Pricing Currency Risk: Facts and Puzzles from Currency Boards ♣

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Abstract

This paper investigates the patterns and determinants of the currency risk premium in two currency boards – Argentina and Hong Kong. Despite the presumed rigidity of currency boards, the currency premium is almost always positive and at times very large. Its term structure is usually upward sloping, but flattens out or even becomes inverted at times of turbulence. Currency premia differ across markets. The forward discount typically exceeds the currency premium derived from interbank rates, particularly during crisis times. The large magnitude of these cross-market differences can be the consequence of unexploited arbitrage opportunities, market segmentation, or other risks embedded in typical measures of currency risk. The premium, its term structure, and the cross-market spread depend on domestic and global factors, related to devaluation expectations and risk perceptions.

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Interest rates increased sharply after launching a proposal to modify Argentina's currency board, according to which the peso will be pegged to a basket composed of U.S. dollars and euros. To stop speculation against the peso, Argentina's economy minister explained to Brazilian investors the newly proposed currency board.

"I try to do as much as possible to explain the new currency board, but I see much myopia in the markets ... I am going to give new glasses to investors ... Whoever does not trust Argentina and speculates against the peso will lose a lot of money."

Domingo Cavallo, April 18, 2001

I. Introduction

Interest rate differentials, the spread between local interest rates and international interest rates, are a key variable for emerging countries. Spreads are usually positive for these countries, which implies a higher cost of capital relative to the cost faced by developed economies. Interest rate differentials vary substantially over time and increase in periods of local and foreign financial turmoil, and this has lead to "sudden stops" of economic activity in emerging economies.[1] Lower spreads typically translate into lower borrowing costs, for both the public and private sector, and higher growth. For that reason, the ways to achieve a reduction in interest rate differentials have been recently at the center of academic debate and have been a major concern for policy makers, as reflected in the efforts made by Domingo Cavallo to calm down market participants.

Conceptually, the total differential between interest rates on domestic currency-loans issued by local borrowers and those on foreign-currency loans issued by foreign borrowers reflects both country and currency premia. The former refers to the gap between the borrowing costs of domestic and foreign borrowers in a common currency. The latter, on which this paper focuses, refers to the gap between the domestic-currency and foreign-currency interest rates faced by a given borrower; it is often called "currency risk premium" and, less precisely but more popularly, currency risk.

Of the two components of interest rate differentials, the country risk premium has been intensively studied, perhaps due to the availability of daily cross-country data. Yield spreads of emerging market bond indexes (EMBIs) are compiled by JP Morgan. Data on primary issues also exist. This literature has studied the behavior of yield spreads including their time pattern, determinants, and cross-country comovement.[2] Other papers study the country risk premium in relation to the currency risk premium.[3]

The other component of interest rate differentials, the currency risk premium, has received less direct empirical attention in the context of emerging economies. Still, the currency premium is relevant to several strands of the literature – like those on exchange rate determination, uncovered interest parity, and real interest parity. The present study relates directly to at least four different strands of the international finance literature: the debate on the choice of exchange rate regime, the assessment of economic performance under currency boards, the term structure of currency premia, and covered interest parity.

First, the debate on the choice of exchange rate regime pays particular attention to the currency risk premium. Participants in this debate, which intensified during the currency crises of the 1990s, have claimed that countries should opt for either hard pegs

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[1] See Calvo (1998).

[2] See, for example, Favero, Giavazzi, and Spaventa (1997), Eichengreen and Mody (1998), Kamin and von Kleist (1999), Mauro, Sussman, and Yafeh (2000), Kaminsky and Schmukler (2001), Merrick (2001), and Rigobon (2001).

or floating regimes. Proponents of hard pegs argue that, other things equal, the adoption of a rigid parity – such as a currency board – should reduce the currency risk premium, even eliminating it entirely if the peg is viewed as irrevocable. In this view, hard pegs are thought to be credible and transparent, and this yields financial stability and low inflation. As a consequence, hard pegs would reduce the level of domestic interest rates.[4] Credible hard pegs would also reduce the probability of currency attacks and contagion effects. But as Edwards (2000) suggests, the currency premium can still be significantly positive even in hard pegs, if they are not fully credible.

Second, the debate on exchange rate regimes has generated a related literature on economic performance under currency boards. Ghosh, Gulde, and Wolf (1998) find that currency boards are associated with better inflation performance and higher output growth. Kwan and Lui (1996) argue that currency boards tend to slow down output growth but reduce inflation. They also claim that currency boards might result in higher output volatility than flexible regimes. Ribera Batiz and Sy (2000) argue that currency boards yield more credibility and better economic performance than simple pegs. Hausmann (2001) discusses the conditions that might help alleviate potential problems due to the rigidity of currency boards. Calomiris and Powell (2001) describe how the Argentine currency board helped in the development of the financial system.

The third strand of the literature relevant to this paper is the one that studies the term structure of currency risk premia. The term structure reflects markets' perception of

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[3] See Domowitz, Glen, and Madhavan (1998), Sturzenegger and Powell (2000), Didier and Garcia (2001), and Druck, Moron, and Stein (2001).

[4] Note, however, that even if the currency premium declines the country premium could rise if adopting a rigid peg is perceived to weaken the country's solvency. In such case, the net effect on the level of borrowing cots would be ambiguous.

currency risk at different horizons, and has been studied mostly in the literature on target zones. For example, Svenson (1991) shows that under a credible target zone the absolute value of the interest rate differential is decreasing in the time to maturity, since the expected depreciation until maturity is bounded by the exchange rate band. Bartolini and Bodnar (1992) study the term structure of forward premia to assess the implied credibility of the French/German target zone under the European Monetary System. Weak currencies are found to be associated with positive forward premia, as investors forecast a further depreciation of the currency over the next periods. Their results also show that the short-term premium fluctuates more than the long-term premium. Domowitz, Glen, and Madhavan (1998) examine the term structure of currency risk in the case of Mexico up to the Tequila crisis. They show that the term premium turned negative before and during the crisis.

The fourth strand of the literature directly relevant to this paper is the one that studies covered interest parity. This literature shows that, in the absence of country barriers or other risks, interest rate differentials are equal to the forward discount implied by the future and spot exchange rates. This fact is generally supported by the literature on industrial economies. The evidence for emerging markets is much more limited and concentrated on few countries.[5]

The present paper sheds new light on these strands of the international finance literature by providing a comprehensive characterization of currency risk in two currency boards, Argentina and Hong Kong. Focusing on these two economies has two major

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[5] See, for example, Branson (1969), Frenkel and Levich (1977), Deardorff (1973), Dooley and Isaard (1980), Giavazzi and Pagano (1985), Artis and Taylor (1990), Frankel (1992), Chinn and Frankel (1994), Obstfeld (1995), and Kumhof (2000).

advantages. First, these two currency boards have a rich history, which permits analyzing how domestic and international events impact on currency risk. Second, these two cases offer a wide range of data not available for other economies.

This paper explores four major dimensions of the currency risk premium. First, we assess the extent to which hard pegs have in fact resulted in low and/or stable currency premia, an aspect of currency boards that has so far received little attention in the debate on exchange rate regimes. We document the time pattern of the currency premium and its response to major domestic and foreign events. Second, we study the term premium of currency risk in different markets – the money market and the foreign exchange market. We characterize its behavior during tranquil and turbulent times to gauge investors' expectations about the future of rigid currency pegs. This is possible because in these economies the most important financial contracts are denominated in both local currency and U.S. dollars. Third, we show how different financial instruments embody diverging assessments of currency risk, particularly at times of financial stress. These cross-market discrepancies pose a puzzle that might reflect market segmentation, unexploited arbitrage opportunities, or the presence of other risks embedded in the commonly used measures of currency risk. Fourth, we study the determinants of the currency premium, its term structure, and the cross-market differences, using detailed daily domestic and international financial data as well as political and economic events.

The rest of the paper is organized as follows. Section II provides a simple analytical framework for the paper. Section III documents the empirical regularities of the currency premium and its term structure in Argentina and Hong Kong over time and across instruments and maturities. Section IV empirically studies the determinants of the premium and its term structure. Section V assesses the extent of cross-market differences in currency premia. Section VI studies the determinants of these cross-market differences. Section VII summarizes the results and concludes.

II. A simple analytical framework

The currency premium refers to the difference between the returns on two securities identical in all respects except for their currency denomination. Formally, let $i_{t,k}$ denote the interest rate paid in a country at time *t* on a local-currency contract with *k*-period maturity, let ${}^{offshore}i^{*}_{t,k}$ ($i^{*}_{t,k}$) denote the interest rate paid offshore (onshore) on a contract with the same maturity denominated in foreign currency. The total interest rate differential can be expressed as

$$\left(i_{t,k} - {}^{offshore}i^{*}_{t,k}\right) = \underbrace{\left(i_{t,k} - i^{*}_{t,k}\right)}_{\text{currency premium}_{t,k}} + \underbrace{\left(i^{*}_{t,k} - {}^{offshore}i^{*}_{t,k}\right)}_{\text{country premium}_{t,k}} \quad . \; (1)$$

In general, the currency premium can be further broken down into two components, the expected change in the exchange rate and the exchange rate risk premium; we return to this distinction below. As for the country premium, it also consists of two terms: the default premium and the transaction premium. These two premia are associated with different default risk and transaction risk related to cross-country transactions. The default premium reflects the possibility that the domestic and/or foreign borrowers may not honor their debts. In turn, the transaction premium reflects the cost and risk derived from shifting assets across jurisdictions (Aliber 1973), and thus relates to ingredients such as capital controls, differential taxation, commissions, and fees, as well as the risk of changes in the regulations (e.g., changes in the status of capital controls) or in the market conditions that affect the transaction cost.

Let's concentrate on the currency premium. With risk-neutral investors, speculation would result in the well-known uncovered interest parity condition:

$$\left(1+i_{t,k}\right)=\left(1+i_{t,k}^{*}\right)\frac{E_t S_{t+k}}{S_t}, \qquad (2)$$

where $E_t S_{t+k}$ is the expectation at time *t* of the exchange rate at time *t+k*. The exchange rate is defined as local currency per foreign currency. Letting $\Delta s_{t,k}^{e}$ denote the anticipated percentage change in the spot exchange rate $\frac{E_t S_{t+k}-S_t}{S_t}$, we can approximate (2) as

$$\left(i_{t,k}-i_{t,k}^{*}\right)= \Delta s_{t,k}^{e}, \qquad (3)$$

so that the currency premium equals the expected change in the exchange rate. A considerable empirical literature has investigated the consistency of the data with (2) or its equivalent (3). Failure of uncovered interest parity to hold in practice has been traced to two main sources (Lewis 1995): persistent expectation errors – due to irrationality, agent heterogeneity, or peso problems – and risk aversion, what is more important for our purposes.

Under risk aversion, investors demand a compensation for the risk of exchange rate changes. In such case, (3) has to be expanded so that the currency premium includes also an exchange rate risk premium (*errp*):

$$i_{t,k}-i_{t,k}^{*}=\Delta s_{t,k}^{e}+errp_{t,k}. \qquad (4)$$

There is a literature that attempts to break down empirically the currency premium into these two components – anticipated depreciation and the exchange rate risk premium – using survey data on exchange rate forecasts (Frankel 1991) or Kalman filter techniques (Wolf 1987, Cheung 1993).

If a forward exchange market exists, then risk-free arbitrage between domestic and foreign-currency securities yields a "strict" version of the covered interest parity condition:

$$\left(1+i_{t,k}\right)=\left(1+i_{t,k}^{*}\right)\frac{F_{t+k}}{S_t}, \qquad (5)$$

where F_{t+k} is the forward exchange rate at time *t*. This is a strict version of covered interest parity because the country premium has been removed. The "broad" version of covered interest parity, which is the one that concerns much of the empirical literature, uses ${}^{offshore}i_{t,k}^{*}$ instead of $i_{t,k}^{*}$ or draws no distinction between both. As before, equation (5) can be rewritten to show that the interest rate differential equals the forward discount:

$$\left(i_{t,k}-i_{t,k}^{*}\right)= fd_{t,k}, \qquad (6)$$

where $fd_{t,k}=\frac{F_{t+k}-S_t}{S_t}$. Thus, under strict covered interest parity there are two identical measures of the currency premium, $\left(i_{t,k}-i_{t,k}^{*}\right)$ and $fd_{t,k}$.

Equations (4) and (6) together imply that the exchange risk premium equals the difference between the forward premium and anticipated depreciation:

$$errp_{t,k}=\left(fd_{t,k}-\Delta s_{t,k}^{e}\right). \qquad (7)$$

The patterns and determinants of the exchange risk premium, as measured by (7), have received considerable attention in the literature (e.g., Engel 1996, Lewis 1995).

So far we have ignored the country premium, which needs to be considered when using offshore interest rates. The country premium leads to deviations from the broad version of covered interest parity:

$$\left(i_{t,k} - {}^{offshore}i^{*}_{t,k}\right) - fd_{t,k} = \text{country premium}_{t,k} \quad . (8)$$

In contrast, the strict version of covered interest parity should be expected to hold quite generally. However, even after removing the country premium, onshore instruments may still entail different transaction costs and default risks,[6] and these may lead to a failure of the strict version of covered interest parity as well. In such case, deviations from strict covered interest parity will be bounded by the default premium and the transaction premium specific to the instruments used. Formally,

$$\left|\left(i_{t,k} - i^{*}_{t,k}\right) - fd_{t,k}\right| \leq \text{default premium}_{t,k} + \text{transaction premium}_{t,k} \quad . \quad (9)$$

We will discuss this in more detail in Section V below.

III. The empirical regularities

We next document the empirical regularities of the currency risk premium under two currency boards, Argentina and Hong Kong. We use daily data obtained from Bloomberg, the Central Bank of Argentina, Deutsche Bank, and the Hong Kong Monetary Authority. The data set contains rates from different markets and instruments (money market rates, interbank rates, and non-deliverable forwards), different currencies (Argentine pesos, Hong Kong dollars, and U.S. dollars), and different maturities

[6] A considerable literature has explored how various forms of transaction costs may lead to market segmentation, what impacts covered interest arbitrage; see for example Blenman (1991). Note also that forward exchange contracts themselves may not be free of counterparty default risk; see Hodrick (1987).

(typically 1-, 3-, 6-, and 12-month).[7] See Appendix Table 1 for a thorough description. This data set allows us to construct different measures of the premium for each of the two currency boards.

We first present an overview of the evolution of the currency risk premium under the two currency boards, going as far into the past as the data permit, and relating the observed developments in the premium with major local and global events. To do this, we use the measure of the currency premium offering the longest time coverage. We then discuss the different measures of the currency premium available from the data and compare their behavior. Finally, we characterize the term structure of the currency premium.

III.a The currency premium: evolution over time

The case of Argentina[8]

On April 1, 1990, the Convertibility Law established the unrestricted convertibility of the peso into U.S. dollars at a fixed rate of 1 to 1 for both current and capital account transactions. The convertibility of the peso and its parity are defined by law; any modifications must be approved by Congress. The law requires the central bank to hold an amount of dollars equal to the entire monetary base at all times, although a limited proportion of this backing can be held in domestic government bonds. For this reason, some argue that the Argentine scheme is not a currency board in a strict sense.

[7] Non-deliverable forwards are derivatives designed to hedge foreign currency exposure, whose settlement at maturity is made in U.S. dollars at the prevailing exchange rate, so that no local currency changes hands.

[8] We collected the events in Argentina from Ganapolsky and Schmukler (2001), who provide a detailed description of the 1995 crisis management in Argentina. We also collected news from two local newspapers, Clarin and La Nacion, available online at www.clarin.com and www.lanacion.com.

The currency board in Argentina offers a fruitful ground to study the behavior of the currency risk premium. Figure 1 and Table 1 display the time pattern of the currency premium, measured by the difference between the 1-month peso and dollar local deposit rates (in annual terms), and its summary statistics. We use deposit rates, which are generally less sensitive than other rates to the different political and economic events.

Table 1 shows that in Argentina the currency premium remained positive throughout the period for which data is available, although in general its magnitude was modest – the sample mean equals 189 basis points. However, the premium varied significantly over time, reflecting major domestic and international events that impacted on actual and anticipated monetary and financial conditions in Argentina. During these "crisis" episodes the average currency premium was 382 basis points, while during the "tranquil" periods after the Mexican crisis the average currency premium was 124. We next review briefly the main discrete events affecting the Argentine currency premium.

The Mexican crisis that started in December 1994 had strong spillover effects on Argentina. The Argentine peso came under attack and there was a run on bank deposits. A number of measures were taken to avert the collapse of the currency board, but markets recovered only after Mexico and Argentina signed an agreement with the International Monetary Fund (IMF) in March 1995. During the Mexican crisis period the average currency premium was 578 basis point, well above the average 242 basis points registered in October 1994 and the 163 in August 1995.

On May 15, 1995, former president Menem was reelected. His relation with the then economy minister Cavallo (the architect of the Convertibility Law) deteriorated and on July 26, 1996 Cavallo was replaced by central bank president Roque Fernandez. This triggered an increase of the currency premium to 158 basis points, from 85 in the previous month. In October 1997, Argentina was hit by the Asian crisis, in particular by the attack on the Hong Kong currency board. The currency premium hit 393 basis points on November 6. Then the Russian devaluation and default on August 18, 1998 also impacted Argentina, as well as other markets around the world. The currency premium jumped to 405 basis points on September 15. Argentina was also hit by the devaluation of the Brazilian real on January 13, 1999, with the currency premium rising to an average of 210 basis points in the aftermath of this event. The then former minister Cavallo declared to the Financial Times newspaper on May 17, 1999 that Argentina could eventually float its currency while maintaining the convertibility program. The markets reacted with an increase in the currency premium to 185 basis points on June 1. The currency premium continued climbing due to the political uncertainty surrounding the upcoming presidential election.

On October 23, 1999, De la Rua was elected as the new president of Argentina. The currency premium continued increasing but declined significantly in January 2001. Almost one year after taking his post, vice president Carlos Alvarez resigned on October 6, 2000, due to disagreements with the president upon how to resolve an existing bribery scandal in the Senate. This generated a political crisis in the government alliance, and the currency premium rose to an average of 216 basis points in the aftermath of the resignation. The political and economic situation stabilized until economy minister Machinea resigned on March 2, 2001, after agreeing to a 40 billion package with the international community on December 2000. Two weeks later, on March 19, the newly appointed economy minister Lopez Murphy resigned, upon strong opposition to the new package he had sent to Congress on March 16. The currency premium rose sharply on March 16 to 387 basis points. Cavallo assumed once more as economy minister and, on April 16, he sent to Congress a proposed amendment to the Convertibility Law, according to which the peso would be pegged to a basket consisting of U.S. dollars and euros with equal weights.[9] On April 20, after a week in which the government had actively promoted the newly proposed currency board, former president Menem advised citizens to convert their pesos into U.S. dollars, arguing that the proposed law entailed a devaluation of the peso. The currency premium peaked again, hitting 1,100 basis points. On the whole, over the two-month period following the change in economy ministers the currency premium averaged 548 basis points.

The case of Hong Kong[10]

The currency board in Hong Kong also offers an interesting case study of the currency premium. In this case, we use the currency premium implied from deliverable forwards. The premium and the corresponding summary statistics for the 1-month maturity (in annual terms) are also reported in Figure 1 and Table 1.

The Hong Kong currency board was established in October 1983. The Hong Kong dollar is pegged to the U.S. dollar 7.80 to 1, but in September 1998 the rate changed to 7.75 to 1. Between April 1999 and August 2000 the exchange rate moved gradually from 7.75 back to 7.80. Since 1983 the Hong Kong dollar has been freely convertible. The Hong Kong Monetary Authority is responsible for keeping the peg.

[9] Congress approved the law in mid June.

Table 1 shows that, unlike in Argentina, the currency premium was at times negative (although of small magnitude) in Hong-Kong. Its sample mean is close to zero in tranquil times, and equal to 301 basis points in turbulent times. Another difference with Argentina is that there are fewer identifiable events, and instead there is a prolonged period of turbulence surrounding the East Asian crisis.

Although not very large, the Mexican crisis had some spillover effects on East Asia, where it put pressure on strong currencies. On January 12, 1995, the currency premium in Hong Kong jumped to 193 basis points from 63, and hit 340 on January 23. But the impact of the East Asia crisis was much stronger. On January 27, 1997, after the collapse of a large South Korean chaebol and signs of financial distress, Hong Kong decided to take part in an International Monetary Fund scheme to help countries threatened with financial or economic crises and to secure its position as an international financial center. The following day, the currency premium jumped from –19 to 375 basis points. On May 14 and 15, 1997, the Thai baht was hit by a speculative attack. Some governments intervened in the foreign exchange markets and even introduced selective capital controls. The Hong Kong currency premium jumped from 83 to 288 basis points on May 19 and then to 621 on June 15, as the financial situation deteriorated in Thailand. On July 2, 1997, Thailand was forced to float the baht, and the crisis spread to other countries.

During the East Asian crisis the Hong Kong dollar suffered four major attacks. The first attack started on August 15. The currency premium increased from 178 to 826

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[10] We collected the events in Hong Kong from Bloomberg, the Financial Times, and Nouriel Roubini's website, www.stern.nyu.edu/globalmacro/AsiaChronology1.html, and Cheng, Kwan, and Lui (1999b).

basis points on that day and further to 1,157 basis points on August 18. The attack on the Hong Kong dollar peaked the week of October 20, after the devaluation of the Taiwan dollar the previous week. The currency premium hit its all-time high of 2,840 basis points on October 23. The attack on the Hong Kong dollar was different from the typical currency attack because speculators were shortening both stocks and the currency. Investors borrowed equities in Hong Kong dollars and held long position on U.S. dollars. Due to the currency board constraints, the interest rate rose to compensate the reserve outflow, further depressing equity prices. To stop speculation, the monetary authority intervened in the equity market buying stocks and futures.[11]

In early 1998, the crisis continued deepening as several currencies in the region – including those of Indonesia, Malaysia, Thailand, and the Philippines – reached historic lows relative to the U.S. dollar. The currency premium went from 366 to 849 on January 7 and 1,165 on January 12, when the Hong Kong dollar suffered the second major attack during January 12-20. Markets throughout the Pacific Rim hit another low on June 10, with worries spreading to Japan. The third major attack on the Hong Kong dollar followed in June 11-19. The currency premium increased again that day to 664 from 325, jumping to 1,119 on June 15. On August 5, when Chinese officials threatened to devalue the yuan if the yen kept falling, the Hong Kong currency risk jumped to 664. The fourth attack took place between August 26 and September 2, with the Hong Kong dollar reaching 1,309 on August 28 after the Russian default. The mean currency premium during the attacks is much higher than the one during tranquil periods, reaching values between 386 and 598 basis points. On September 13, the chief executive of the Hong

[11] See Chakravorti and Lall (2000) for an explanation of this simultaneous attack.

Kong Monetary Authority acknowledged a possible change in the peg from 7.75 to 7.8, what prompted an increase in the currency premium. Markets started to calm down on September 16, when the Hong Kong Monetary Authority announced that the parity would not change for six months and that it would then adjust gradually over a period of 500 working days.

III.b Alternative measures of currency risk premia

In this section, we compare alternative measures of currency premia. In Argentina, interest rates for different types of loans and deposits are quoted both in pesos and U.S. dollars. Domestic and large international banks participate in the local financial market. The differentials between the dollar and peso interest rates on these instruments provide measures of currency premium derived from the money market. In addition, forward exchange rates are available from non-deliverable forward (NDF) contracts, traded mostly offshore by international investors. The forward discount implied by NDFs provides another measure of currency premium. In the case of Hong Kong, deliverable forward contracts are also available. But to construct the currency premium from intebank rates, we need to use the total interest rate differential, namely the difference between the Hong Kong interbank offer rate (HIBOR) and the London interbank offer rate (LIBOR). This is the same measure used by Cheng, Kwan, and Lui, (1999a). This measure contains not only currency risk but also country risk, which is assumed to be small in the case of Hong Kong.

The different measures of the currency premium implied by the various assets are displayed in Figure 2, while Table 2 presents their summary statistics for the 1-month maturity over the sample for which all measures are available. Figure 2 shows that the different premia move generally together. For example, Table 2 shows that the correlation among the Argentine instruments is between 0.70 and 0.93. In the case of Hong Kong, the correlation between the two available rates is 0.94. Even thought the different measures of currency premia present a strong comovement, there are visible differences across instruments and maturities. Table 2 shows that the currency premium implied by the forward market tends to be higher than the various measures of money market premia. In Argentina, for the whole sample, the (annualized) average premium from the NDFs exceeds 400 basis points, while the average premia derived from the money market is between 134 and 205 basis points. This reflects in part a few large spikes in the forward discount, whose mean is considerably above the median. Among the money market measures, only the currency premium implied by lending rates shows spikes of comparable magnitude. In the case of Hong Kong, the average forward discount is 60 basis points, while the average difference between local interbank rates and LIBOR rates is 34, despite the fact that the latter contains the country risk premium.

III.c Term structure of currency risk premia

Comparison of the currency premia at different maturities can reveal information on market perceptions regarding the likelihood, anticipated magnitude and riskiness of exchange rate changes at different horizons, as well as show how those perceptions are affected by domestic and external developments.

We focus on the term premium between long and short maturities, defined as the differential between the 12-month and the 1-month currency premia.[12] Figure 3 portrays the term premium for Argentina and Hong Kong, while Table 3 presents the corresponding descriptive statistics. We present two term premia, one derived from the forward market, and another from the interbank market. [13]

Figure 3 illustrates how the term premium reacts to relevant events to the economies. In the case of Argentina, the "yield curve" of the currency premium appears to have become steeper after the Brazilian crisis, up to the final portion of the sample corresponding to the resignation of the economy ministers. This suggests that devaluation of the real raised expectations of *eventual*, more than *immediate*, devaluation of the peso. A similar effect appears to have arisen from the 1999 Financial Times article mentioned above, in which Cavallo first advanced the idea of modifying the currency board. Figure 3 shows that the term premium increased; in fact, the 1-month currency premium was flat, while it rose at longer maturities. In other words, markets perceived that no change was likely in the immediate future, but there was increased uncertainty about future changes after the upcoming presidential election. The term premium becomes negative at times, in particular during the Asian crisis, Russia's default, and the 2001 crisis.

In Hong Kong, the term premium is close to zero during most of the sample. But the term premium turns slightly negative during the Mexican crisis and the early signs of distress in South Korea. The term turns sharply negative at the peak of the different attacks on the Hong Kong dollar. The term premium increased significantly right after the

[12] This is the same approach used by Domowitz, Glen, and Madhavan (1998) to analyze the term structure of the country and currency premium in Mexico prior to the Tequila crisis.

first attack on the Hong Kong dollar and only converged to close to zero in late 1999. This evidence suggests that investors revised their expectations about the sustainability of the currency board during the crisis, becoming somewhat pessimistic about the future of the peg in the long run after the Hong Kong dollar was heavily attacked. In the midst of the financial stress they were more concerned about the short-tem prospects.

Table 3 displays summary statistics of the term premia for Argentina and Hong Kong. The table shows that on average the term premium is positive. It is also larger for Argentina than for Hong Kong, suggesting that markets are more uncertain about the long-run viability of Argentina's peg than that of Hong Kong.

The table also shows that the term premium is typically larger in tranquil as opposed to turbulent periods. Indeed, at times of extreme turbulence – such as those corresponding to the economy minister resignations in 2001 in Argentina – the term premium becomes negative, particularly in the case of the Argentine NDF, for which the 1-month over 12-month differential reached a peak of 7,200 basis points. This echoes bond market evidence that the slope of the yield curve changes from positive to negative when markets perceive a higher default probability; see Gavin and Kulesz (2000) for an example. In the case of Hong Kong, the mean term premium is negative during the Mexican crisis and the beginning of the Asian crisis. The term premium reached large negative numbers during each of the different crisis episodes, hitting 1,854 basis points during the first attack on the Hong Kong dollar. The mean term premium is positive during the subsequent attacks because the negative values only last for a few days.

[13] As before, in the case of Hong Kong the latter measure is based on the difference between onshore Hong Kong dollar deposit rates and U.S. dollar deposits in the U.S., so it may include a country premium.

IV. Determinants of the currency risk premium and its term structure

We turn to an empirical analysis of the determinants of the currency premium. Our objective is to identify the impact of economic variables as well as local and global events on the premium. Here we focus on the NDF-based premium measure. In section VI below we assess the determinants of the observed differential between the NDF and the premium implied by interbank interest rates. Data constraints force us to limit the econometric analysis to Argentina. The primary reason is the unavailability of daily domestic financial data for Hong Kong with an adequate time coverage.

The starting point for the econometric analysis is equation (7) above, rearranged to read

$$fd_{t,k} = \left(\Delta s^{e}_{t,k} + errp_{t,k}\right). \qquad (10)$$

We can further decompose anticipated depreciation $\Delta s^{e}_{t,k}$ into the subjective probability held at time t of a depreciation happening prior to $t+k$, that we denote $P_{t,k}$, and the magnitude of the depreciation, that we denote by $\left(s_{t,k} - s_{t}\right)$. With probability $1 - P_{t,k}$ the exchange rate stays unchanged at its current level s_{t} through time $t+k$. $s_{t,k}$ is the log spot exchange rate expected to prevail at time $t+k$ if a devaluation should occur between times t and $t+k$. Thus from (10) we have:

$$fd_{t,k} = P_{t,k}\left(s_{t,k} - s_{t}\right) + errp_{t,k}. \quad (11)$$

The next step is to relate the anticipated magnitude of the depreciation, the subjective devaluation probability, and the risk premium to observable counterparts. Starting with the first of these, the most common approach in the literature is to relate the anticipated devaluation to some measure of real misalignment of the currency, typically summarized by the departure of the real exchange rate from some equilibrium value. However, given that we will be working with daily data, no information on prices or real variables exists. Moreover, since we will be using a relatively short period, it might be reasonable to assume that there is little variation in the magnitude of the peso's perceived real misalignment over the sample period, beyond what can be captured by a time trend and a dummy variable for the devaluation of the Brazilian real.

As for the subjective probability of devaluation, we assume that it is inversely related to the stock of international reserves relative to total bank deposits, which provides a measure of the ability of the currency board to deter a run on the Argentine peso or on the banking system. Hence this variable is a proxy for the sustainability of the convertibility system. Furthermore, we are interested in assessing the role of foreign reserves taking the form of hard currency assets vis-à-vis those in the form of public sector debt, which are also permitted by Argentina's regulations but are viewed with some suspicion by international investors. Then in the regressions we allow these two components of reserves to carry different coefficients.

Finally, to capture the risk premium component of (11), we use three measures that reflect markets' perceptions about risk, in the spirit of Lewis (1995). The first one is the premium on U.S. high yield assets, which we take as a measure of international investors' overall "appetite for risk." The second is the EMBI spread for Latin American debt, which we take as a measure of the perceived riskiness of Latin American assets. These two variables should capture the risk perceptions of international investors; other things equal, they should have a positive impact on the currency premium. The third variable is the liquidity position of Argentine banks, as reflected in the ratio of their cash reserves to total deposits, that we take as a summary measure of banks' perceptions about the volatility of their deposits and hence of the financial environment. An increase in financial volatility (as perceived by banks) or an increase in their risk aversion should be reflected in the banks' decision to maintain higher liquidity ratios. Thus, other things equal, an increase in the liquidity ratio should lead to an increase in the currency premium. In addition to these variables, we also add in the empirical specifications dummy variables to control for the effects of the domestic political and economic events summarized in section III.

Some considerations regarding econometric technique are necessary. Regarding the time-series properties of the data, preliminary augmented Dickey-Fuller (ADF) tests of unit roots yielded mixed results. Forward premia were found to be I(0) – in agreement with the results of, e.g., Clarida and Taylor (1993) – while for the other variables the results varied depending on sample size and lag length. This is unsurprising given the short time coverage of our sample, which surely results in very low power of the tests and makes them rather uninformative. Since our regressors are basically interest rate spreads and financial ratios, we follow the views expressed by Cochrane (1991) and proceed under the assumption that they are all stationary.[14]

A second consideration regards the potential endogeneity of the right-hand side variables. The domestic financial ratios (the central bank's foreign assets and banks' cash reserves relative to deposits) are publicly announced with a 3-day delay; hence we take these variables as predetermined. Next, we take the high-yield spread to be exogenous. Finally, the Latin American EMBI spread that we use refers to region-wide assets

[14] Obviously, since we have no formal statistical evidence to support this assumption, our empirical results below have to be taken with some caution.

excluding Argentina,[15] and as a working hypothesis we shall assume it exogenous as well.[16]

The third issue refers to dynamics. To allow for some degree of persistence, we use a dynamic specification including lags of the dependent and independent variables. Our starting point follows along the lines of Hendry's GUM (general unrestricted model) specification:

$$y_t = c_0 + \sum_{j=1}^{k}\sum_{\tau=0}^{q} b_{j\tau} x_{j,t-\tau} + \sum_{i=1}^{p} a_i y_{t-i} + u_t \ . \qquad (12a)$$

This is just an unrestricted autoregressive-distributed lag (ARDL) model of order (*p, q*). With some straightforward manipulations, it can be rewritten as

$$\Delta y_t = \sum_{j=1}^{k}\sum_{\tau=0}^{q-1} B_{j\tau}\Delta x_{t-\tau} + \sum_{i=1}^{p-1} A_i \Delta y_{t-i} + \left[c_0 + \alpha_1 y_{t-1} + \sum_{j=1}^{k} \beta_j x_{j,t-1} \right] + u_t \ . \quad (12a')$$

The term in square brackets in the right-hand side of (12a') captures the "long-run" version of (12a). Here $\alpha_1 = \left(\sum_{i=1}^{p} a_i \right) - 1$ and $\beta_j = \sum_{\tau=1}^{q} b_{j\tau}$ are the sums of coefficients on the dependent and independent variables, respectively. The long-run impact of regressor *j* on *y* can be found as $-\frac{\beta_j}{\alpha_1}$.

In the empirical implementation, we estimate (12a') starting from a generous parameterization with up to 7 lags of the dependent and independent variables (beginning with lag 3 in the case of the domestic financial ratios). Then we trim down the

[15] Specifically, it is a weighted average of the EMBIs from individual Latin American countries excluding Argentina, with 1999 GDP weights.

[16] We are well aware that developments regarding the perceived solvency of Argentina might impact on that of other countries in the region. However, we presume this effect to be smaller than the one operating in the opposite direction, namely the impact of the region as a whole on Argentina.

specification using Wald tests to discard insignificant lags and arrive at a more parsimonious parameterization. In a number of instances, this procedure still leaves us with a relatively large number of parameters. Thus, to save space in the tables below we only report the long-run coefficients α_1 and β_j and omit the dynamics.

Finally, we allow for conditionally heteroskedastic disturbances using the exponential GARCH (EGARCH) specification of Nelson (1991), which can be written as

$$\log\sigma_t^2 = \pi_0 + \sum_{j=1}^{N}\pi_{1,j}\log\sigma_{t-j}^2 + \sum_{j=1}^{M}\pi_{2,j}\left\{\left|v_{t-j}\right| - E\left|v_{t-j}\right|\right\} + \sum_{j=1}^{M}\pi_{3,j}v_{t-j} \qquad (12b)$$

where $v_t = \dfrac{u_t}{\sigma_t}$. This is computationally simpler than standard GARCH, which given our dynamic specification with multiple lags is no small concern. Moreover, this model offers the added flexibility of allowing asymmetric effects on volatility of positive and negative disturbances (which arise when the $\pi_{3,j}$ are not zero), a feature that has proven useful in modeling financial asset prices (e.g., Pagan and Schwert 1990). In the estimations reported below we use an EGARCH(1,1) specification.

Regression results using this specification are reported in Table 4. The first two columns present results with the 1-month NDF premium as dependent variable. Column 1 uses as regressor the total foreign reserve ratio to deposits, while column 2 breaks down foreign reserves into their hard currency and public debt components. In both cases we find that the variables measuring the foreign reserve ratios carry significant negative coefficients, as expected. However, in column 2 the coefficient on foreign currency assets is considerably larger in magnitude than that on the stock of reserves taking the form of public debt. This suggests that market participants may discount to some extent the contribution of the latter type of reserves to sustaining the currency board, and accords to our *a priori* expectations too.

As for the three variables capturing risk perceptions, the Latin EMBI spread carries a significant positive coefficient in both columns 1 and 2. The magnitude of the coefficient, relative to that of the lagged dependent variable, indicates that in the long run a 100 basis points rise in the EMBI spread raises the 1-month forward premium by some 25 basis points. The results for the other two risk variables differ across specifications: the high-yield spread is significant only in column 1, where it carries a positive coefficient, as expected, while the liquidity ratio of domestic banks is significant only in column 2, where it also carries a positive coefficient.

The EGARCH parameters, shown at the bottom of the table, reveal asymmetric effects of shocks. Negative innovations (those that lower the forward premium) reduce subsequent volatility, while positive ones raise it (in column 1) or reduce volatility less than negative ones (column 2). However, in column 1 the estimated GARCH parameter is roughly equal to one, which suggests nonstationarity of the log-variance process. Finally, the Box-Pierce statistics show no sign of residual autocorrelation.

Columns 3 and 4 in the table report results for the 12-month NDF premium. The available sample is considerably larger than in the case of the 1-month NDF. The results are also much less precise, suggesting that the 12-month forward premium reacts much less strongly to the variables under consideration. In column 3, only the total foreign reserve ratio is significant, and negative as before. Column 4 suggests that this result captures mainly the impact of hard currency reserves; bond reserves in turn are insignificant. In addition, column 4 shows significant positive effects of the high yield spread and the liquidity position of banks, although the magnitude of the implied long-run impact of the former appears implausibly large, due to the small coefficient of the lagged dependent variable.

The EGARCH parameters continue to show asymmetric effects of shocks, with positive shocks raising volatility more than negative ones. However, column 4 again suggests nonstationarity of the log variance process. Finally, the Box-Pierce statistics reveal no symptoms of serial correlation.

Columns 5 and 6 of Table 4 turn to estimation of the determinants of the NDF term premium, measured by the difference between the 12-month and 1-month premia. In addition to the explanatory variables in the preceding columns, we introduce also the term premium of U.S. interest rates, to capture expectations about the future course of U.S. monetary policy and hence the time path of the exchange rate of the U.S. dollar vis-à-vis third currencies, which provides information about the anticipated time path of peso misalignment under the convertibility regime. Other things equal, we should expect a steeper U.S. yield curve to raise anticipations of future peso devaluation and hence tilt the NDF term structure upwards.

Column 5, which combines foreign reserves into a single variable, offers very little precision. Only the EMBI spread is significant, and positive as before. Column 6, which disaggregates foreign reserves into their hard currency and debt components, yields much more precise estimates. The foreign reserve measures now carry positive and significant coefficients. The implication is that the announcement of higher reserves reduces more the short-term NDF premium than the longer-term one – which suggests that higher reserves lower the perceived probability of *immediate* devaluation relative to the probability of *eventual* devaluation. As before, this effect appears to be associated more strongly with hard currency reserves than with those taking the form of public debt.

As for the variables measuring markets' risk perceptions, the Latin EMBI spread and the high-yield spread carry positive coefficients. This is consistent with the fact that both spreads refer to long-term instruments and thus capture perceptions of risk over a long horizon. The magnitude of the coefficient estimates suggests that about 80 percent of an increase in the high-yield spread, and some 30 percent of an increase in the EMBI, are eventually translated into a higher forward term premium. In contrast, the liquidity ratio of domestic banks carries a negative coefficient, which suggests that banks' decision to hold larger cash reserves relates more to perceived short-term risks than long-term ones. Finally, the U.S. term premium carries a positive coefficient, as expected, although it falls just short of significance at 5 percent.

The EGARCH specification again gives indication of asymmetric effects of positive and negative shocks on volatility, with positive shocks adding more to volatility than negative ones, although the distinction is significant only in column 5. The serial correlation statistics only suggest some remaining autocorrelation at lag 10 in column 6, although it is not significant at the 5 percent level, and no indication of autocorrelation is apparent at higher or lower lags.

V. The cross-market currency premium differential

In section III we saw that the currency risk premium varies across instruments. In this section, we investigate those differences more closely by analyzing the case of Argentina, for which we have data for various instruments. In particular, we focus on the difference between the currency premium implied by the NDF and that implied by interbank offer (or lending) interest rates. The interbank market is the most liquid onshore/domestic money market.

V.a Analytical considerations on the cross-market currency premium differential

In a world of perfectly integrated markets with no restrictions on capital movements, covered arbitrage would equalize the discount in the forward market with the currency risk premium implied by interest rates. However, the textbook case of covered interest parity ignores various types of transaction costs that tend to segment the markets. A large empirical literature, originated in the 1970s and 1980s, focuses on testing covered interest parity after taking into account such transaction costs, and examines alternative ways to do arbitrage.[17]

Here we consider three different arbitrage scenarios. The first one assumes that the arbitrageur has "own" funds. In such case, she will simply compare the currency premium in the foreign exchange rate market and in the money market. The second and third scenarios assume that the arbitrageur does not have funds, and hence she needs to borrow in one currency and lend in the other currency to perform the arbitrage. In this case, the relevant deposit and lending rates need to be considered.

[17] Most of these papers focus on identifying "neutral" bands taking into account of the various transactions costs involved in arbitrage operations. For example, Frenkel and Levich (1977) consider: (i) costs of selling (buying) a domestic security; (ii) costs of buying (selling) spot the foreign currency; (iii) costs of buying (selling) a foreign security; (iv) and the transactions costs of forward coverage. In addition, other papers (e.g., Blenman 1991) consider differentials between borrowing and lending rates and introduce heterogeneous arbitrageurs. Some researchers have used offshore Euromarket rates for these tests, in addition to the more commonly used onshore domestic currency rates. See also Clinton (1988).

It is important to note that in each case, there is some risk involved, so there is no pure arbitrage in a strict sense. Gains can be realized but at the expense of taking some risk. The current literature has, however, abstracted from some of these risks. For example, forward market contracts may not be free of counterparty default risk; this applies in all three scenarios below. In addition, each scenario involves some specific risks; we mention them briefly in turn.[18]

Case 1. Arbitrageur with funds

If the arbitrageur has funds invested in the domestic banking sector, she will compare the interbank rates with the forward discount. If the forward discount is greater than the interest rate differential, investors with peso assets will switch their investment to a dollar investment and buy pesos in the forward market. If the forward discount is smaller than the interest rate differential, investors with dollar assets will switch their investment to peso assets and buy dollars in the forward market. If the arbitrageur is a financial institution, the relevant rates are lending rates. Otherwise, the relevant rates are deposit rates. A similar analysis can be performed from the borrowers' side.

Arbitrage yields the following covered parity condition:

$$\left(i_{t,k}^{lending} - i_{t,k}^{lending,*}\right) = fd_{t,k} = \left(i_{t,k}^{deposit} - i_{t,k}^{deposit,*}\right). \quad (13)$$

Thus, if arbitrageurs possessed sufficient funds, they would equalize the currency premia in the different markets.

Note that this arbitrage might not be risk free. By lending or depositing in one currency, the arbitrageur might be taking some credit risk if the borrower is more likely to repay the loan in one currency – typically the local currency – than in the other.

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[18] In the three cases we assume that the bid-ask spread on the forwards is negligible. If the spread is

Case 2. Arbitrageur without funds: borrow and deposit in the same (domestic) market.

If the currency premium implied from the forward market is greater than the one implied from interest rates, the arbitrageur performs the following arbitrage. She takes a loan at the interest rate $i_{t,k}^{lending}$ and deposits the dollar amount $i_{t,k}^{deposit,*}/s_t$ in the domestic market. To cover the position, the arbitrageur buys pesos in the forward market at the rate $f_{t,k}$. In the opposite case, if the currency premium implied from the forward market is smaller than that implied from the interest rates, the arbitrageur does the reverse operation. She borrows in dollars and makes a deposit in pesos, buying dollars in the forward market. According to this type of arbitrage, the forward discount lies between two bands

$$\underbrace{\left(i_{t,k}^{lending} - i_{t,k}^{deposit,*}\right)}_{\text{upper band}} \geq fd_{t,k} \geq \underbrace{\left(i_{t,k}^{deposit} - i_{t,k}^{lending,*}\right)}_{\text{lower band}}. \quad (14)$$

This arbitrage might impose some risk as well, because the arbitrageur deposits the loan in the domestic financial system. If the domestic bank fails, the arbitrageur may still be liable for the loan she took, even though the bank does not return her own deposit. The arbitrage in case 3 avoids in part this risk.

Case 3. Arbitrageur without funds: borrow in one market and deposit in the other market.

The arbitrage in this case is similar to the one in case 2, but the arbitrageur deposits the dollar amount $i_{t,k}^{deposit,*}/s_t$ in the offshore market when the currency premium implied from the forward market is greater than the one implied from interest rates. In the

significantly different from zero, the parity conditions would need modification to reflect it.

opposite case, when the forward discount is smaller than the currency premium implied from interest rates, the arbitrageur borrows in the offshore market and makes a deposit in a domestic bank. This type of arbitrage implies that the forward discount lies within two bands,

$$\underbrace{\left(i_{t,k}^{lending} - {}^{offshore}i_{t,k}^{deposit,*}\right)}_{\text{upper band}} \geq fd_{t,k} \geq \underbrace{\left(i_{t,k}^{deposit} - {}^{offshore}i_{t,k}^{lending,*}\right)}_{\text{lower band}}. \quad (15)$$

If offshore deposits are less risky than onshore deposits arbitrage will probably take place when the forward discount is larger than the upper band, since this arbitrage involves relatively no risk. In contrast, when the forward discount is below the lower band arbitrage might not take place, because the arbitrageur would have to bear the differential risk of the onshore bank. The arbitrageur would need to contract a liability in the offshore market and absorb the onshore risk.

V.b Evidence on the cross-market currency premium differential

We next review in more detail how different markets price currency risk. First we assess whether the evidence seems consistent with no-arbitrage opportunities. To do this, Figure 4 displays three charts. The top panel plots the 1-month forward discount along with the currency premium derived from 1-month lending and deposit rates. The middle panel plots the forward discount along with the upper and lower bands described in equation (14), while the bottom panel uses the bands displayed in equation (15).

Figure 4 shows that the forward discount differs from the currency premium derived from interbank rates. For most of the sample the two measures are roughly similar, but in many instances the forward discount is significantly different from the currency premium. This is especially the case during turbulent times, when the forward discount becomes considerably larger than the currency premium derived from interbank rates. The forward discount has very few values below the interbank currency premium.

A similar picture is displayed in the middle and lower panels of Figure 4, corresponding to cases 2 and 3 above. In these panels the forward discount lies for the most part within the no-arbitrage bands. But in some observations the forward discount jumps above the upper band. As we shall discuss below, these are not just one-day events. The lower panel uses offshore deposit and lending rates. Relative to the middle panel, the bands shift upward because country risk is not present in the offshore rates. These rates are lower than domestic interbank rates, so the differential shrinks. Despite the upward shift in the band, the forward discount still lies above the band during crisis times. But in this case there exist a few observations in which the forward discount lies below the lower band.

Does this evidence imply that arbitrage opportunities exist? The answer is just maybe. There are three alternative explanations for the evidence found, which can be described better by referring to equation (9) above. One explanation is that in fact there are unexploited arbitrage opportunities in the short run and, thus, covered interest parity fails to hold. The currency premium derived from the exchange market is significantly different from the one derived from the money market, and is larger than any existing transaction costs. For some reason, arbitrage does not take place.[19] Using equation (9),

[19] Informal evidence gathered from market participants suggests that at times of turbulence, when the forward premium becomes quite large, domestic banks refrain from getting involved in short-term arbitrage operations and prefer to "stay liquid." While this is consistent with the opening of a gap between the interbank and forward currency premia, the precise reasons for this decision are not known to us.

this case can be thought as the default premium and the transaction premium being equal to 0 and $\left(i_{t,k} - i^*_{t,k}\right) - fd_{t,k} \neq 0$.

A second possible explanation is that unobserved transaction costs are large enough to rule out profitable arbitrage opportunities. However, this argument does not explain the causes for the differences in currency risk premia across markets. The differentials might be reflecting heterogeneous expectations among market participants or heterogeneous agents participating in each market, who price risk differently. In this case, the cross-market differential will be bounded by the transaction premium,

$$\left| \left(i_{t,k} - i^*_{t,k}\right) - fd_{t,k} \right| \leq \text{transaction premium}_{t,k} \quad . \qquad (16)$$

The transaction premium is the consequence of existing and/or anticipated transaction costs. In such case, the cross-market differential lies within the bounds implied by transaction costs and does not need to be strictly equal to the transaction premium.

In the case of Argentina, there are no obvious transaction costs to support this explanation. There are no restrictions on capital movements, and local residents can operate in the local and foreign markets without being taxed on interest, dividend, or capital gains.[20] Yet the fact that currency premia are not equal across markets suggests that other types of transaction costs or market imperfections leading to market segmentation might be responsible for our findings. For example, there might be large bid-ask spreads unknown to us in the forward market, or it might not be possible to perform transactions at quoted prices.

[20] In April 2001 a small transaction tax of 0.2 percent was imposed on some financial transactions in Argentina, what cannot explain the large differentials found before and after that date. In countries with substantial explicit costs, like capital controls, there is a wedge between local and foreign rates, as shown by Herrera and Valdés (2001) for the case of Chile.

A third possible explanation to our findings is that the differences in currency premia reflect in fact differences in other risks across markets. In other words, the measures of currency risk that we (and the rest of the literature) use embed other types of risks and do not solely measure currency risk. For example, it could be the case that the spread between interbank rates reflects default risk, or a higher default risk than that in the forward market. Therefore, the difference between peso and dollar rates not only reflects currency risk but also default risk. As noted earlier, this might be the case if borrowers or banks are more likely to default on dollar loans and deposits than on peso contracts.[21] In this case, the cross-market differential will be equal to the default premium,

$$\left(i_{t,k} - i^{*}_{t,k}\right) - fd_{t,k} = \text{default premium}_{t,k} \quad . \qquad (17)$$

In sum, at one extreme, the differences between the forward discount and the currency premium derived from interbank rates might reflect divergent expectations that are not or cannot be arbitraged away. At the other extreme, the difference might reflect the perceived default risk of the interbank market relative to the one from the forward market. Of course, it is also possible that the three explanations are simultaneously behind the cross-market differentials. It is difficult to disentangle these alternative explanations without detailed information on market transactions.

Though we cannot determine exactly the source of the spread between the forward discount and the interbank currency premium, it is still interesting to study its behavior, as it provides information about the differential behavior of both markets. Formally, we define the spread between the forward and the interbank market as follows

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[21] Collin-Dufresne and Solnik (2001) describe a similar case for the swap and LIBOR markets.

$$\pi_{t,k} = fd_{t,k} - \left(i_{t,k} - i^*_{t,k}\right). \qquad (18)$$

These interbank rates can be either lending or deposit rates. Here we work with lending rates.

The literature on covered interest parity has employed two main approaches to analyzing this spread. The first one simply takes the observed deviations from covered interest parity and assesses whether they frequently exceed what would be justified by transaction costs. The second approach performs unit root tests on the covered interest differential to determine whether non-stationarity can be rejected; failure to reject non-stationarity implies that the covered differential persists indefinitely and thus covered interest parity fails to hold. Still, even if non-stationarity is rejected the covered differential may converge very slowly to its mean, reflecting persistent (albeit not permanent) failures of covered interest parity.

In our case, we take the case most favorable to covered interest parity – namely that in which the arbitrageurs have no funds. We also work with the onshore rates used in the strict form of covered interest parity described in section II. We then examine the behavior of the forward discount relative to the no-arbitrage band defined by borrowing and lending rates, using the band displayed in the middle panel of Figure 4. For those observations where the forward discount lies above the band, we examine the dynamics of the differential between the forward discount and the upper band. For the observations inside the band, we study the dynamics of the forward discount.[22]

[22] Since we have no observations below the lower band, we ignore this case.

This approach is in the spirit of the threshold autoregression (TAR) models used to study arbitrage in goods and assets markets.[23] These models typically need to estimate the "commodity points" or thresholds of no arbitrage. In our case, however, the problem is simpler because the thresholds are known, and given by the no-arbitrage bands in Figure 4. Therefore, we estimate the following model:

$$\begin{cases} \Delta\left(fd_{t,k} - \left(i_{t,k} - i^*_{t,k}\right)\right) & = & c^{out} + \lambda^{out}\left(fd_{t-1,k} - \left(i_{t-1,k} - i^*_{t-1,k}\right)\right) + \varepsilon^{out}_{t,k} & \text{if} \quad fd_{t,k} > \left(i_{t,k} - i^*_{t,k}\right) \\ \Delta fd_{t,k} & = & c^{in} + \lambda^{in} fd_{t-1,k} + \varepsilon^{in}_{t,k} & \text{if} \quad fd_{t,k} \leq \left(i_{t,k} - i^*_{t,k}\right) \end{cases} . \quad (19)$$

Note that the mean and the speed of adjustment, as well as the variance of the disturbance, are allowed to differ across equations. Our primary concern is to assess the speed of adjustment λ both within and outside the band.

The top panel of Table 5 shows the number of observations for which the forward discount lies outside and inside the no-arbitrage band. Around 20 percent of the observations are above the no-arbitrage bands (133 observations). The histogram displayed in Table 5 shows the distribution of observations relative to the upper band. Negative numbers represent observations below the upper band, while positive numbers are observations above the band. The histogram shows that the observations above the band can take very large values, with a number of them above 1,000 basis points.

The bottom of Table 5 reports the results from estimating this model. The parameter estimates show some modest variation depending on the number of lags used to estimate the model. In all cases we can reject nonstationarity of the dependent variable. The estimates reflect a rapid reversal to the mean when the forward discount lies above

[23] These models have been used to examine issues such as the validity of purchasing power parity, or the extent of arbitrage under the gold standard. See for example, Obstfeld and Taylor (1997), Prakash and Taylor (1997), Taylor and Peel (2000), and Taylor, Peel, and Sarno (2001).

the band, and a much slower reversal when it lies inside the band. Above the band, the half-life of the differential [calculated as $\ln(0.5)/\ln(1+\lambda)$] is around one day. This means that half of the deviation from the band will be eroded in one day, so that even after one day half the deviation from the band still persists. Thus, while departures from the arbitrage band are certainly not permanent, they are nevertheless more lasting than should be expected under perfect arbitrage. Inside the band, the half life is much higher – around 10 days.

To conclude this section, we document the main features of the cross-market currency premium differential, as a reflection of unspecified heterogeneity across markets rather than specifically as a potential failure of covered arbitrage. Figure 5 plots the 1-month forward-interbank spread $\pi_{t,k}$, while Table 6 displays summary statistics of the spread for the 1- and 12-month maturities. The spread is on average positive, particularly for the 1-month maturity. But the mean is affected by large positive values reaching as high as 7,100 basis points during the 2001 crisis. The distribution is skewed to the right, so that the median is smaller than the mean, but still positive. It is noteworthy that all the large values take place during crisis times. In tranquil times, the cross-market difference is also positive but smaller. The differential takes on only a few negative numbers, reaching at most –173 basis points. In the next section we turn to an empirical assessment of the determinants of these spreads.

VI. Determinants of the cross-market currency premium differential

To explore the factors behind the forward-interbank currency premium spread $\pi_{t,k}$, we estimate simple empirical equations in the same spirit of those used in section

IV above to describe the forward discount. Our primary objective here is to assess the differential effect of devaluation expectations and risk perceptions on the interbank and forward markets. Thus, we use the same empirical specification (12a') from section IV in EGARCH regressions with $\Delta\pi_{t,k}$ as dependent variable, for both the 1-month and 12-month maturities.

Estimation results are presented in Table 7. As before, we consider specifications both combining and splitting the two components of international reserves. Columns 1 and 2 report the two sets of estimates for the 1-month maturity. Like in the forward premium regressions, the international reserve ratios carry significant negative coefficients under both specifications, which suggests that the NDF market is more strongly affected than the interbank market by news about international reserves. Or, put differently, forward market participants attach more informational value than interbank market participants to foreign reserves as an indicator of the sustainability of the convertibility regime. Also like in previous regressions, hard currency reserves have a larger impact than reserves taking the form of public debt.

In turn, the three variables related to risk perceptions carry positive and significant coefficients in column 1, suggesting that the forward premium is more sensitive also to risk than the interbank premium. In column 2, however, their estimates are less precise, and only the Latin EMBI spread is moderately significant (at the 10 percent level).

The EGARCH parameters in columns 1 and 2 continue to show asymmetric effects of positive and negative shocks, with the former (i.e., those that increase the differential) having a larger impact on volatility than the latter. In fact, in column 1 negative shocks tend to reduce volatility. However, the column 1 estimates suggest a nonstationary log variance process, which is not the case in column 2. Finally, the residuals show some traces of autocorrelation at lag 10, although short of significance at 5 percent.

Columns 3 and 4 in Table 7 report the results for the 12-month premium differential across markets. On the whole, the sign pattern of the coefficient estimates is similar to that just described. As with the shorter maturity, we find that total (column 3) or hard currency (column 4) reserves carry a negative and significant coefficient; however, debt reserves are now insignificant in column 4. Among the risk indicators, the high-yield spread is now insignificant in both specifications. The EMBI spread and banks' liquidity ratio carry positive coefficients, but they are significant (at 10 percent) only in column 4.

Unlike in the 1-month estimates, in this case the estimated EGARCH parameters provide no indication of asymmetry. The Box-Pierce statistics do not reveal any symptoms of autocorrelation.

VII. Summary and Conclusions

Emerging economies typically show positive interest rate differentials vis-à-vis industrial economies. They reflect two ingredients: the country premium and the currency premium. While the former has been studied in depth by the recent literature, the latter has received much less empirical attention, probably due to lack of adequate data. Nevertheless, the currency premium has attracted considerable interest in the debate on the choice of exchange rate regime for emerging countries, as well as in the analysis of target zones and covered interest parity, both of which focus mainly on developed countries.

In this paper we have characterized the behavior of the currency premium for two currency boards that have been able to maintain a hard peg to the U.S. dollar for a very long time. Several interesting findings emerge from the paper, and some puzzles are left open for future research. They can be summarized in five main points.

First, despite the presumed rigidity of the peg underlying currency boards, currency risk premia tend to be uniformly positive, suggesting that markets persistently anticipate a devaluation of the exchange rate. We find very few instances in which the currency premium is negative. This raises the question of whether currency boards really yield sufficient credibility as to minimize currency risk. Of course, to answer the question one would need to examine also the currency premium under other exchange rate regimes; perhaps that observed under currency boards is consistently lower than in other regimes. But in any case the implication is that even full backing of the monetary base does not suffice to eliminate currency risk. The ensuing question is whether dollarization offers the only road to achieve that end.

Second, political and economic events seem to be important factors in the behavior of currency risk premia. The currency premium in Argentina increased during the Mexican, Asian, Russian, and Brazil crises. Moreover, several political and economic events – such as the crisis ignited in March 2001 – had a large impact on the premium. Regarding Hong Kong, the currency premium increased significantly during the Mexican crisis, the Asian crisis and, especially, during the attacks on the Hong Kong dollar.

In a related paper we have argued that it is easier for currency regimes to achieve credibility when they are easily verifiable by available data.[24] In this paper we find that Argentine markets reacted negatively to the announcement of a proposal to replace the simple dollar peg underlying the convertibility system with a basket peg composed of U.S. dollars and euros. The immediate result was a jump in the currency premium, as markets perceived the peso to be riskier rather than more stable as the government had intended. This is also consistent with the evidence found during the management of the Mexican crisis. When the government took measures to reinforce the existing currency board, markets welcomed those moves. But any actions viewed as departures from the rigid currency board generated a negative reaction among investors.[25]

Third, the yield curve of currency premia tends to slope upward, but invariably flattens out or turns negative at the peak of crises. This is consistent with previous research that has found short-term premia to be more volatile than long premia, and can be explained by several factors. During financial turmoil, markets may revise upward their perceived probability of immediate collapse of the regime more than the probability of eventual collapse. Furthermore, fluctuations in the term structure might also reflect different liquidity in the short- and long-term markets. These fluctuations in the term premia imply that one needs to proceed with care when comparing interest rate differentials, currency premia, and country premia of different maturities. A remaining question is whether this seemingly predictable behavior of term premia generates opportunities for arbitrage; it certainly prompts investors to take speculative bets.

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[24] See Frankel, Fajnzylber, Schmukler, and Servén (2000).

[25] See Ganapolsky and Schmukler (2001).

Fourth, we find that prices of currency risk differ across markets. The spread between the forward discount and the currency premium derived from interbank currency and deposit rates tends to be positive, and increases substantially during times of financial turbulence. This finding admits different interpretations. It might reflect a failure of covered interest parity that leaves unexploited arbitrage opportunities. In principle, domestic banks could arbitrage them away, but anecdotal evidence suggests that at times of financial stress banks prefer to protect their liquidity and refrain from cross-market arbitrage. Alternatively, it is also possible that heterogeneity across markets, reflected in different pricing of the same risk, cannot be arbitraged due to the existence of large transaction costs. In the Argentine case, however, formal transaction costs are not large in the markets we analyze, and they are unlikely to get much larger during crises – although bid-ask spreads can certainly increase at times of high volatility. Finally, the two measures of the currency premium might involve risks not considered in most analyses, such as differential default risk in the exchange and money markets. Without detailed information on market transactions it is not possible to disentangle this puzzle, whose resolution remains open to future research.

Fifth, in the case of Argentina we find that domestic and foreign monetary and financial factors related to risk perceptions and anticipations of devaluation exert a systematic effect on the currency premium, its term structure, and the cross-market spread. Risk related to high-yield instruments and Latin American bonds have in most cases a positive effect on currency premia and cross-market spreads. Reserves – especially hard currency reserves, more than government-bond reserves – have a negative impact on currency premia and cross-market spreads, and a positive one on the term premium. The liquidity position of the financial sector, which reflects the risk perceived by financial institutions, affects positively currency premia and the cross-market spread and negatively the term premium.

In this paper we have made some progress towards understanding the currency premium, and we have also raised new puzzles. It would be useful to know whether similar facts and puzzles emerge for other countries and other currency regimes. Preliminary research suggests that this is the case, but the question remains open for future work.

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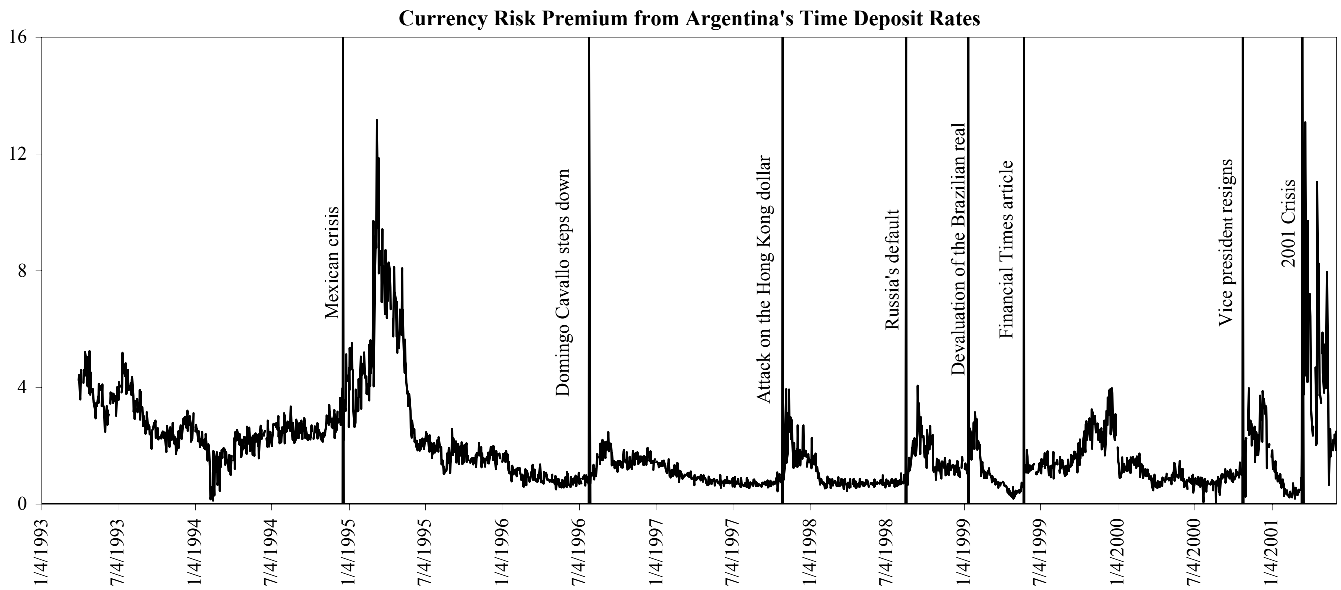
Figure 1
Currency Premia under Currency Boards

Figure 1 shows historical values of daily of currency risk premia in Argentina (top panel) and Hong Kong (lower panel). The currency risk premium for Argentina is calculated as the spread of local peso time deposit rates over local U.S. dollar interbank deposit rates, with maturities up to 2 months. The currency risk premium for Hong Kong is calculated with the forward discount, the forward exchange rate minus spot exchange rate, using 1-month contracts. All rates are in percentages, annualized, and continuously compounded. The sample for Argentina covers the period 4/1/93 - 5/6/01, for Hong Kong it covers the period 1/4/93 - 6/5/01.



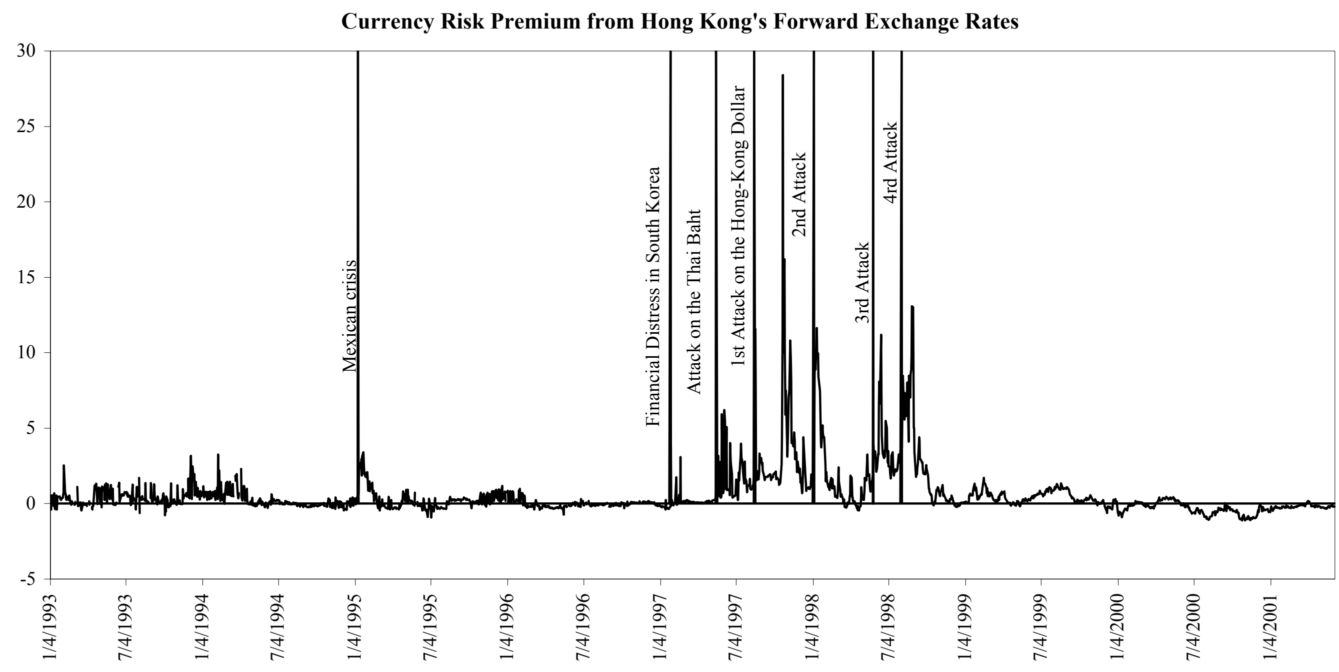


Table 1
History of Currency Premia in Argentina and Hong Kong
Summary Statistics

The table shows summary statistics of daily currency risk premia in Argentina and Hong Kong for different samples. The currency risk premium for Argentina is calculated as the spread of local peso time deposit rates over local U.S. dollar interbank deposit rates, with maturities up to 2 months. The crisis periods for Argentina are the following: (i) Mexican crisis, (ii) Attack on the Hong Kong dollar, (iii) Russia's default, (iv) Devaluation of the Brazilian real, (v) Financial Times article and presidential elections, (vi) Vice president resigns, (vii) 2001 Crisis. The crisis periods for Hong-Kong are: (i) The Mexican crisis, (ii) the Financial distress in Korea, (iii) the Attacks on the Thai baht and the four attacks on the Hong Kong dollar. See text for a description of all the events.

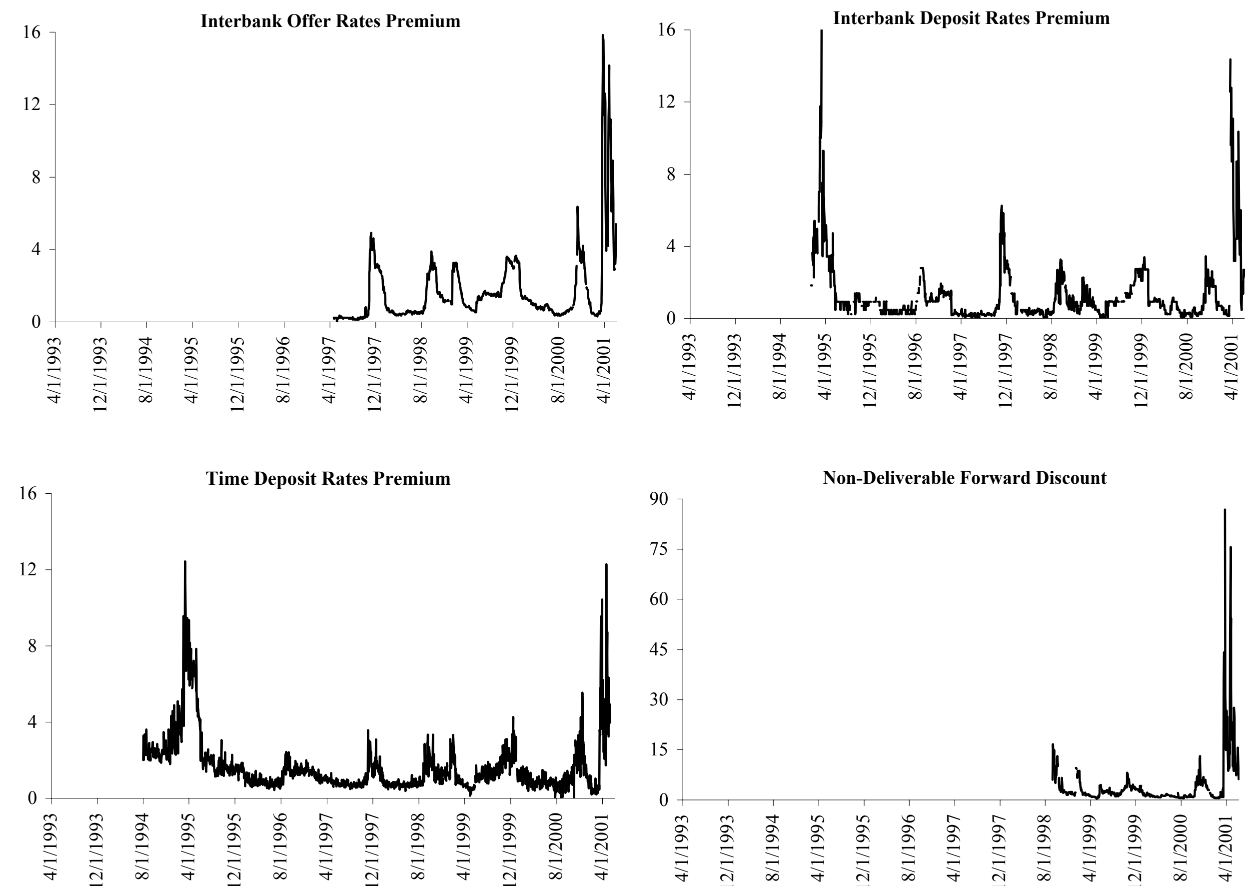
	Dates	*Number of Observations*	*Mean*	*Median*	*Standard Deviation*	*Min*	*Max*
Argentina							
Time Deposit Rates							
Up to 2 month							
Total	04/01/93 - 06/05/01	2,044	1.89	1.45	1.50	0.01	13.16
Tranquil Periods (after the Mexican Crisis)		1,205	1.22	0.98	0.92	0.01	8.12
Crisis Periods		392	2.97	2.32	2.20	0.25	13.16
Mexican crisis	01/10/95 - 04/10/95	63	6.03	5.20	2.43	2.64	13.16
Attack on the Hong Kong dollar	10/29/97 - 11/26/97	21	2.23	2.23	0.90	0.83	3.93
Russia's default	08/19/98 - 10/16/98	42	2.01	1.93	0.69	0.65	4.05
Devaluation of the Brazilian real	01/13/99 - 02/12/99	23	2.10	2.06	0.56	0.97	3.15
Financial Times article and elections	05/17/99 - 12/17/99	149	1.86	1.55	0.74	0.88	3.97
Vice president resigns	10/06/00 - 12/29/00	56	2.16	2.20	0.90	0.25	3.97
2001 Crisis	03/16/01 - 05/18/01	38	5.48	4.80	2.52	2.02	13.08
Hong Kong							
Forward Rates							
Total Sample	01/04/93 - 06/05/01	2,161	0.60	1.14	1.67	-1.11	28.40
Tranquil Periods		1,829	0.17	0.08	0.54	-1.11	3.25
Crisis Periods		332	3.01	2.17	3.13	-0.47	28.40
Mexican crisis	01/10/95 - 04/10/95	62	0.73	0.38	1.06	-0.47	3.41
Early signs of financial distress	01/27/97 - 02/21/97	19	0.50	0.09	1.12	-0.19	3.76
Attack on the Thai bath	05/14/97 - 7/24/97	51	1.82	1.01	1.63	0.23	6.21
1st Attack on the Hong-Kong dollar	08/15/97 - 12/15/97	87	3.86	2.25	3.98	0.70	28.40
2nd Attack on the Hong-Kong dollar	01/05/98 - 02/04/98	22	5.98	4.91	2.93	1.47	11.65
3rd Attack on the Hong-Kong dollar	05/27/98 - 07/06/98	29	4.18	3.48	2.05	2.12	11.19
4th Attack on the Hong-Kong dollar	07/10/98 - 10/06/98	62	4.26	3.05	2.72	1.78	13.09

Figure 2
Alternative of Measures of Currency Premia

The figure shows different measures of currency premia for Argentina and Hong Kong, using daily 1-month interest rate premia and 1-month forward exchange rate discounts. The interest rates used for Argentina include the interbank offer rate (BAIBOR), the money market rate index (MMR), both obtained from Bloomberg, and the time deposit rates (TDP), obtained from the Central Bank of Argentina. For each type of rate, the currency risk for Argentina is measured by the difference between the rate denominated in domestic currency and in U.S. dollars. The forward exchange rates for Argentina are non-deliverable forward (NDF) rates and the NDF currency risk is measured by the forward discount. NDF forward rates are from two sources: Deutsche Bank and Bloomberg.

The interest rates used for Hong Kong are interbank offer rates (HIBOR), obtained from the Hong Kong Monetary Authority. The premium is obtained over the U.S.-dollar LIBOR. The forward rates used for Hong Kong are from Bloomberg and correspond to deliverable contracts (FWD). All the rates are annualized, in percentages, and continuously compounded.

Argentina



Hong Kong

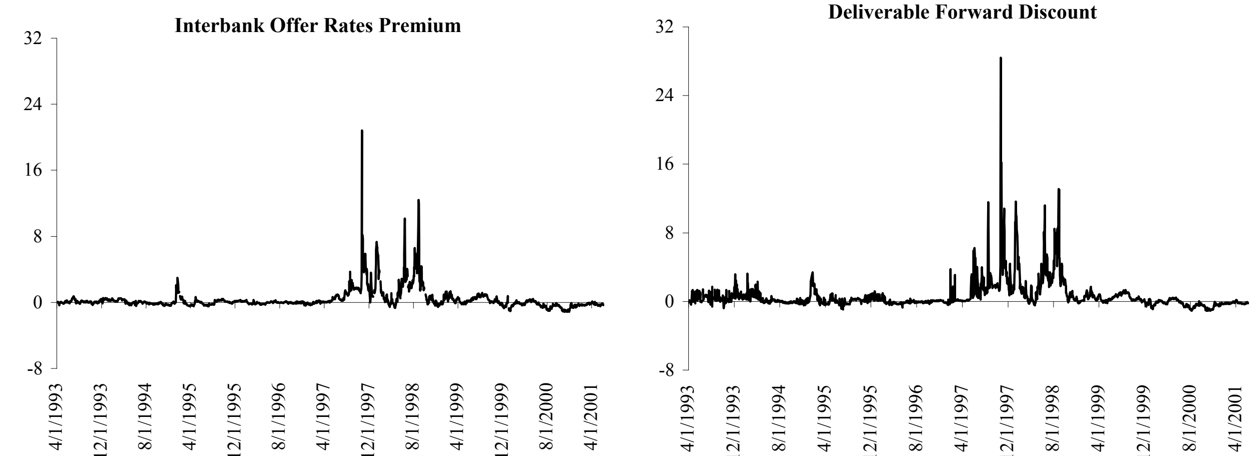


Table 2
Alternative Measures of Currency Premia
Summary Statistics

The table shows summary statistics for different measures of currency premia for Argentina and Hong Kong, using daily 1-month interest rates and 1-month forward discounts from 9/9/98 to 6/5/01 for Argentina and 1/4/93 to 6/5/01 for Hong Kong. The differences in the number of observations are due to missing values. The interest rates used for Argentina include the interbank offer rate (BAIBOR), the money market rate index (MMR), both obtained from Bloomberg, and the time deposit rates (TDP), obtained from the Central Bank of Argentina. For each type of rate, the currency risk for Argentina is measured by the difference between the rate denominated in domestic currency and in U.S. dollars. The forward exchange rates for Argentina are non-deliverable forward (NDF) rates and the NDF currency risk is measured by the forward discount. NDF forward rates are from two sources: Deutsche Bank and Bloomberg.
The interest rates used for Hong Kong are interbank offer rates (HIBOR), obtained from the Hong Kong Monetary Authority. The premium is obtained over the U.S.-dollar LIBOR. The forward rates used for Hong Kong are from Bloomberg and correspond to deliverable contracts (FWD). All the rates are annualized, in percentages, and continuously compounded.

	Number of Observations	*Mean*	*Median*	*Standard Deviation*	*Min*	*Max*
Argentina						
Interbank Offer Rates	649	2.05	1.33	2.26	0.29	15.83
Time Deposit Rates	651	1.52	1.30	1.19	0.04	12.29
Interbank Deposit Rates	632	1.34	0.93	1.70	0.00	14.37
Non-Deliverable Forward Rates	659	4.15	2.04	7.28	0.42	86.85
Hong Kong						
Interbank Offer Rates	2065	0.34	0.03	1.26	-1.14	20.81
Deliverable Forward Rates	2161	0.60	0.14	1.67	-1.11	28.40

Correlations

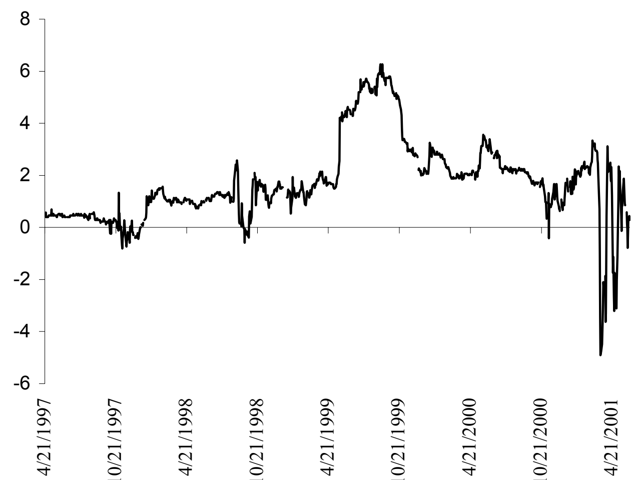
	Interbank Offer Rates	Time Deposit Rates	Interbank Deposit Rates	Non-Deliverable Forward Rates
Interbank Offer Rates	1			
Time Deposit Rates	0.85	1		
Interbank Deposit Rates	0.93	0.78	1	
Non-Deliverable Forward Rates	0.81	0.77	0.70	1

	Interbank Offer Rates	Deliverable Forward Rates
Interbank Offer Rates	1	
Deliverable Forward Rates	0.94	1

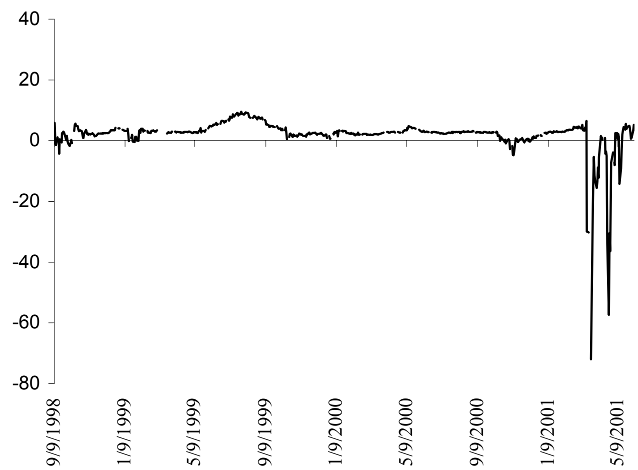
Figure 3
Term Structure of Currency Premia

The figure shows the term structure of the currency risk premium in Argentina (top panel) and Hong Kong (bottom panel), calculated with the difference between the 12-month and 1-month currency premium. For each country, the currency premium is measured using both interbank offer rates and forward exchange rates. For Argentina the peso interbank offer premium is obtained with the spread of peso over dollar denominated Argentine interbank offer rates, while for Hong Kong the interbank offer risk is measured with the spread of the Hong Kong interbank offer rates over the U.S.-dollar LIBOR. The forward discounts are measured by the spreads of non-deliverable forward (NDF) exchange rates, for Argentina, and deliverable forward rates, for Hong Kong, over the spot exchange rate, respectively. The interest rates for Hong-Kong were obtained from the Hong Kong Monetary Authority. The Argentine interbank rates are from Bloomberg and the NDF rates were obtained from Deustche Bank and Bloomberg.

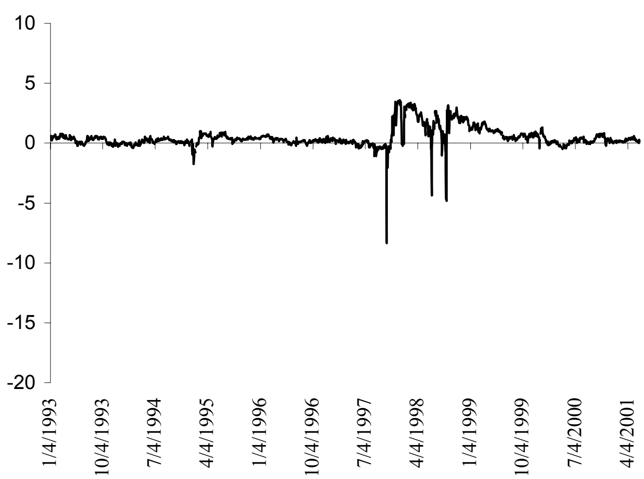
Argentina's Interbank Offer Term Structure



Argentina's NDF Discount Term Structure



Hong Kong's Interbank Offer Term Structure



Hong Kong's Forward Discount Term Structure

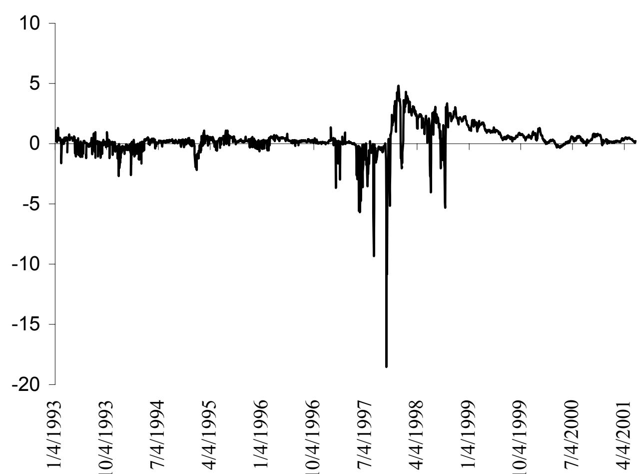


Table 3
Term Structure of Currency Premia
Summary Statistics

The table shows the summary statistics for the term premia, spread between the currency premium measured with 12-month rates over the one from 1-month rates, during crisis and tranquil periods, for Argentina and Hong Kong.
The crisis periods for Argentina are the following: (i) Mexican crisis, (ii) Attack on the Hong Kong dollar, (iii) Russia's default, (iv) Devaluation of the Brazilian real, (v) Financial Times article and presidential elections, (vi) Vice president resigns, (vii) 2001 Crisis. The crisis periods for Hong-Kong are: (i) The Mexican crisis, (ii) the Financial distress in Korea, (iii) the Attacks on the Thai baht and the four attacks on the Hong Kong dollar. See text for a description of all the events.

	Dates	*Number of Observations*	*Mean*	*Median*	*Standard Deviation*	*Min*	*Max*
Argentina							
Interbank Offer Rates							
Total	04/21/97-06/05/01	1,026	1.73	1.52	1.59	-4.91	6.27
Tranquil Periods		697	1.45	1.39	0.89	-0.78	4.42
Crisis Periods		329	2.32	1.96	2.38	-4.91	6.27
Attack on the Hong Kong dollar	10/29/97 - 11/26/97	21	-0.24	-0.30	0.35	-0.81	0.54
Russia's default	08/19/98 - 10/16/98	42	0.81	0.49	0.95	-0.59	2.58
Devaluation of the Brazilian real	01/13/99 - 02/12/99	23	1.30	1.31	0.31	0.54	1.93
Financial Times Article and elections	05/17/99 - 12/17/99	149	4.44	4.86	1.26	2.00	6.27
Vice president resigns	10/06/00 - 12/29/00	56	1.24	1.30	0.47	-0.41	1.88
2001 Crisis	03/16/01 - 05/18/01	38	-0.73	-1.14	2.49	-4.91	3.11
Argentina							
NDF Rates							
Total	10/20/97-06/05/01	654	2.05	2.73	5.76	-72.00	9.56
Tranquil Periods (after the Mexican Crisis)		370	2.89	2.84	0.78	-2.92	6.43
Crisis Periods		284	0.97	2.05	8.58	-72.00	9.56
Russia's default	08/19/98 - 10/16/98	27	1.06	0.28	2.45	-4.25	5.79
Devaluation of the Brazilian real	01/13/99 - 02/12/99	22	1.93	2.09	1.56	-0.44	3.98
Financial Times Article	05/17/99 - 12/17/99	141	4.81	4.70	2.62	0.49	9.56
Vice president resigns	10/06/00 - 12/29/00	56	0.33	0.46	1.59	-4.85	2.97
2001 Crisis	03/16/01 - 05/18/01	38	-12.95	-8.46	16.48	-72.00	2.51
Hong Kong							
Interbank Offer Rates							
Total	01/04/93-06/05/01	2065	0.49	0.30	0.81	-8.36	3.58
Tranquil Periods		1754	0.50	0.32	0.69	-0.51	3.58
Crisis Periods		311	0.44	0.17	1.30	-8.36	3.46
Mexican crisis	01/10/95 - 04/10/95	59	0.24	0.58	0.65	-1.75	0.99
Early signs of financial distress	01/27/97 - 02/21/97	18	0.18	0.19	0.09	-0.07	0.38
Attack on the Thai Bath	05/14/97 - 7/24/97	46	-0.08	-0.11	0.20	-0.44	0.25
1st Attack on the Hong-Kong dollar	08/15/97 - 12/15/97	81	0.06	-0.34	1.52	-8.36	3.45
2nd Attack on the Hong-Kong dollar	01/05/98 - 02/04/98	20	1.37	1.69	1.39	-0.24	3.46
3rd Attack on the Hong-Kong dollar	05/27/98 - 07/06/98	28	0.81	1.04	1.29	-4.37	2.69
4th Attack on the Hong-Kong dollar	07/10/98 - 10/06/98	59	1.18	1.56	1.58	-4.83	3.16
Hong Kong							
Forward Rates							
Total	01/04/93-06/05/01	2152	0.37	0.25	1.18	-18.54	4.81
Tranquil Periods		1820	0.45	0.26	0.81	-2.69	4.81
Crisis Periods		332	-0.09	-0.06	2.28	-18.54	4.30
Mexican crisis	01/10/95 - 04/10/95	62	-0.16	0.11	0.79	-2.17	1.08
Early signs of financial distress	01/27/97 - 02/21/97	19	-0.37	0.07	1.13	-3.66	0.28
Attack on the Thai Bath	05/14/97 - 7/24/97	51	-1.43	-0.55	1.60	-5.70	0.03
1st Attack on the Hong-Kong dollar	08/15/97 - 12/15/97	87	-0.76	-0.37	3.12	-18.54	3.54
2nd Attack on the Hong-Kong dollar	01/05/98 - 02/04/98	22	1.39	2.63	2.19	-2.05	4.30
3rd Attack on the Hong-Kong dollar	05/27/98 - 07/06/98	29	0.93	1.25	1.63	-4.05	2.63
4th Attack on the Hong-Kong dollar	07/10/98 - 10/06/98	62	1.14	1.75	1.86	-5.32	3.34

Table 4
Determinants of Currency Premia and Term Premia in Argentina

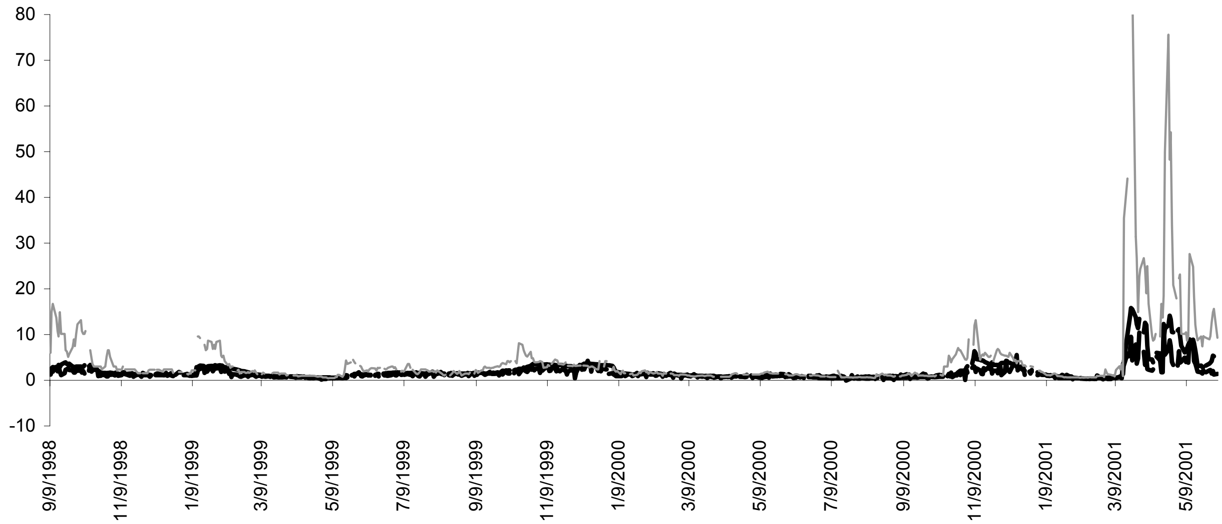
The columns of the table show the results for exponential garch (EGARCH) regressions of the currency premia and term premia on a set of explanatory variables. The models estimated are described in equations (12a') and (12b) in the paper. The first two columns of the table shows the results for the 1-month NDF discount, the next two columns for the 12-month NDF discount, and the last two columns for the term structure (12-month minus 1-month). The first specification, columns (1), (3), and (5), includes the ratio of total reserves of the central bank to total deposits of the fiancial system as a regressor. The second specification, columns (2), (4), and (6), disagregates the reserves of the central bank into the ratio of reserves held in the form of government bonds to total deposits and the ratio of hard currency reserves held to total deposits.
The regessors common to both specifications are: (i) the spread of a high yield bond index over a comparable U.S. government bond, (ii) the EMBI spread of Latin American countries excluding Argentina, and (iii) the ratio of total cash held by the financial system over its total deposits. To explain the term premia, the term structure of the U.S. treasury bill rate (12-month minus 1-month) is also included in the set of regressors. A few deterministic variables are also included in all regression: a contant, a trend, dummy variables for the Russian crisis, the Brasilian devaluation, the resignation of the vice president, the declarations of Domingo Cavallo reported by the Financial Times, and the 2001 crisis. Standard errors are in parentheses. * (**) means significant at the 10 (5) percent level.

Dependent Variable in First Differences:	1-month NDF Discount (f_1-s)		12-month NDF Discount (f_{12}-s)		NDF Term Structure (f_{12}-f_1)	
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged Dependent Variable	-0.220 **	-0.241 **	-0.037 **	-0.021 *	-0.060 **	-0.204 **
	(0.009)	(0.016)	(0.010)	(0.011)	(0.011)	(0.014)
U.S. Term Structure	-	-	-	-	0.054	0.164 *
					(0.092)	(0.941)
High Yield Spread	0.148 **	-0.063	-0.086	0.238 **	-0.120	0.163 **
	(0.051)	(0.105)	(0.101)	(0.089)	(0.116)	(0.068)
Latin EMBI Spread	0.058 **	0.056 **	0.011	-0.013	0.053 **	0.068 **
	(0.008)	(0.026)	(0.014)	(0.011)	(0.017)	(0.020)
Total Reserves over Deposits (t-3)	-0.038 **	-	-0.016 **	-	0.001	-
	(0.006)		(0.005)		(0.006)	
Bond Reserves over Deposits (t-3)	-	-0.033 **	-	-0.005	-	0.058 **
		(0.010)		(0.007)		(.007)
Hard Currency Reserves over Deposits (t-3)	-	-0.548 **	-	-0.152 *	-	0.560 **
		(0.148)		(0.097)		(.090)
Banks' Cash over Deposits (t-3)	-0.001	0.013 **	-0.001	0.009 **	-0.004	-0.021 **
	(0.003)	(0.005)	(0.002)	(0.003)	(0.003)	(0.003)
earch	2.325 **	0.917 **	0.247 **	0.215 **	0.397 **	0.097
	(0.289)	(0.130)	(0.068)	(0.037)	(0.119)	(0.090)
arch-abs.	-1.920 **	-1.828 **	0.836 **	-0.021	1.863 **	2.112 **
	(0.298)	(0.183)	(0.106)	(0.027)	(0.161)	(0.116)
egarch	1.031 **	0.767 **	0.875 **	1.124 **	0.921 **	0.832 **
	(0.020)	(0.055)	(0.036)	(0.020)	(0.037)	(0.039)
Number of observations	287	304	440	436	333	353
Maximum number of lags	7	6	6	6	5	5
Q(5) p-value	0.94	0.89	0.69	0.79	0.13	0.13
Q(10) p-value	0.99	1.00	0.72	0.89	0.14	0.08
Log-likelihood	-316.27	-443.35	-228.81	-305.53	-355.54	-392.66
Wald test of joint significance (p-value)	0.00 **	0.00 **	0.00 **	0.00 **	0.00 **	0.00 **

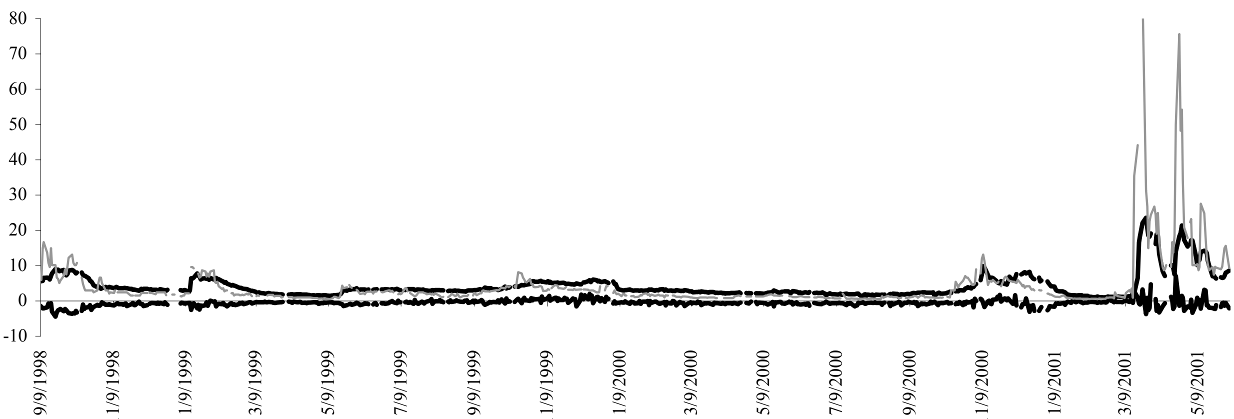
Figure 4
Non-Deliverable Forward Discount and No-Arbitrage Bands

The figure shows the 1-month Non-Deliverable Forward (NDF) discount and two threshholds defining no-arbitrage bands. The top panel displays the forward discount and two currency premia, the spread between peso and dollar denominated Argentine interbank rates and the spread between peso and dollar Argentine time deposit rates. In the middle panel, the upper threshhold consists of the difference between the interbank offer rate in pesos and the time deposit rate in dollars; the lower threshhold is the difference between the time deposit rate in pesos and the interbank offer rate in dollars. In the lower panel, the upper threshold is the difference between the BAIBOR in pesos and the U.S. deposit rate in dollars; the lower threshold is the spread of the Argentine time deposit rate in dollars over the U.S. Federal Funds Rate. All rates are annualized. See text for a discussion on arbitrage in case 1, 2, and 3.

Case 1: $\left(i_{t,k}^{lending} - i_{t,k}^{lending,*}\right) = fd_{t,k} = \left(i_{t,k}^{deposit} - i_{t,k}^{deposit,*}\right)$



Case 2: $\underbrace{\left(i_{t,k}^{lending} - i_{t,k}^{deposit,*}\right)}_{\text{upper band}} \geq fd_{t,k} \geq \underbrace{\left(i_{t,k}^{deposit} - i_{t,k}^{lending,*}\right)}_{\text{lower band}}$



Case 3: $\underbrace{\left(i_{t,k}^{lending} - {}^{offshore}i_{t,k}^{deposit,*}\right)}_{\text{upper band}} \geq fd_{t,k} \geq \underbrace{\left(i_{t,k}^{deposit} - {}^{offshore}i_{t,k}^{lending,*}\right)}_{\text{lower band}}$

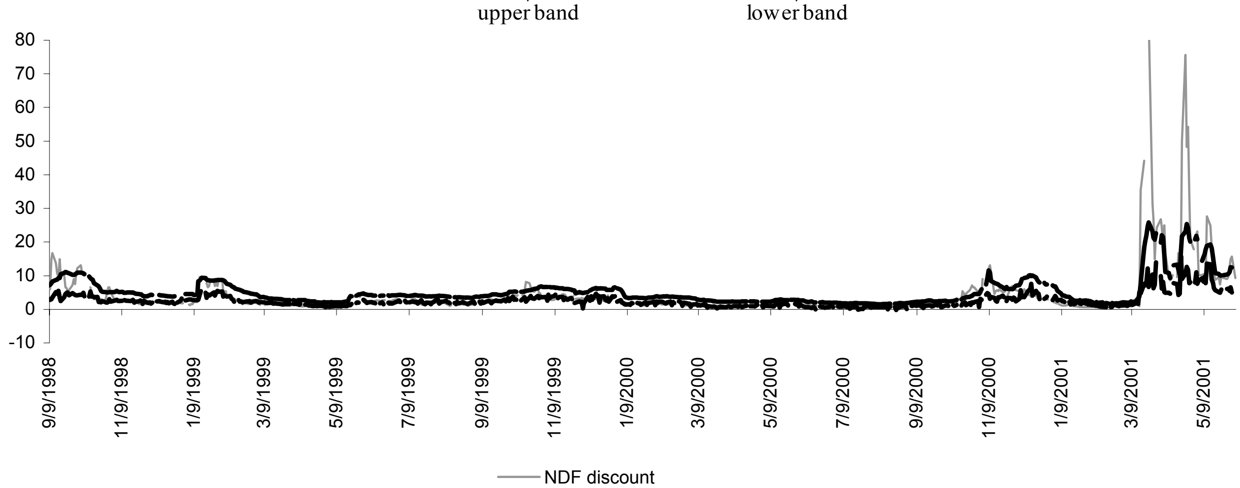


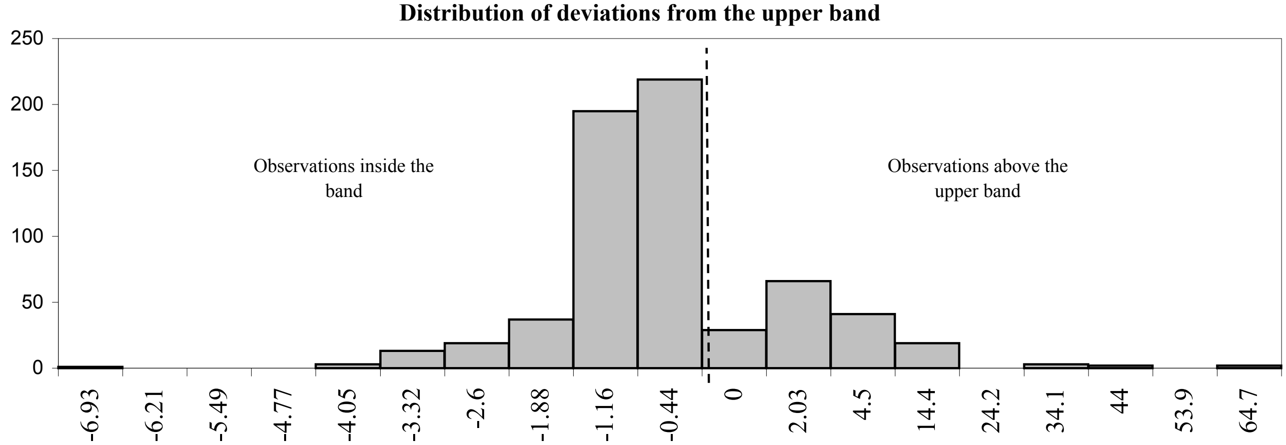
Table 5
Currency Premia and the No-Arbitrage Band

The top panel shows summary statistics fo the 1-month Non-Deliverable Forward (NDF) discount and two threshholds defining the no-arbitrage band. The upper threshhold consists of the difference between the interbank offer rate in pesos and the time deposit rate in dollars. The lower threshhold is the difference between the time deposit rate in pesos and the interbank offer rate in dollars. The mid panel shows the histogram of the difference between the NDF discount and the upper band. Since there are no observations bellow the lower band, negative observations correspond to observations inside the no-arbitrage band, while positive observations correspond to deviations from the no-arbitrage condition. The lower panel shows econometric estimations of revertion to the no-arbitrage band for observations of the NDF discount outside the band and to the conditional mean for observations of the NDF discount inside the band.

Summary Statistics

	Number of Observations	*Obs. as Percent of Total*	*Mean*	*Stdandard Deviation*	*Min*	*Max*
NDF discout	649	-	4.11	7.27	0.42	86.85
Upper band	665	-	4.05	3.33	1.00	23.61
Lower band	665	-	-0.57	0.91	-4.49	7.07
Obs. above the no-arbitrage band	133	20%	12.07	12.96	1.20	86.85
Obs. inside the no-arbitrage band	516	78%	2.06	1.69	0.42	14.91

Distribution of deviations from the upper band



Revertion of Forward Discount

$$\begin{cases} \Delta\left(fd_{t,k} - \left(i_{t,k} - i^*_{t,k}\right)\right) & = & c^{out} + \lambda^{out}\left(fd_{t-1,k} - \left(i_{t-1,k} - i^*_{t-1,k}\right)\right) + \varepsilon^{out}_{t,k} & \text{if} \quad fd_{t,k} > \left(i_{t,k} - i^*_{t,k}\right) \\ \Delta fd_{t,k} & = & c^{in} + \lambda^{in} fd_{t-1,k} + \varepsilon^{in}_{t,k} & \text{if} \quad fd_{t,k} \le \left(i_{t,k} - i^*_{t,k}\right) \end{cases}$$

$$\varepsilon_t^{out} \sim N(0, \sigma^{out2}) \text{ and } \varepsilon_t^{in} \sim N(0, \sigma^{in2})$$

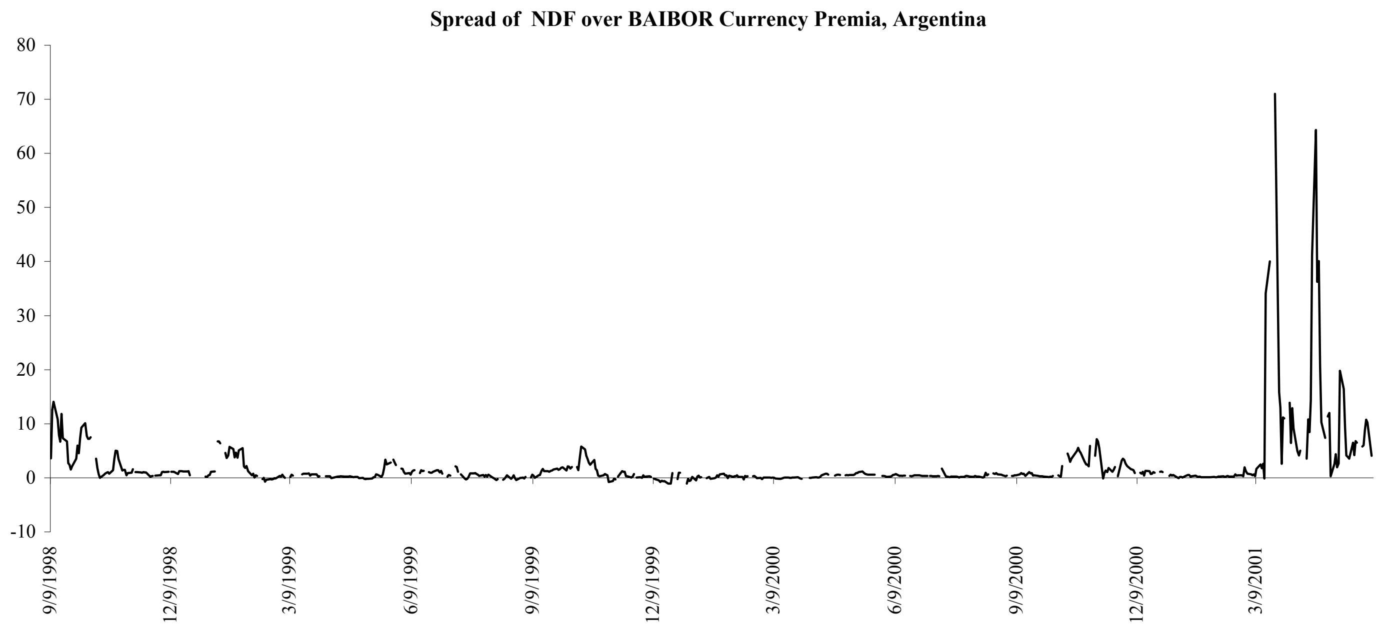
		λ^j	*t-ratio*	*Dickey-Fuller 1% critical value*	*Half life*
Without lags in 1st differences	*outside no-arbitrage band* [1]	-0.45	-7.24	-3.50	1.17
		(0.06)			
	inside no arbitrage band [2]	-0.07	-6.28	-3.28	9.68
		(0.01)			
Includibg 4 lags in 1st differences	*outside no-arbitrage band* [1]	-0.56	-12.70	-3.71	0.85
		(0.04)			
	inside no arbitrage band [2]	-0.06	-3.70	-2.64	10.68
		(0.02)			

1 The half-life corresponds to the convergence to the non-arbitrage band

2 The half-life corresponds to the convergence to the conditional mean

Figure 5
Cross-Market Currency Premium Differential

The figure shows the spread between the 1-month forward discounts and interbank currency risk premium for Argentina and Hong Kong. The interbank rate for Argentina is the interbank offer rate (BAIBOR) obtained from Bloomberg. Since these rates are denominated only in Hong Kong dollars, the measure of risk is the spread of these rates over the U.S. dollar LIBOR. All the rates are annualized, in percentages, and continuously compounded. The forward exchange rates for Argentina are non-deliverable forward (NDF) rates obtained from Deutsche Bank and Bloomberg. The forward rates for Hong Kong correspond to deliverable contracts and come from Bloomberg. The interbank rates used for Hong Kong are interbank offer rates (HIBOR) obtained from the Hong Kong Monetary Authority.



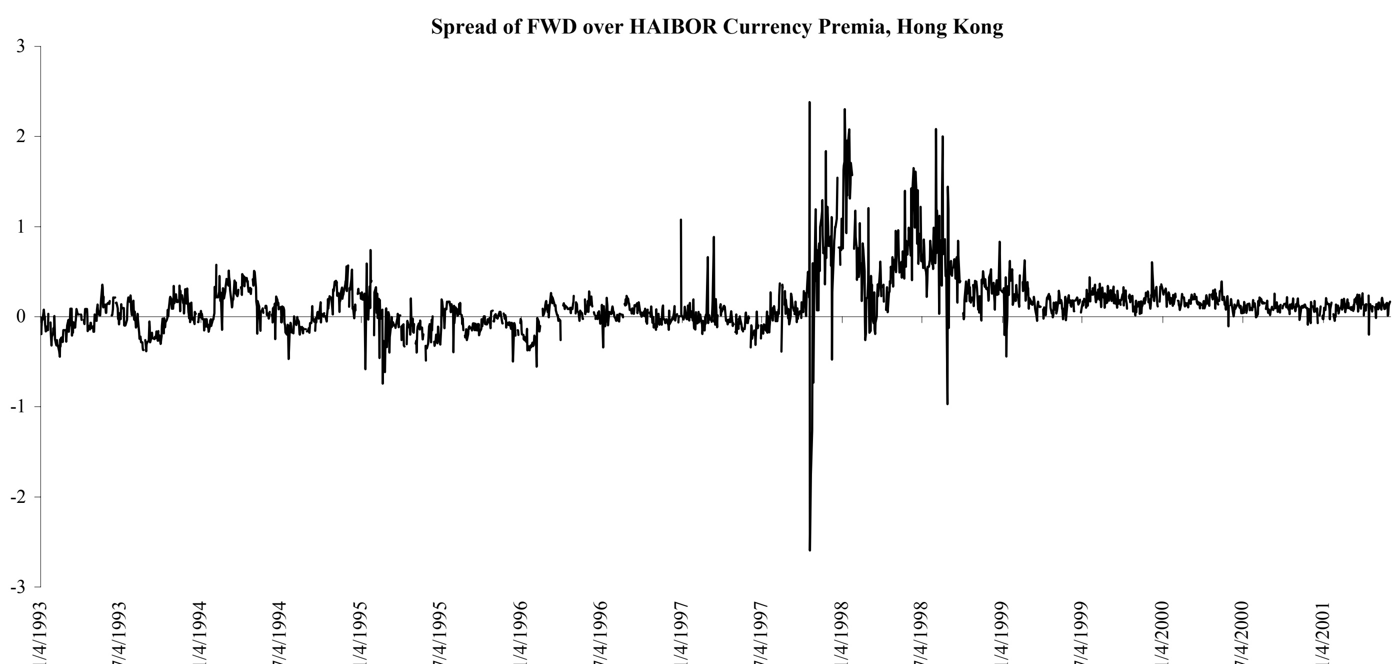


Table 6
Cross-market currency premium differential
Summary Statistics

The table shows summary statistics of the spread between the 1- and 12-month forward discounts and interbank currency risk premia for Argentina and Hong Kong, using different samples. The currency risk premium for Argentina is calculated as the spread of local peso time deposit rates over local U.S. dollar interbank deposit rates.
The crisis periods for Argentina are the following: (i) Mexican crisis, (ii) Attack on the Hong Kong dollar, (iii) Russia's default, (iv) Devaluation of the Brazilian real, (v) Financial Times article and presidential elections, (vi) Vice president resigns, (vii) 2001 Crisis. The crisis periods for Hong-Kong are: (i) The Mexican crisis, (ii) the Financial distress in Korea, (iii) the Attacks on the Thai baht and the four attacks on the Hong Kong dollar. See text for a description of all the events.

	Dates	*Number of Observations*	*Mean*	*Median*	*Standard Deviation*	*Min*	*Max*
Argentina							
NDF-BAIBOR 1-month							
Total	04/21/97-06/05/01	649	2.06	0.53	5.63	-1.09	71.02
Tranquil Periods		369	0.71	0.33	1.40	-1.05	10.74
Crisis Periods		280	3.83	1.37	8.09	-1.09	71.02
Russia's default	08/19/98 - 10/16/98	27	6.18	6.74	3.77	0.01	14.07
Devaluation of the Brazilian real	01/13/99 - 02/12/99	22	3.43	3.74	2.25	0.05	6.73
Financial Times Article and elections	05/17/99 - 12/17/99	141	0.79	0.60	1.09	-1.09	5.80
Vice president resigns	10/06/00 - 12/29/00	54	2.31	1.58	1.83	-0.14	7.12
2001 Crisis	03/16/01 - 05/18/01	36	16.51	11.07	16.95	0.29	71.02
NDF-BAIBOR 12-month							
Total	04/21/97-06/05/01	825	1.99	1.50	2.11	-1.73	12.21
Tranquil Periods		518	1.66	1.37	1.62	-1.31	12.14
Crisis Periods		307	2.53	2.02	2.67	-1.73	12.21
Attack on the Hong Kong dollar	10/29/97 - 11/26/97	13	3.02	2.52	1.26	1.22	5.68
Russia's default	08/19/98 - 10/16/98	41	6.88	6.56	2.14	4.09	12.21
Devaluation of the Brazilian real	01/13/99 - 02/12/99	22	4.05	3.80	1.87	1.92	9.81
Financial Times Article and elections	05/17/99 - 12/17/99	139	1.06	0.54	1.68	-1.73	4.57
Vice president resigns	10/06/00 - 12/29/00	54	1.41	1.27	0.90	-0.15	3.62
2001 Crisis	03/16/01 - 05/18/01	38	3.74	3.52	2.45	-0.83	9.16
Hong Kong							
FWD-HIBOR 1-month							
Total	01/04/93 - 06/05/01	2,046	0.25	0.09	0.65	-1.57	8.12
Tranquil Periods		1,738	0.14	0.08	0.30	-0.86	3.30
Crisis Periods		308	0.89	0.43	1.34	-1.57	8.12
Mexican crisis	01/10/95 - 04/10/95	58	0.34	0.25	0.36	-0.41	1.24
Early signs of financial distress	01/27/97 - 02/21/97	17	0.56	0.03	1.20	-0.12	3.83
Attack on the Thai Bath	05/14/97 - 7/24/97	46	1.32	0.21	1.62	-0.27	5.30
1st Attack on the Hong-Kong dollar	08/15/97 - 12/15/97	81	1.01	0.44	1.73	-0.54	8.12
2nd Attack on the Hong-Kong dollar	01/05/98 - 02/04/98	19	1.83	1.53	1.60	-0.38	4.83
3rd Attack on the Hong-Kong dollar	05/27/98 - 07/06/98	28	0.94	0.71	0.85	0.10	3.75
4th Attack on the Hong-Kong dollar	07/10/98 - 10/06/98	59	0.68	0.44	0.89	-1.57	4.15
FWD-HIBOR 12-month							
Total	01/04/93 - 06/05/01	2062	0.13	0.10	0.33	-2.59	2.38
Tranquil Periods		1751	0.09	0.09	0.21	-0.55	1.54
Crisis Periods		311	0.36	0.19	0.64	-2.59	2.38
Mexican crisis	01/10/95 - 04/10/95	59	-0.01	-0.01	0.26	-0.74	0.74
Early signs of financial distress	01/27/97 - 02/21/97	18	-0.03	-0.05	0.09	-0.19	0.19
Attack on the Thai Bath	05/14/97 - 7/24/97	46	-0.11	-0.10	0.09	-0.34	0.06
1st Attack on the Hong-Kong dollar	08/15/97 - 12/15/97	81	0.28	0.22	0.72	-2.59	2.38
2nd Attack on the Hong-Kong dollar	01/05/98 - 02/04/98	20	1.47	1.52	0.44	0.75	2.30
3rd Attack on the Hong-Kong dollar	05/27/98 - 07/06/98	28	1.00	0.91	0.34	0.41	1.65
4th Attack on the Hong-Kong dollar	07/10/98 - 10/06/98	59	0.65	0.61	0.44	-0.97	2.08

Table 7
Determinants of Cross-Market Currency Premium Differential in Argentina

The columns of the table show the results for exponential garch (EGARCH) regressions of the difference betwen the non-deliverable forward (NDF) discount and the Argentine interbank offer rate currency risk premium on a set of explanatory variables. The models estimated are described in equations (12a') and (12b) in the paper. The first two columns of the table show the results for the 1-month differential and last two columns for the 12-month differential.

Two different specifications are used for each maturity. The first specification, columns (1) and (3), includes the ratio of total reserves of the central bank to total deposits of the financial system as a regressor. The second specification, columns (2) and (4), disagregates the reserves of the central bank into the ratio of the reserves held in the form of government bonds to total deposits and the ratio of hard currency reserves to total deposits. The regessors common to both specifications are: (i) the spread of a high yield bond index over a comparable U.S. government bond, (ii) the EMBI spread of Latin American countries excluding Argentina, and (iii) the ratio of total cash held by the financial system over its total deposits. A few deterministic variables are also included in all regression: a contant, a trend, dummy variables for the Russian crisis, the Brasilian devaluation, the resignation of the vice president, the declarations of Domingo Cavallo reported by the Financial Times, and the 2001 crisis. Standard errors are in parentheses. * (**) means significant at the 10 (5) percent level.

Dependent Variable in First Differences:	1-month Differential $(f1\text{-}s)\text{-}(i_1\text{-}i^*_1)$		12-month Differential $(f12\text{-}s)\text{-}(i_{12}\text{-}i^*_{12})$	
	(1)	(2)	(3)	(4)
Lagged Dependent Variable	-0.351 **	-0.191 **	-0.022 **	-0.034 **
	(0.013)	(0.016)	(0.011)	(0.012)
High Yield Spread	0.246 **	-0.096	-0.116	-0.093
	(0.087)	(0.067)	(0.093)	(0.097)
Latin EMBI Spread	0.054 **	0.020 *	0.004	0.015 *
	(0.010)	(0.013)	(0.010)	(0.010)
Total Reserves over Deposits (t-3)	-0.056 **	-	-0.007 *	-
	(0.005)		(0.004)	
Bond Reserves over Deposits (t-3)	-	-0.025 **	-	-0.001
		(0.007)		(0.004)
Hard Currency Reserves over Deposits (t-3)	-	-0.220 **	-	-0.140 **
		(0.095)		(0.054)
Banks' Cash over Deposits (t-3)	0.027 **	0.004	0.004	0.004 *
	(0.002)	(0.003)	(0.003)	(0.002)
earch	1.166 **	0.381 **	0.023	-0.044
	(0.099)	(0.108)	(0.055)	(.053)
arch-abs.	-0.913 **	2.709 **	0.902 **	0.890 **
	(0.088)	(0.119)	(0.069)	(.062)
egarch	1.118 **	0.789 **	0.962 **	0.963 **
	(0.012)	(0.037)	(0.027)	(.026)
Number of observations	315	354	485	485
Maximum number of lags	6	5	4	4
Q(5) p-value	0.09	0.08	0.50	0.27
Q(10) p-value	0.44	0.25	0.77	0.52
Wald Test of Joint Significance (p-value)	0.00 **	0.00 **	0.00 **	0.00 **

Appendix Table 1
Data Description

	Decription	*Maturiy*	*Sample*	*Source*
Argentine data				
Non-deliverable forward exchange rates (NDF)	Pesos per U.S. dollar; for some dates the rates are reported as points for others as outright.	1 and 12 months	9/9/98-6/14/01 (1-month) 10/20/97-6/14/01 (12-month)	Bloomberg (1 and 12 months from 9/9/98); and Deutsche Bank (12-month before 9/9/98)
Spot exchange rate	Pesos per U.S. dollars	-	10/20/97 - 6/14/01	Bloomberg
Interbank offer rates in pesos and dollars (BAIBOR)	Annualized rate	1 and 12 months	4/21/97 - 6/14/01	Bloomberg
Time deposit rates in pesos and dollars	Annualized rate	1 month and up to 2 months	1/4/1993 - 6/5/01	Central Bank of Argentina
Interbank deposit rates in pesos and dollars	Annualized rate	1 month	1/13/1995 - 6/14/01	Bloomberg
Total reserves of the Central Bank	Total reserves held by the Central Bank of Argentina (government bonds and hard currency, U.S. dollar, billions)	-	12/29/1994 - 6/14/01	Bloomberg (original source: Central Bank of Agentina)
Bond reserves of the Central Bank	Reserves in BONEX (Bonos Externos) sold by the government of Argentina, (U.S. dollar, billions)	-	12/29/1994 - 6/14/01	Bloomberg (original source: Central Bank of Agentina)
Hard currency reserves	Reserves in hold, currency and short and long-term deposits (U.S. dollar, billions)	-	12/29/1994 - 6/14/01	Bloomberg (original source: Central Bank of Agentina)
Total deposits of the financial system	Total Argentine bank deposits (U.S. dollar, millions)	-	12/29/1994 - 6/14/01	Bloomberg (original source: Central Bank of
Total cash holdings of the financial system	Cash holdings (effectivo) in local and foreign currency (U.S. dollars, millions)	-	12/29/1994 - 6/14/01	Bloomberg (original source: Central Bank of Agentina)
Hong Kong data				
Deliverable forward exchange rate (FWD)	Hong Kong dollars per U.S. dollar	1 and 12 months	1/4/93 - 6/14/01	Bloomberg
Spot exchange rate	Hong Kong dollars per U.S. dollar	-	1/4/93 - 6/14/01	Bloomberg
Interbank rate in Hong Kong dollars (HIBOR)	Annualized rate	1 and 12 months	1/4/93 - 6/14/01	Hong Kong Monetary Authority
International data				
U.S. Federal Funds rates (FFR)	Annualized rate	1 month	1/4/93 - 6/14/01	Bloomberg
U.S. Deposit rates	Annualized rate	1 month	9/25/96-6/14/01	Bloomberg
U.S. Treasury bill rates	Annualized rate	3 and 12 months	1/4/93 - 6/14/01	Bloomberg
U.S. dollar LIBOR	Annlualized rate	1 and 12 months	1/4/93 - 6/14/01	Bloomberg
High yield spread	Spread of Moody's junk bond index over the U.S. 30-year government bond yield	-	1/4/93 - 6/14/01	Bloomberg
EMBI spread for Latin American Countries	Weighted average of the EMBI spreads of Latin American countries excluding Argentina, using 1999 GDP weights	-	1/4/93 - 6/14/01	JP Morgan