and Economic Activity



Sources: Haver Analytics and RiskAmerica.

18. ***A simple model of the predictive power of the yield spread for economic activity can be formalized in the following regression***:

$$g_t^{k,n} = \alpha_k + \beta^{k,n} spread_t^n + \varepsilon_t^{k,n}$$

where future economic growth for the next k months is regressed on the term spread between the n-year maturity and the two-year maturity. The analysis uses three-, six-, and 12-month ahead growth horizons. Given that overlapping periods are used, the estimation uses a moving average correction to solve for serial correlation in the residuals. Real economic activity is measured by the seasonally-adjusted monthly indicator of economic activity (IMACEC). Table 2 reports the results of the regressions over the period January 1995–March 2004. All regressions have been adjusted to solve for heteroskedasticity and autocorrelation.

19. ***The results in Table 2 show that the term spreads at various maturities can help predict GDP growth in the near term.*** This finding is consistent with various ranges of the yield curve. Panel A uses medium-term spreads, as measured by the difference of yields between PRCs maturing in two and eight years. The coefficients of yield spreads on these regressions are all positive indicating that a positively sloped yield curve implies a pick up in growth, or conversely, a downward yield curve foretells a slowdown in activity. The relationship is significant when predicting six- and 12-month ahead growth.

[13] Following the nominalization of the monetary policy target, short-term UF yields moved closely with inflation as short-term nominal interest rates were anchored around the monetary policy target.

Table 2. Forecast of GDP Growth in the Near Term from Yield Spreads

	1-month ahead		3-months ahead		6-months ahead		12-months ahead	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Panel A: Regression on GDP growth using spread PRC8-PRC2								
Sample: January 1995 - March 2004								
Constant	0.24 *	0.13	1.12 **	0.37	2.18 **	1.00	4.22 **	2.02
Yield Spread	0.15	0.12	0.11	0.19	0.53 **	0.23	0.57 **	0.25
Lag GDP growth	-0.31 **	0.10	-0.30 **	0.12	-0.46 **	0.10	-0.60 **	0.08
Adj. R-squared	0.13		0.32		0.61		0.84	
Durbin-Watson stat	0.00		2.02		2.04		2.05	
Sample: January 1995 - August 2001								
Constant	0.45	0.30	1.31 **	0.48	2.80 **	1.23	3.56	3.55
Yield Spread	0.44 **	0.21	0.39	0.39	0.93 **	0.24	0.81 **	0.30
Lag GDP growth	-0.29 **	0.13	-0.29 **	0.14	-0.49 **	0.11	-0.62 **	0.09
Adj. R-squared	0.33		0.33		0.64		0.85	
Durbin-Watson stat	2.16		2.02		2.02		2.05	
Panel B: Regression on GDP growth using spread PRC5-PRC2								
Sample: January 1995 - March 2004								
Constant	0.26	0.22	1.11 **	0.36	2.17 **	0.99	4.28 **	2.07
Yield Spread	0.19	0.19	0.25	0.31	1.03	0.52	0.65	0.49
Lag GDP growth	-0.28 **	0.10	-0.30 **	0.12	-0.47 **	0.09	-0.59 **	0.09
Adj. R-squared	0.26		0.32		0.62		0.84	
Durbin-Watson stat	2.16		2.02		2.03		2.04	
Sample: January 1995 - August 2001								
Constant	0.05 **	0.02	1.28 **	0.49	2.82 **	1.15	3.52	3.58
Yield Spread	0.07 *	0.04	0.50	0.60	1.66 **	0.68	1.08 *	0.59
Lag GDP growth	0.87 **	0.05	-0.29 **	0.14	-0.50 **	0.10	-0.61 **	0.09
Adj. R-squared	0.11		0.33		0.65		0.85	
Durbin-Watson stat	1.98		2.02		2.02		2.06	

Source: Staff estimates using data from RiskAmerica.com and Haver Analytics.

Notes: (*) and (**) denotes significance at the 10 and 5 percent level, respectively
All regressions are corrected for heteroskedasticity and autocorrelation using the Newey-West method.

20. ***The longer-term yields do not appear to improve the predictive ability of term spreads.*** A common finding in the literature using data for other countries suggests that the long maturity segment of the yield curve may lead to more efficient and accurate forecasts of GDP. In the case of Chile, however, using 18-year yields does not improve the fit of the regression, with the smaller, but still significant, coefficients of the yield spread. Nonetheless, the shorter range of the UF yield curve appears to be less successful in helping predict future GDP growth. None of the coefficients of the yield spreads in Panel B is significant for the entire period.

21. ***Not surprisingly, the ability of term spreads to anticipate GDP growth, however, appears to have diminished following the nominalization of the monetary policy target.*** The regressions using the January 1995-August 2001 subsample show more positive results. The size and significance of the coefficients of the yield spreads in the regressions increase noticeably with shorter range of UF yield becoming significant for the one-, six-, and 12-month ahead GDP growth horizon. The higher volatility of short-term UF interest rates in the aftermath of the nominalization of the monetary policy target appear to have clouded the information content of forward yields about expectations of economic activity in the near term.

22. ***For longer horizon forecasts, the predictive ability of yield spreads is less robust.*** The slope of the curve does not appear to be significantly correlated with output growth beyond the twelve-month ahead horizon (Table 3, Panel A). Interestingly, the long-term spreads measured by the difference between eight and 18-year yields is negatively correlated with 2-4 years ahead GDP growth. A negatively sloping curve in long range would be consistent with an expected business cycle recovery two to three years ahead.

23. ***Simple predictive regressions of future economic activity assume the exogeneity of yield spreads with regard to future economic activity.*** A VAR specification modeling the interaction between yield spreads and GDP growth shows that GDP growth does not Granger-cause changes in the slope of the yield curve. On the other hand, high yield spreads Granger-cause future GDP growth consistent with the univariate regressions. Hence, yield processes and future GDP growth do not appear to be jointly endogenous.

24. ***These findings underscore the forward-looking nature of the market information embedded in the yield curve and its ability to anticipate future economic growth.*** The entire yield curve has some predictive ability over the short run, in particular in the sub-period prior to the nominalization of the central bank monetary target. The predictive power of the real yield curve remains, however, low, especially after 2001. Out-of-sample forecasts using the simple model show the limited power to predict the magnitude of GDP growth at longer horizons.

Table 3. Chile: Forecast of GDP Growth from Yield Spreads

	24-months ahead		36-months ahead		48-months ahead	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Panel A: Regression on GDP growth using spread PRC8-PRC2						
Sample: January 1995 - March 2004						
Constant	4.63 **	1.65	1.72	1.45	3.17 **	0.98
Yield Spread	-0.26	0.21	0.00	0.24	0.03	0.22
Lag GDP growth	-0.64 **	0.09	0.18	0.13	0.01	0.13
Adj. R-squared	0.83		0.65		0.61	
Durbin-Watson stat	2.02		2.02		1.96	
Panel B: Regression on GDP growth using spread PRC18-PRC8						
Sample: January 1995–March 2004						
Constant	4.85 **	1.81	1.83	1.36	2.96 **	0.91
Yield Spread	-2.86 **	1.27	-1.56	2.23	-1.54	2.89
Lag GDP growth	-0.64 **	0.09	0.18	0.13	0.02	0.12
Adj. R-squared	0.84		0.66		0.61	
Durbin-Watson stat	2.02		2.02		1.96	

Source: Staff estimates using data from RiskAmerica.com and Haver Analytics.

Notes: (*) and (**) denotes significance at the 10 and 5 percent level, respectively
All regressions are corrected for heteroskedasticity and autocorrelation using the Newey-West method.

C. The Role of Inflation-Linked Bonds in the Chilean Bond Market

25. ***The domestic corporate bond market has seen a remarkable growth in the past few years.*** Private sector bond issuance has doubled since the late 1990s, contributing to a fivefold increase in total outstanding debt stock from 1999 to 2003. Despite the central bank's shift to nominalization and increased focus on nominal debt issuance, the corporate bond market remains, however, largely concentrated on the UF segment with most of the bond issues denominated in UF. Corporate debt is also characterized by its long duration, with the average maturity of bonds issued of about 14 years.

26. ***Several factors explain the preference for long-term UF-denominated paper.*** A key driver of the market is the large presence of institutional investors representing the main source of demand of corporate bonds, with pension funds and insurance companies having a natural preference for UF-denominated paper. Corporate firms have sought to cater to institutional investors, with most bond issuances in two tranches, one of 8–12 years, targeted to pension funds, and the other of 20 years, targeted to insurance companies.

27. ***Cost savings regarding inflation risk premium could remain another reason in favor of UF bonds.*** While inflation has seen a significant drop in the past decade and inflation expectations are well anchored within the central bank's inflation target range, inflation volatility is still above that of more developed economies, suggesting that inflation risk premium could remain a significant cost. For economies with low inflation such as the United States and the United Kingdom, estimates of inflation risk premium suggest a cost of around 50 bps.[14] Nonetheless, the cost savings from inflation risk premium in Chile is less evident when considering that the actual inflation premium has been consistently below most indicators of expected inflation.[15]

28. ***The existence of benchmark UF-denominated paper issued by the central bank has also been a critical factor for the development of the corporate bond market.*** Walker (2002) underscores the role played by the economic authorities in the development of the bond market with the issuance of indexed securities with diverse maturities, noting that the liquidity and benchmarking that these bonds provide are necessary signals for the private sector. In particular, the central bank sought to promote longer-term bonds with more than a third of its instruments with maturities five years or higher. In addition, while the average maturity of the central bank paper in UF has fallen since 2001 (with less than 15 percent of outstanding UF paper at end 2003 having maturities five years or higher), the 20-year bonds first issued by the central bank (BCUs) and recently issued by the central government (BTUs) have longer duration than previously issued central bank bonds and have served as a reference for long-term placements of corporate bonds.

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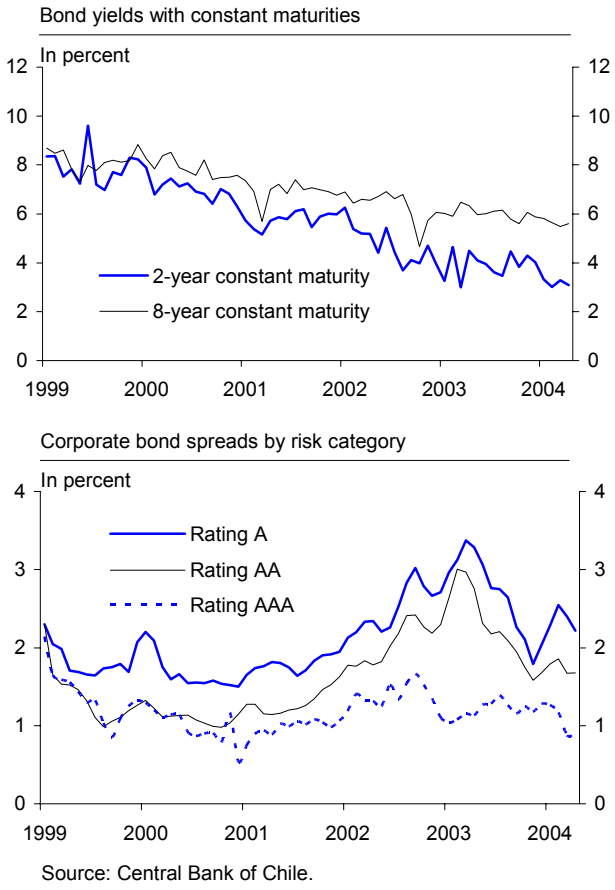
[14] See Campbell and Shiller (1996).

[15] Indeed, breakeven inflation, measured as the difference between nominal and real yields of central bank paper, has been consistently below inflation expectation measure of the Central Bank of Chile's survey of market participants and the Bank's inflation projections.

29. ***The shift to a nominal monetary policy target and recent changes in the central bank's debt program does not appear to have had a significant impact on the volatility of corporate bond yields.*** Specifically, the higher volatility in benchmark short-term yields did not translate into higher volatility for long-term corporate bond yields (Figure 7). Short-term yields, however, have shown increased volatility in recent years, similar to that observed on central bank short-term bonds. Volatilities of yields across risk categories were also largely unaffected. In fact, since the implementation of the central bank's new bond program, there has been improved liquidity in the markets, providing market price signaling for private issuers.

Figure 7. Corporate Bond Yields



Source: Central Bank of Chile.

30. ***A key challenge for corporate financial officers remains the diversification of their liabilities toward peso debt.*** The central bank has aggressively expanded the issuance of short- and medium-term peso debt. Indeed, the issuance of two- and five-year maturity peso bonds accounted for 40 percent of the central bank's total primary offerings. The recent announcement of the new 10-year bond will probably help complete the market of peso bonds and provide an important stimulus to the issuance of corporate peso bonds. In this regard, long-term nominal bonds could have a role, not only in terms of clarifying private sector expectations about future inflation rates, but also to facilitate the participation of foreign investors that might perceive nominal bonds as a simpler instrument to invest in.

D. Concluding Remarks

31. ***This chapter has reviewed the role of UF-denominated paper in the central bank's debt program.*** The analysis compared the development of the UF bond market to the rapid growth of the global market of inflation-linked bonds. In particular, IL bond yields across markets show some degree of correlation and variance decomposition indicates the presence of common factors. Granger-causality tests indicate that the U.S. market plays a leading role in global IL bond markets. Chilean UF yields, however, would appear to have less interaction with other markets, suggesting that Chilean domestic markets could also reflect differences in Chile's economic structure and on sources of economic fluctuations relative to those of typical advanced countries. In this regard, Chilean bonds could potentially provide good diversification value.

32. ***The analysis considers one of the ancillary merits of maintaining a well-functioning UF bond market pointing to the value of the real yield curve as a tool for policy makers to assess market expectations about future economic activity.*** The main result shows the ability of the real yield curve to anticipate future economic activity, underscoring the forward-looking nature of the information embedded in the yield curve. In particular, spreads between two- and eight-year maturity UF bonds are strongly related to the 12-months ahead GDP growth. However, with the nominalization of the monetary policy target, the predictive power of the UF yield curve has diminished, as short-term UF yields have been more affected by high frequency noise of inflation dynamics.

33. ***Finally, the chapter underscores the role of the central bank's UF-denominated paper in the development of the corporate bond market.*** The shift to nominalization of the monetary policy target rate does not appear to have had an impact on the volatility of UF yields. The higher standardization of central bank issuance since September 2002 has facilitated price discovery in the corporate sector issuance by boosting the liquidity and size of benchmark bonds. The simplification and standardization of the interest term structure could help promote foreign investors' participation in the Chilean domestic market. In addition, the central bank's efforts to extend the maturity range of the peso yield curve could provide the appropriate stimulus for the development of a corporate peso-denominated bond market.

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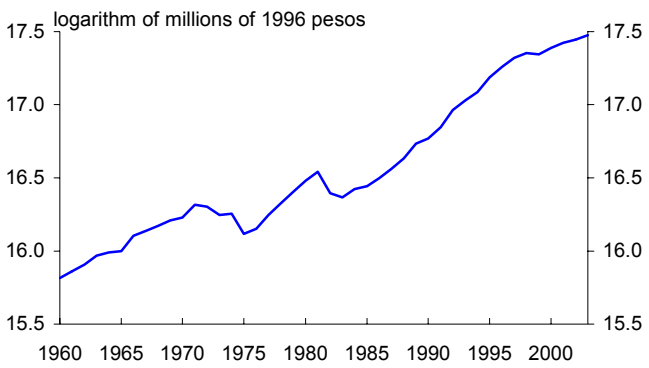
IV. Recent Developments in Trend GDP[1]

1. ***Since 1960, output growth in Chile has shown three distinct phases.***[2] During 1960–1975, growth averaged 2 percent, with a sharp recession at the end of this period (Table 1 and Figure 1). During 1976–1990, growth rose sharply, by 4¼ percent a year on average, as the economy recovered from the upheavals in the early 1970s and the banking crisis of the early 1980s. At the end of this second period, the government embarked on a comprehensive reform process, which encouraged foreign investment and helped expand the formal labor force. During the most recent phase (1991-2003), growth has averaged above 5¼ percent a year, reflecting the ongoing process of reforms and stabilization, including a further opening up of the economy, fiscal consolidation, and successful price stabilization, which enabled the economy to take advantage of the supportive external environment.

Figure 1. Real GDP, 1960-2003



2. ***Estimates of trend GDP are a key component in fiscal policy making in Chile.*** The Ministry of Finance uses a measure of trend output to estimate a cyclically-adjusted fiscal balance (the "structural balance"), and spending plans are adjusted accordingly, to help keep the structural balance at a surplus of 1 percent of GDP. While growth averaged 8¼ percent a year during the first half of the 1990s, it fell to less than 3 percent during 1997–2003. This slower growth has led to a downward revision in the official estimate of trend output growth, from just over 6 percent to around 4-4¼ percent.

3. ***This paper provides an overview of the methodology used to estimate official trend output and uses an atheoretical test of whether there is a structural break in GDP in the late 1990s.*** The Ministry of Finance uses a production function to estimate trend GDP, and there have been recent improvements in the capital and labor data series, which are inputs to the production function. These new data permit a more precise description of GDP developments since 1960. In addition, this paper subjects the GDP data to an atheoretical, "segmented trends" estimate of trend GDP. An essential component of the "segmented trends" approach is to choose the break dates correctly. In this paper, a data-dependent

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[1] Prepared by Chris Faulkner-MacDonagh (Ext. 3-5978).

[2] Even after the economy recovered from the 1982 banking crisis, Chile's GDP has been very volatile. According to staff estimates using data from the WEO database since 1985, Chile has the highest coefficient of variation (standard deviation divided by average GDP from 1985–2003) in Latin America. This variability reflects Chile's high growth rate, and Chile's coefficient of variation for GDP (0.325) is similar to that for the Newly Industrialized Economies in Asia (0.320).

methodology chooses the break dates. These break points are close to those used in the official estimate of trend GDP, and there does not seem to have been a break in the level of GDP in the late 1990s. Furthermore, the trend growth rate is estimated to be around 4½ percent, close to the current estimates of 4–4¼ percent. However, the paper concludes that substantial uncertainty remains about the exact estimates of the growth rate and level of trend GDP, since these estimates are based on an incomplete business cycle.

A. Determinants of Growth in the Chilean Production Function[3]

4. ***The official estimate of trend GDP is based on a production function.*** The advantage of a production function is that it decomposes output growth into its components: capital, labor, and a residual representing technological progress (Total Factor Productivity, or TFP). Recently, the authorities have improved both the methodology and data used in the function, including by adjusting the capital and laboring stock series to reflect utilization and quality improvements, respectively.[4]

5. ***As a first step, GDP is decomposed into its major components, providing an estimate of the TFP residual.*** To estimate TFP, GDP is regressed on capital and labor (to estimate the share of capital in national income, α). Then, TFP is taken as the residual in the following equation:

$$y_t = tfp_t + \alpha k_t + (1-\alpha) l_t, \qquad (1)$$

where y is the logarithm of GDP (in millions of 1996 pesos); *tfp* is a measure of total factor productivity; k is the logarithm of a utilization-adjusted measure of the capital stock (in millions of 1996 Chilean pesos); and l is the logarithm stock of quality-adjusted labor.

6. ***In a second step, trend GDP is estimated using a production function, using cyclically-adjusted components.*** After discussion with the expert panel, the Ministry of Finance suggested adjusting the labor stock (l) and TFP residual (*tfp*, from equation 1) using

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[3] The details of the estimation approach are available in Ministry of Finance (2003a, 2003b). An expert panel suggests methodological improvements to estimating trend GDP. It also provides inputs to the production function during the forecast horizon (specifically, the growth of investment and TFP). As such, they help to implicitly set the trend growth rate used by the structural balance rule.

[4] Formally, the utilization-adjusted capital stock is equal to: $\frac{1-u_t}{1-u_t^*} k_t^R$, where u is the unemployment rate, u^* is a measure of the NAIRU (taken as the average unemployment rate for the sample period: 1960–1975, 1976-1990, or 1991–2003), and k^R is the real capital stock. The labor stock is taken as the product of total employment, average hours worked by employee, and the average years of schooling.

a Hodrick-Prescott filter, to remove the cyclical component in these data.[5] Trend GDP $(\tilde{y}_t)$ is measured as:

$$\tilde{y}_t = \tilde{tfp}_t + 0.45\,k_t + (1-0.45)\tilde{l}_t, \qquad (2)$$

where, after discussion with the expert panel, the capital-labor ratio, α, for the trend GDP estimate in equation (2) is fixed at 0.45 for the entire sample.

7. ***The results of the production function approach suggest that factor accumulation was the primary determinant of GDP growth until 1975*** (Table 1).[6] During this period, economic policy was inwardly focused, and an aggressive policy of import substitution and nationalization of industries.[7] At the end of this period, there was a sharp recession, and GDP growth averaged only 2 percent for the whole period. Reflecting this sharp, cyclical downturn, TFP fell by around ¾ percent per year.[8] Similarly, the growth in the capital stock averaged only 1 percent a year, and for the entire period, capital stock was underutilized. While the labor stock grew by around 1½ percent, over three-quarters of the increase was due to an improvement in the educational quality of the labor force; employment growth averaged only ½ percent, while average hours worked fell.

8. ***While the economic reforms of the 1970s and 1980s improved the economy's ability to allocate resources, growth was driven by factor accumulation.*** From 1976–1990, GDP growth picked up to 4¼ percent, with factor accumulation accounting for over ninety percent of total growth. The growth in labor contributed 2½ percentage points to GDP growth. Furthermore, labor quality improved, as the average years of schooling continued to rise. Also, thanks to an improvement in the utilization of the capital stock, capital contributed more to GDP growth—even though investment slowed. TFP growth was subdued, growing only ¼ percent a year, but this represented a substantial improvement from before.

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[5] The capital stock series is not smoothed because it is already very smooth to begin with. Even with the adjustment, above, the capital stock series does not vary much over the business cycle.

[6] The break points in Table 1 reflect the periods chosen by the Ministry of Finance; however, the economy was still at near a cyclical low 1975–1976. From 1960-1969, the economy averaged nearly 4¼ percent growth per year, and much of the poor performance of the period is due to the poor performance of the economy from 1972–1975.

[7] The characterization of Chilean economic history is taken from Chumacero and Fuentes (2002), which provides a broad overview of the Chilean economy from 1960. The growth accounting results that are presented here are similar to those in Gallego and Loayza (2002) and Contreras and García (2002). However, the estimates in this paper suggest a greater role for labor accumulation than previously recognized, possibly because of the methodological improvements to the data in 2003.

[8] The cyclically-adjusted TFP shows a similar decline. However, even the cyclically-adjusted TFP series still moves with the business cycle, reflecting the strong cyclicality in TFP.

9. ***During the 1990s, economic growth soared, reflecting a sharp improvement in the efficiency of the economy and capital accumulation, while labor accumulation slowed.*** In the early part of the decade (1991–1996), GDP growth averaged 8 percent a year, reflecting the impact of the reforms of the late 1980s, the improved external environment of the early 1990s, and the ongoing efforts at economic stabilization, including successful efforts at price stabilization, which lowered inflation from 25 percent on average in 1990 to 2¾ percent in 2003, and fiscal prudence, which has kept central government net debt under 10 percent of GDP for the past decade. These reforms allowed an improvement in the use of capital and labor, and as a result, TFP grew rapidly (1¾ percent a year during 1991-2004). The reforms also encouraged capital accumulation, and capital stock grew by around 2½ percent a year. In contrast, there was a marked slowdown in employment growth, to only 1 percent a year, and the total number of hours worked fell.

10. ***GDP growth has slowed during the late 1990s, to less than 3 percent, mainly due to a slowdown in TFP growth.*** Almost two-thirds of the growth slowdown has been due to a sharp slowdown in TFP growth. While TFP is a residual (in equation 1), typically such a slowdown corresponds to a slowdown in efficiency growth. However, in this case, the growth in the non-cyclically adjusted measure of TFP has slowed by more than the cyclically measure, suggesting that weak external and domestic demand has had a marked effect on the economy (Table 2). Furthermore, labor accumulation has slowed markedly as well, with a decline in employment growth by nearly ¾ percentage points.

B. An Alternate Measure of Trend GDP: the Segmented Trends Approach

11. ***To assess the robustness of the production function estimates, this section estimates trend GDP using the segmented trends approach.*** This approach takes an atheoretical approach to estimating trend GDP growth, by dividing the data into subsamples. GDP is thus regressed on the logarithm of a time trend and constant, in each subsample:

$$y_t = \alpha + \beta t + u_t, \tag{3}$$

where all variables are taken in logarithms.[9] The detrended estimate of GDP growth $\left(\hat{\alpha} + \hat{\beta} t\right)$ is taken as an estimate of trend GDP in each subsample, so that the estimates do not depend on the correct specification of an economic model. However, the data must be correctly divided into subsamples, to provide accurate estimates of α and β in each subsample.

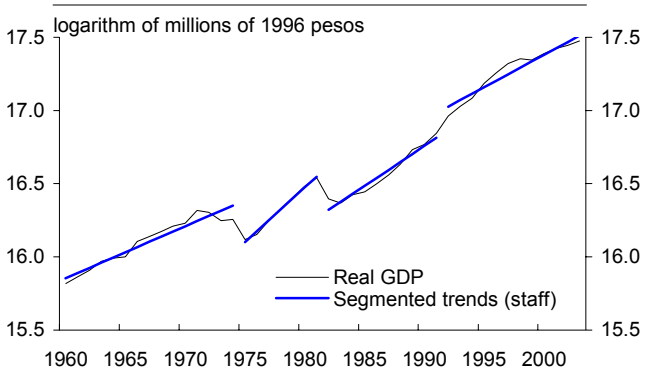
12. ***The subsamples are chosen to reflect evidence of structural change in the data.*** Here, it is assumed that breaks in the GDP data correspond to a change in the underlying economic fundamentals and trend GDP. In De Masi and Kaufman (2000), these break points

[9] This approach follows De Masi, Chan-Lau, and Keenan (1999) and De Masi and Kaufman (2000), which use segmented trends as one of several methods to estimate U.S. potential output. These estimates confirm those using more sophisticated statistical techniques and the production function approach (similar to the approach used in section A).

were estimated using recursive residual tests of structural change. These recursive residual tests, however, are not guaranteed to provide the correct estimate of the break points. Instead, Bai and Perron (1998, 2003) suggest a methodology that optimally selects the number of breaks, along with the dates (see Appendix for details).

13. ***A close examination of the data suggests that there are three structural breaks in trend GDP*** (Table 2 and Figure 2).[10] The first break is 1974, reflecting a sharp economic contraction (GDP fell by 13 percent between 1974 and 1975), and it was not until 1978 before GDP had fully recovered. The second break occurred in 1982, when GDP fell by 13½ percent (and a further 2¾ percent in 1983). The final break was in 1991, when GDP growth picked up markedly in response to economic reforms and stronger external environment.

Figure 2. Real and Trend GDP, 1960-2003



14. ***There does not appear to be a structural break in the late 1990s.*** The test statistics suggest that there are, at most, three structural breaks; the test statistic for four breaks, **supF(4|3)**, is statistically insignificant. The three break points are similar to those chosen by the expert panel. Two break dates (1974, 1991) are essentially identical to the dates selected by the expert panel. The break point in the middle (1982)—selected by the Bai and Perron methodology—is not surprising, given the large decline in GDP during this period. In addition, two other test statistics (using an alternate methodology) suggest that there are only two breaks, in 1974 and 1982.

15. ***Nevertheless, these results should be interpreted with some caution, because it may be too early to see evidence of structural change.*** While this testing methodology is sensitive, there are only 7 data points, from 1998–2004. As a result, there might not be enough time in the sampling period to accumulate evidence that trend GDP has changed. Indeed, because GDP data are serially correlated, it would be preferable to use even longer series to test for evidence of structural breaks.[11]

16. ***Furthermore, previous episodes of structural change were associated very large GDP shocks.*** During the first two structural breaks (in 1974-1975 and 1982-1983), GDP fell

[10] The data are available from the Ministry of Finance, and equation (3) is estimated on the GDP series from 1960-2004. An estimate for GDP growth is used for 2004, because the Bai and Perron methodology requires that the samples be of a minimum length. For this paper, I used a sample length of 7 period, or 15 percent of the sample, to allow for a possible structural break in 1998.

[11] Bai and Perron (2003) suggest using 15 to 20 percent of the sample (in this case, 7–10 data points), at a minimum, when the data are serially correlated.

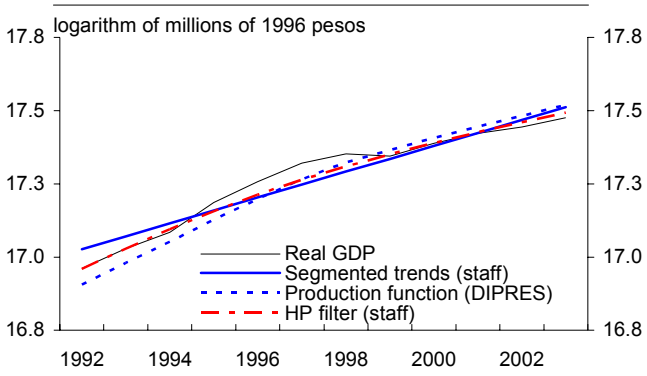
by more than 13 percent. Meanwhile GDP grew by over 12 percent in 1991, the year corresponding to the final structural break.

17. ***In contrast, the slowdown of the late 1990s-early 2000s is relatively mild, by standards of Chilean economic history.*** Real GDP growth slowed from 7¾ percent in the early 1990s, to around 3¼ percent from 1996–2003 (trend GDP growth fell by from 7¾ percent to 4¾ percent). As a result, while this decline in growth is significant, it is not comparable to the change in growth rates experienced in earlier periods. Thus, it may be not be possible for the test statistics to discern a change.

C. Comparisons of Estimates of Recent Trend GDP

18. ***The levels of trend GDP of the segmented trends and production function approaches are very similar, especially toward the end of the sample*** (Figure 3). The estimated difference in the level of trend GDP between the two approaches is small, averaging around 1½ percent over 1992–2003, well within the standard error of the regression (Table 3). Furthermore, the estimated output gaps in 2003 are similar, of between 3½-4¼ percent.[12] Indeed, by 2004, the official level of trend GDP and the level estimated by the segmented trends approach are essentially identical.

Figure 3. Trend GDP, 1992-2003
By different estimation strategies



19. ***The Hodrick-Prescott (HP) filtered estimate of trend GDP also provides broadly similar results and represents an intermediate estimate between the production function and segmented trends approach.*** The HP filter is used to smooth data over the business cycle.[13] The filtered estimates suggest that trend GDP growth is around 5 percent, using data

[12] Table 3 also presents a long-run estimate of the output gap for each methodology. The methodology used in the Ministry of Finance (2003a) assumes that the output gap should average zero over the business cycle, since the economy should (over the cycle) operate at potential. The segmented trends and production function approaches meet this test; the HP filter approach does not (on average, real GDP is around 1½ percent below the level of trend GDP estimated by the HP filter).

[13] The data were filtered using the HP filter command in Eviews 4.1; the smoothing parameter (λ) is chosen to be 100, the value suggested for annual data by Eviews. For more information, see Hodrick and Prescott (1997). Because the HP filter smoothes real GDP over the business cycles, it tends to oversmooth the data at the end of a sample, where (typically) the data are still in the middle of a business cycle. This leads estimates that are either too low (if economy is near a cyclical low) or too high (if the economy is near a cyclical peak).

from 1992–2003. Indeed, the HP filtered estimates seem to be an intermediate estimate, between the segmented trends and production function approaches (Table 2).

20. ***The estimated trend GDP growth rates are also similar in more recent periods.*** Since 1996, the production function estimate of growth (4¾ percent) is nearly identical to that of the segmented trends estimate (4½ percent). The estimates from the HP filtered routine are somewhat lower, at around 4 percent. In addition, all the estimates show a distinct slowdown in trend GDP growth in the most recent years and point to the difficulty of estimating trend GDP when the economy is at a cyclical low. Using the estimates from 1992-1995, trend GDP growth is well above 5 percent for all estimation methods. Using the estimates from the latest period only, trend GDP is estimated to be 4-4¾ percent, irrespective of the methodology used (production function, segmented trends, or HP filter).

21. ***The segmented trends growth rate estimates may also be biased downward because the output gap is substantial at the end of the sample.*** If the economy had not fully closed the output gap by the end of the sample period, estimates of trend GDP would tend to be artificially low because the trend would not yet captured the "upswing" in growth expected in the recovery phase of the cycle. Indeed, with a large output gap, the data at the end of the sample are a large, negative outlier, which could impart a downward bias to the estimate of trend GDP. There is some evidence that this may be the case, because the segmented trends estimate of trend GDP growth in 1996–2003 is about ¼ percentage points lower than real GDP growth over the same period (Table 3).

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Table 1. Contribution to GDP Growth from Factor Accumulation
(average annual percent growth)

Period	GDP	TFP	Capital	Labor
1960-1975	1.85	-0.80	1.08	1.59
1976-1990	4.16	0.37	1.24	2.57
1991-2003	5.36	1.69	2.30	1.40
Memorandum item: (i) GDP and factor growth since 1991				
1991-1996	8.12	3.59	2.41	2.05
1997-2003	3.05	0.09	2.20	0.85
Memorandum item: (iii) decomposition of factors into individual components				
	Capital	Utilization	Stock growth	
1960-1975	1.08	-0.26	1.34	
1976-1990	1.24	0.43	0.82	
1991-2003	2.30	-0.27	2.57	
	Labor	Employment	Hours	Schooling
1960-1975	1.59	0.49	-0.24	1.33
1976-1990	2.57	1.75	0.21	0.62
1991-2003	1.40	0.92	-0.29	0.78
1991-1996	2.05	1.39	-0.37	1.04
1997-2003	0.85	0.52	-0.22	0.57
Memorandum item: (ii) growth of trend GDP an d cyclically adjusted factors				
	Trend GDP	TFP 1/	K	L 1/
1960-1975	2.91	-0.21	1.34	1.74
1976-1990	3.27	0.17	0.82	2.28
1991-2003	5.77	1.47	2.57	1.73
1991-1996	7.15	2.05	2.81	2.28
1997-2003	4.60	0.98	2.36	1.26

Source: Ministry of Finance and staff estimates. Periods are selected by the Ministry of Finance.

1/ Cyclically adjusted using the Hodrick-Prescott filter by the Ministry of Finance.

Table 2. Statistical Test for Structural Breaks in a Model of Trend GDP

Test for structural change in the regression of:

$y_t = \alpha + \beta$ t

Step 1: Test to see if there is a structural break

supF(k) is a test of k breaks vs. the null of no breaks

supF(1)	36.2 [a]
supF(2)	27.0 [a]
supF(3)	26.6 [a]
supF(4)	18.0 [a]

Step 2: Estimate the number of structural breaks

supF(ℓ+1|ℓ) test of ℓ+1 breaks vs. only ℓ breaks

supF(1|0)	31.0 [a]
supF(2|1)	14.0
supF(3|2)	20.3 [a]
supF(4|3)	10.8

Step 3: Estimate the break dates and 95 percent confidence intervals

Date:	1974	1981	1991
Interval:	(1973 : 1975)	(1980 : 1982)	(1990 : 1996)

Memorandum items: Estimates of α and β during each period

(standard errors in parentheses)

	1960-1974	1975-1981	1982-1991	1992-2004
α	-53.715[a]	-131.188[a]	-92.350[a]	-70.872[a]
	(7.970)	(3.208)	(9.868)	(9.228)
β	0.035[a]	0.075[a]	0.055[a]	0.044[a]
	(0.004)	(0.002)	(0.005)	(0.005)

Source: Staff estimates.

[a] Statistically significant at the 5 percent confidence level.

Table 3. Recent Estimates of Trend GDP

Method/Source	Average annual growth	Level difference 1/	Long-run output gap 2/
Trend GDP: Staff estimates (1992-2003)			
Segmented trends	4.5 percent	1.5 percent	-0.1 percent (1983-2003)
Hodrick-Prescott filter	5.0 percent	0.7 percent	-1.4 percent (1983-2003)
Trend GDP: DIPRES estimates (1992-2003)			
Production function	5.7 percent	...	-0.2 percent (1983-2003)
Trend GDP: 1992-1995			
Production function	7.7 percent	...	
Hodrick-Prescott filter	6.5 percent	4.4 percent	
Trend GDP: 1996-2003			
Production function	4.7 percent	...	
Hodrick-Prescott filter	3.9 percent	-1.2 percent	
Memorandum items			
Real GDP growth (in percent), by period			
1992-2003	4.8 percent		
1992-1995	7.8 percent		
1996-2003	3.2 percent		

Source: Ministry of Finance and staff estimates.

1/ Average difference between the level estimate of trend GDP and the Ministry of Finance estimate; a positive number indicates that the method (segmented trends or HP filter) produces a higher estimate of trend GDP than the Ministry of Finance (in percent of Minstry of Finance trend GDP estimates).

2/ Average output gap (as estimated by each method) over the past two decades.

Identifying Structural Change in Linear Regression Models

Bai and Perron (1998) suggest using a series of F-tests to identify evidence of structural change in the parameters of a regression model. Their algorithm involves dividing the data sample into *k* subsamples (representing *k-1* possible break points). The following regression is run on both the entire sample (of size *T*), and on each subsample (i=1,..., k):

$$y_t = x_t'\beta_i + z_t'\gamma + u_t,$$

where the data that are suspected of having a structural break are contained in *x*, and the parameter estimate β_i is allowed to differ across each of the *k* subsamples (i=1,…, k). The data that do not change across the subsamples are contained in *z*. The researcher then calculates the F-statistics, between the unrestricted model (with no structural change) and the restricted model (where the β_i is allowed to be different across the *k* different subsamples), *for all possible combinations of k subsamples*. In general, there will be approximately T^2 subsamples—and hence, T^2 F-statistics.[47]

There is evidence of a structural change in the parameters of the model if the maximum value of all of the F-statistics is sufficiently large. Bai and Perron call this test the **supF(k)** test for structural change, and its critical values are in Bai and Perron (1998).

The second step involves determining the total number of structural breaks. A second round of F-tests is run, comparing a model of ℓ+1 possible structural breaks vs. ℓ structural breaks (this is called the **supF(ℓ+1|ℓ)** test). In addition, Bai and Perron (1998) suggests comparing the results from two information criteria metrics (a modified Bayesian Information Criterion and modified Schwartz criterion). However, these information criteria tend to under select the total number of structural breaks when the data are serially correlated (such as time series data as GDP), and they are not used in this paper.

The final step involves selecting the break points and estimating the confidence intervals. Since the total number of break points (*k*) is known from the second step, the estimate of the *k* break points is taken as those breaks that minimize the sum of squared residuals for the regression, above. While the break points are simple to calculate, the confidence intervals are more difficult. To calculate the intervals, this paper uses the asymptotic cumulative distribution functions, which have been calculated in Bai (1997).

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[47] There are T^k possible combinations of subsamples. However, if each β_i contains *p* parameters, and γ contains *q* parameters, then each of the *i* subsamples must contain $p+q$ data points, providing an upper bound on the number of possible subsamples. Bai and Perron (2003) suggest an algorithm that limits the number of searches to $O(T^2)$.