Published in
Journal of Development Economics
Volume 69, Issue 2, 1, pp. 367-391
December 2002

Pricing Currency Risk under Currency Boards *

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Abstract

Currency risk is one of the two components of the total interest rate differential. Hard pegs, such as currency boards, are meant to reduce or even eliminate currency risk, thus reducing domestic interest rates. 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. The premium and its term structure depend on domestic and global factors, related to devaluation expectations and risk perceptions.

JEL classification codes: F31, F36, G12, G15

Keywords: currency risk; currency premium; forward discount; currency board; term structure; covered interest parity; market segmentation; financial crises

* We are grateful to Gustavo Cañonero, Stijn Claessens, James Conklin, Sebastian Edwards, Chang Hsieh, Marcio Garcia, Michael Kumhof, Eduardo Levy Yeyati, John Merrick, Maury Obstfeld, Roberto Rigobon, and David Sekiguchi for their valuable comments and suggestions. We also benefited from feedback received at presentations held at the NBER Inter-American Seminar on Economics in Cambridge, the Latin American meetings of the Econometric Society in Buenos Aires, the LACEA meetings in Montevideo, and the World Bank/IMF Joint Research Seminar. For excellent research assistance, we are particularly grateful to Leonor Coutinho Gouveia. We also thank Andrea Bubula, Tatiana Didier, Penny Lermanometee, and Yaye Sakho, who helped us at different stages of the project. For help in obtaining data we thank Alberto Ades, Gustavo Cañonero, Starla Cohen, Kevin Fan, Ricardo Martinez, Daniel Oks, and Daniel Tenengauzer. For financial support we thank the World Bank Latin American Regional Studies Program, PREM anchor unit, and the Research Support Budget. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors and do not necessarily represent the views of the World Bank. Contact address: World Bank, 1818 H Street NW, Washington, DC 20433. Phone (202) 458-4167. Fax: (202) 522-3518. Email addresses: sschmukler@worldbank.org, lserven@worldbank.org

I. Introduction

The differential between local and international interest rates is a key variable for emerging countries. These countries typically face positive interest rate differentials (or spreads) – i.e., a higher cost of capital than developed economies. Moreover, interest rate differentials for emerging markets vary substantially over time. In particular, they often rise abruptly during periods of local and foreign financial turmoil. Lower spreads typically translate into lower borrowing costs for both the public and private sector and, other things equal, result in higher growth. For this reason, the fluctuations in interest rate differentials have been recently at the center of academic debate and have been a major concern for policy makers.

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 (sovereign) 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. Indexes of secondary-market yield spreads on emerging market bonds (EMBI) are compiled by JP Morgan. Data on primary issues also exist. The literature has studied the behavior of yield spreads including their time pattern, determinants, and cross-country

comovement.¹ Some papers also study the country risk premium in relation to the currency premium.²

The other component of interest rate differentials, the currency premium, has received less direct empirical attention in the context of emerging economies. The present study relates directly to at least three different strands of the international finance literature: the debate on the choice of exchange rate regime, the assessment of economic performance under currency boards, and the term structure of currency premia.³

First, the debate on the choice of exchange rate regime pays particular attention to the currency premium. Participants in this debate, which intensified during the currency crises of the 1990s, have claimed that countries should opt for either hard pegs 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 premium, even eliminating it entirely if the peg is viewed as irrevocable. 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.

¹ See, for example, Edwards (1984), Edwards (1986), Favero, Giavazzi, and Spaventa (1997), Eichengreen and Mody (1998), Kamin and von Kleist (1999), Mauro, Sussman, and Yafeh (2002), Kaminsky and Schmukler (2001), Merrick (2001), and Rigobon (2002).

² See Domowitz, Glen, and Madhavan (1998), Sturzenegger and Powell (2000), Didier and Garcia (2001), and Druck, Moron, and Stein (2001).

³ The literature on covered interest parity is also related to this paper. See, for example, Chinn and Frankel (1994), Frenkel and Levich (1977), Obstfeld (1995), and Schmukler and Servén (2002).

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 costs would be ambiguous.

Second, the debate on exchange rate regimes has generated a related literature on economic performance under currency boards. Ghosh, Gulde, and Wolf (2000) 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. Rivera 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 premia. The term structure reflects markets' perception of depreciation and exchange 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. Domowitz, Glen, and Madhavan (1998) examine the term structure of the currency premium in the case of Mexico up to the Tequila crisis.

The present paper sheds new light on these strands of the international finance literature by providing a comprehensive characterization of the currency premium in two currency boards, Argentina and Hong Kong. Focusing on these two economies has two major advantages. First, these two currency boards have a rich history, which permits

analyzing how domestic and international events impact on the currency premium. Second, these two cases offer a wide range of data not available for other economies.

This paper explores three major dimensions of the currency 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 structure of the currency premium 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. Third, we study the determinants of the currency premium and its term structure, 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 documents the empirical regularities of the currency premium and its term structure in Argentina and Hong Kong over time and across instruments and maturities, and presents information on the institutional features of forward markets. Section III describes the empirical methodology that we employ to study the determinants of the premium and its term structure. Section IV presents the results. Section V concludes.

II. Institutional features and empirical regularities

We next document the empirical regularities of the currency premium under two currency boards, Argentina and Hong Kong.⁵ Since we will work mainly with premia

⁵ 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

embedded in forward contracts, we begin by describing the institutional characteristics of forward markets, which are not widely known. Next, we 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, for each of the two countries we use the measure of the currency premium offering the longest time coverage. We then characterize the term structure of the currency premium.

II.a The forward exchange market

Forward contracts are derivatives designed to hedge foreign currency exposure. There are two types of forward contracts. Foreign exchange forwards (outright forwards) are currency trades to be settled at an agreed time in the future. These contracts are also called deliverable forwards. Non-deliverable forwards (NDFs) are forward transactions whose settlement is made by a cash payment in U.S. dollars reflecting the market value of the contract, so that no local currency changes hands. NDF contracts are mostly used for emerging market currencies. The main participants in this market are large international banks. The most important NDF currencies are the Argentinean peso, the Brazilian real, the major currencies in Asia, and the Hungarian forint.

Volume information on NDF transactions is limited, because the corresponding data are not publicly available and because market participants do not necessarily mark their deliverable and NDF transactions separately. The Federal Reserve Bank of New

(money market rates, interbank rates, and non-deliverable forwards), different currencies (Argentine pesos, Hong Kong dollars, and U.S. dollars), and different maturities (typically 1-, 3-, 6-, and 12-month). See Appendix Table 1 for a thorough description. This data set allows us to construct

York (2001) shows that forward markets are large when compared with spot markets. In the overall U.S. market, forward contracts represent about one third of the spot foreign exchange market. When looking beyond the major six world currencies against the U.S. dollar, forward markets become even more important. They are almost as large as spot markets.

II.b The currency premium: evolution over time

*The case of Argentina*⁶

The currency board in Argentina offers a fruitful ground to study the behavior of the currency premium. On April 1, 1991, 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 were defined by law; any modifications needed to be approved by Congress.⁷

Figure 1 displays the time pattern of the currency premium, measured by the difference between the 1-month peso and dollar local deposit rates (in annual terms). We use deposit rates, which are generally less sensitive than other rates to the different political and economic events.

different measures of the premium for each of the two currency boards. For more details, see Schmukler and Servén (2002).

⁶ 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, Clarín and La Nación, available online at www.clarin.com and www.lanacion.com. A much more detailed account of the impact of all these events on the currency premium is given in Schmukler and Servén (2002).

⁷ The law required 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 could be held in domestic government bonds. For this reason, some argue that the Argentine scheme was not a currency board in a strict sense. The currency board lasted until January 2002, when the financial crises prompted the devaluation and floating of the peso.

The currency premium remained positive throughout the period for which data are available, although in general its magnitude was modest – the sample mean equals 189 basis points. However, as Table 1 shows, 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.

There were many specific events that affected the Argentine currency premium. These events include external episodes like the Mexican crisis of 1994-95, the 1997-98 Asian crisis (in particular by the attack on the Hong Kong currency board), the Russian crisis of 1998, and the Brazilian crisis of 1999. Internal political and economic events also generated spikes in the currency premium. These events include former minister Cavallo’s statement in the Financial Times that the peso would eventually float, the political uncertainty surrounding the 1999 presidential election, the resignation of vice president Carlos Alvarez in October 2000, the resignation of two economy ministers (Machinea and Lopez Murphy), the proposal of a new currency board in April 2001 (according to which the peso would be pegged to a basket consisting of U.S. dollars and euros with equal weights), and the cut of international credit in July 2001.

To give a rough measure of the economic dimension of these premia, assume that investors are risk neutral. The currency premium then measures the anticipated rate of depreciation, and we can compute the magnitude of the anticipated depreciation consistent with the data for various subjective probabilities of devaluation. During tranquil periods a premium of 812 basis points on a 1-month deposit annualized rate

corresponds to an expected devaluation of 8,122 (902) basis points for a 10 (90) percent probability of devaluation. At the other extreme, when Argentina suffered the cut of international credit, the expected devaluation jumped to 19,861 (2,207) basis points under an expected probability of devaluation of 10 (90) percent. Though these magnitudes based on deposit interest rate differentials are already large, similar calculations applied to the NDF currency premium would yield a much larger anticipated devaluation.

*The case of Hong Kong*⁸

The currency board in Hong Kong also offers an interesting case study of the currency premium. The Hong Kong currency board was established in October 1983, and the Hong Kong dollar was pegged to the U.S. dollar 7.80 to 1. However, 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.

Figure 1 and Table 1 show that in Hong Kong, unlike in Argentina, the currency premium implied by 1-month deliverable forwards was at times negative (although of small magnitude). 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. The most noticeable events that kept the currency premium high are the second, third, and fourth attack on the Hong Kong dollar, which took place during 1998.

⁸ 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 (1999).

II.d Term structure of currency premia

Comparison of the currency premia at different maturities can reveal information on market perceptions regarding the likelihood, anticipated magnitude, and risk of exchange rate changes at different horizons, as well as on the impact of domestic and external developments on these perceptions. 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.⁹

Figure 2 portrays the forward market term premium for Argentina and Hong Kong. The figure illustrates how the term premium reacts to local and global events relevant to these 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, when the yield curve became sharply inverted. Thus, except for the final part of the sample, this suggests that the devaluation of the Brazilian real raised expectations of an *eventual*, more than an *immediate*, devaluation of the peso. A similar effect appears to have arisen when Cavallo first made public the idea of modifying the currency board. In reaction to that event the term premium increased, while the 1-month currency premium remained flat. 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 became negative at times, most notably during the 2001 crisis.¹⁰

⁹ 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.

¹⁰ Market participants closely follow these inversions in the term premium. Investment banks tend to recommend trades according to the slope of the yield curve and their assessments of risks at different horizons.

In Hong Kong, the term premium was close to zero during most of the sample. It turned slightly negative during the Mexican crisis and the early signs of distress in South Korea, and became sharply negative at the peak of the different attacks on the Hong Kong dollar. The term premium increased significantly right after the first attack on the Hong Kong dollar and only converged towards 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-term prospects.

III. Methodology

We turn to an empirical analysis of the determinants of the currency premium and its term structure. Our objective is to identify the impact of economic variables as well as local and global events on the premium. 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 adequate time coverage. Here we focus on the NDF-based premium measure.

The currency premium can be measured in different ways. One way is through differentials between local currency and foreign currency interest rates. Another way is through the forward discount, defined as $fd_{t,k} = \frac{1}{k} \ln \left[\frac{F_{t+k}}{S_t} \right]$, where F_{t+k} is the k -period forward exchange rate at time t , and S_t is the spot rate. The forward discount can be decomposed into the expected depreciation and the exchange rate risk premium:

$$fd_{t,k} = \Delta s_{t,k}^e + errp_{t,k}. \quad (1)$$

We can further decompose anticipated depreciation $\Delta s_{t,k}^e$ 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 $(s_{t,k} - s_t)$. 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 of the spot exchange rate expected to prevail at time $t+k$ if a devaluation should occur between times t and $t+k$.¹¹ Thus from (1) we have:

$$fd_{t,k} = P_{t,k}(s_{t,k} - s_t) + errp_{t,k}. \quad (2)$$

The next step is to relate the anticipated magnitude of the depreciation, the subjective devaluation probability, and the risk premium to observable counterparts.¹² 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, we will be working with daily data, and no information on prices or real variables exists at such frequency. 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. Thus, we include a linear trend in our basic specification. Nevertheless, we also experiment with a proxy for real exchange rate misalignment available from

¹¹ The expected future rate conditional on devaluation taking place could also depend on the precise instant at which the devaluation happens. While this complication could be easily incorporated in (2), we ignore it for simplicity.

Goldman Sachs, which is constructed on the basis of lower-frequency real and financial data and then interpolated to yield daily observations.¹³ Finally, we also allow an impact of the Brazilian devaluation of 1999 on the perceived degree of peso misalignment, by adding a dummy variable (see below).

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. Thus, 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. Public bonds could be held as central bank reserves, but, in light of the government default in 2002, they proved not to be equal to hard-currency reserves. Hence, to study whether the composition of foreign reserves affect market perceptions, we present regressions allowing these two components to carry different coefficients.

To capture the risk premium component of (2), we use measures that reflect markets' perceptions about risk.¹⁴ The first one is the EMBI spread for Latin American debt (excluding Argentina's), which we take as a measure of the perceived riskiness of Latin American assets in general. The second is the premium on U.S. high-yield assets, which we take as a measure of international investors' overall "appetite for risk." In our

¹² The patterns and determinants of the exchange risk premium have received considerable attention in the literature. See, for example, Engel (1992, 1996), Hakkio and Siebert (1995), Obstfeld and Rogoff (1998), and Siebert (1996).

¹³ To construct a measure of the foreign exchange misalignment, Goldman Sachs uses deviations of an estimated equilibrium exchange rate from observed trade-weighted real exchange rates. To obtain the equilibrium exchange rate, Goldman Sachs uses various economic fundamentals such as terms of trade, government consumption, total factor productivity, and capital flows, among others.

basic specification, these two variables capture the risk perceptions of international investors. In addition, we also present some experiments adding in the regression the risk rating of Argentine foreign currency debt as determined by major international risk-rating agencies.¹⁵

To these proxies for international investors' risk perceptions, we also add in our basic specification 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' attitude towards risk. An increase in banks' risk aversion or in their perceived risk (i.e., the degree of financial volatility) should be reflected in banks' decision to maintain higher liquidity ratios.

It is important to emphasize that, as already stated, the literature offers no definite prediction regarding the sign of the impact of these risk preference proxies on the exchange risk premium. However, simulation exercises tend to suggest that higher risk aversion increases the absolute magnitude of the premium.¹⁶ Thus, one might expect that if the peso is regarded as riskier than the U.S. dollar (so that the risk premium is positive) then higher risk aversion would yield a larger risk premium and, other things equal, a larger currency premium, so that the risk aversion proxies just listed would carry positive coefficients in the regression.¹⁷

¹⁴ This is in the spirit of Lewis (1995).

¹⁵ Specifically, we use the average of the risk ratings of the three leading agencies: Moody's, Standard and Poor's, and Fitch-IBCA. We assign numerical values to the various risk categories considered by each agency, and average them over their respective ratings for Argentina's sovereign foreign-currency debt.

¹⁶ See for example Evans and Kenc (2001).

¹⁷ This argument, however, is subject to two caveats in the case of the U.S. high-yield spread, which may capture other forces at play, in addition to investors' overall risk appetite. The first caveat arises from the fact that the perceived riskiness of U.S. junk and Argentine assets may move in different

Finally, we also estimate additional specifications including dummy variables to control for the effects of the domestic and foreign political and economic events summarized in Section II. To limit the number of dummy variables, we combine the two external shocks in our sample (the periods of Russian crisis and the devaluation of the Brazilian real) into a single “external shock” dummy, and likewise combine the various domestic crises episodes into a single “internal shock” dummy.

Before turning to the econometric methodology, we consider briefly the term structure of currency premia. For two different maturities k and k' we can write from (2)

$$fd_{t,k} - fd_{t,k'} = (\Delta s_{t,k}^e - \Delta s_{t,k'}^e) + (errp_{t,k} - errp_{t,k'}). \quad (3)$$

This equation characterizes the term structure of currency premia. It reflects both the time path of anticipated depreciation and the term structure of the exchange risk premia. The literature has focused mostly on the former. Using (3) one can argue that the time paths of the perceived probability of devaluation and the magnitude of the devaluation, conditional on devaluation taking place, affect the term structure of anticipated depreciation and thereby the term structure of currency premia.

Alternative trajectories of the subjective probability and the conditional magnitude of devaluation can result in very different term structures. In particular, the

directions, reflecting investors' substitution among alternative assets. For example, a shift out of U.S. high-yield assets and into emerging market (including Argentine) assets could result in a higher premium for the former but lower for the latter. The second caveat concerns the role of the high-yield spread as a predictor of the U.S. business cycle. As has been amply documented, a higher spread indicates the anticipation of a growth slowdown in the U.S., and conversely for a lower spread. To the extent that the U.S. dollar tends to appreciate in booms and depreciate in slowdowns, an increase in the U.S. high-yield spread could signal an impending depreciation of the dollar vis-à-vis other currencies, and thereby an anticipated reduction in the degree of overvaluation of the Argentina peso in trade-weighted terms, which *ceteris paribus* would tend to reduce the forward discount on the peso. Conversely, a reduction in the high-yield spread would imply larger peso overvaluation in the future and thereby lead to a larger forward discount. Through this channel, changes in the high-yield spread could cause changes in the forward discount in the opposite direction.

term structure can become inverted if the bulk of anticipated depreciation is concentrated in the near rather than the distant future. This may happen, for example, when there is a perceived probability of collapse of a fixed exchange rate regime, and the exchange rate after the collapse is expected to overshoot – so that the magnitude of the conditional depreciation is larger in the short than in the long run. Overshooting aside, term structure inversion is also more likely if agents expect devaluation to take place in the near rather than the long term – e.g., they expect either an immediate devaluation or no devaluation at all.

III.a Econometric approach

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 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.

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 excluding Argentina,¹⁸ and as a working hypothesis we shall assume it exogenous as well.¹⁹

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:

$$y_t = c_0 + \sum_{j=1}^k \sum_{\tau=0}^q b_{j\tau} x_{j,t-\tau} + \sum_{i=1}^p a_i y_{t-i} + u_t . \quad (4)$$

This is just an unrestricted autoregressive-distributed lag (ARDL) model of order (p, q) .

With some straightforward manipulations, it can be rewritten as

$$\Delta y_t = \sum_{j=1}^k \sum_{\tau=0}^{q-1} B_{j\tau} \Delta x_{j,t-\tau} + \sum_{i=1}^{p-1} A_i \Delta y_{t-i} + \left[c_0 + \alpha_1 y_{t-1} + \sum_{j=1}^k \beta_j x_{j,t-1} \right] + u_t . \quad (5)$$

The term in square brackets in the right-hand side of (5) captures the “long-run” version

of (4). Here $\alpha_1 = \left(\sum_{i=1}^p a_i \right) - 1$ and $\beta_j = \sum_{\tau=0}^q b_{j\tau}$ 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 (5) by ordinary least squares (OLS) setting $p=q=4$, i.e., including four lags of the dependent and independent variables

¹⁸ Specifically, it is a weighted average of the EMBIs from individual Latin American countries excluding Argentina, with 1999 GDP weights.

¹⁹ 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.

(beginning with lag 3 in the case of the domestic financial ratios). To save space in the tables below, we only report the long-run coefficients α_1 and β_j and omit the dynamics.

To complement these OLS regressions, we also perform additional estimations allowing for conditionally heteroskedastic disturbances, which are fairly common in high-frequency financial data such as ours. Indeed, Table 1 above clearly suggests that volatility of the premium changes over time, becoming noticeably higher at times of internal and external crises. While OLS estimates of equation (5) remain consistent in the presence of heteroskedasticity, and our inferences are based on robust covariance matrix estimates, efficiency gains are possible by explicitly modeling heteroskedasticity. In particular, we use the exponential GARCH (EGARCH) specification of Nelson (1991), which can be written as

$$\log \sigma_t^2 = \pi_0 + \sum_{j=1}^N \pi_{1,j} \log \sigma_{t-j}^2 + \sum_{j=1}^M \pi_{2,j} \left\{ |v_{t-j}| - E|v_{t-j}| \right\} + \sum_{j=1}^M \pi_{3,j} v_{t-j}, \quad (6)$$

where $v_t = \frac{u_t}{\sigma_t}$. In the estimations reported below we use $N=M=1$. Compared with

standard GARCH, this specification 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). Moreover, the EGARCH model is computationally simpler than standard GARCH, which is a major concern given our relatively short sample and our specification with several regressors and multiple lags. Indeed, to achieve convergence of the EGARCH estimates we were forced to employ a somewhat shorter lag specification in order to preserve sample size. In particular, we omitted lags beyond the fourth one, so

that for the domestic financial ratios (foreign reserves and bank liquidity), available with a three-day delay, we used only the third and fourth lag.

IV. Results

Table 2 reports regression results with the 1-month NDF premium as dependent variable. The first five columns report OLS estimates of equation (5), while the last two columns present EGARCH(1,1) estimates of (5) and (6). As already noted, to save space only the long-run coefficients of (5) appear in the table.

The first column presents the basic specification. As expected, we find that foreign reserves have a negative and significant effect on the premium. Among the risk proxies, the Latin EMBI spread carries a positive and significant coefficient, and the same applies to domestic banks' liquidity ratio. In turn, the U.S. high-yield spread has no significant effect, nor does the time trend intended to capture the peso misalignment. The summary statistics at the bottom of the table show that the estimated equation has a high explanatory power, as reflected by an R-squared in excess of 0.40, which is rather satisfactory given that we are working with daily data. Finally, the Q statistics reveal no symptoms of autocorrelation.

Column 2 in Table 2 replaces the time trend with the Goldman Sachs misalignment proxy. This results in the loss of 20 observations for which the latter variable is not available. Its coefficient estimate carries a positive sign, as expected, but the precision of the estimate is very poor. The remaining estimates are qualitatively similar to those in the first column. In turn, column 3 breaks down foreign reserves into their hard-currency and public-debt components. We find that only hard-currency

reserves have a significant negative impact on the forward premium; bond reserves carry a negative coefficient as well, but statistically not different from zero. The other parameters are very similar to those in column 1.

In column 4 we add to the regressors the risk rating of Argentine foreign currency debt, averaged over the three major rating services. As constructed, a higher value of the variable denotes a better rating (i.e., lower risk). Its coefficient estimate is negative and significant, as expected. Now, however, the coefficient on the foreign reserve/deposit ratio becomes much smaller and insignificant. This is very likely a reflection of the fact that rating agencies view foreign reserves as one (or the) key factor in their risk assessment. The remaining estimates are similar to those in the basic specification of column 1. Next, in column 5 we add the internal and external shock dummies. Both carry positive and significant (at the 10 percent level in the case of the external shock dummy) coefficients, what confirms the finding in Table 1 that the forward discount typically rises at times of turmoil. Interestingly, the coefficients on the Latin EMBI spread and the foreign reserve ratio show a considerable decline in magnitude relative to the basic specification, and the former becomes insignificant. This is a clear reflection of the fact that the Russia and Brazil shocks summarized in the “external shock” dummy were also reflected in major swings in the EMBI, while both internal and external shocks typically resulted in reserve losses. Hence the event dummies capture some of the explanatory power of these two economic variables.

In column 5 we are allowing for crises to affect the conditional mean of the forward premium but not its conditional variance. From Table 1, however, we know that the volatility of the premium is considerably larger at times of shocks. We allow for a

time-varying conditional variance by introducing EGARCH effects in columns 6 and 7 of Table 2. As already noted, we had to use a somewhat reduced dynamic specification to preserve sample size and achieve convergence of the estimation procedure. As a result, the sample underlying these estimates is larger than those used in the OLS regressions. In addition, we further simplified the specification in column 5 by combining the two shock dummies into a single “crisis dummy.”

Column 6 presents an EGARCH(1,1) specification allowing for the effect of crises on the conditional mean of the premium. Qualitatively, the estimates are broadly similar to those in column 5, although their magnitudes change somewhat reflecting the change in sample. We continue to find significant positive effects on the premium of banks’ liquidity ratio and the crisis dummy, and negative and significant effects of the foreign reserve ratio. The Latin EMBI spread remains insignificant like in column 5. Now, however, we also find a significant positive impact of the high-yield spread and the time trend that proxies for misalignment. The GARCH parameters are strongly significant as well, and in particular they suggest an asymmetric effect of disturbances on the conditional variance, with negative disturbances raising the conditional variance more than positive ones. The Box-Pierce statistics, however, suggest some mild evidence of residual autocorrelation.²⁰

In column 7 we expand the EGARCH specification to allow also for an independent effect of crises on the conditional variance. We do this by adding the crisis dummy in the variance equation.²¹ This causes some changes in the parameter estimates

²⁰ Note that the Q statistics in columns 6-7 refer to the “scaled” residuals denoted by v in equation (6).

²¹ We thank Sebastian Edwards for suggesting this specification. See Edwards and Susmel (2001) for a more sophisticated application of GARCH models with regime switches.

relative to those in the preceding column. In particular, the EMBI spread is now positive and significant, and the high-yield spread reverses sign – it now carries a negative and significant coefficient. Foreign reserves and banks’ liquidity remain significant, although their parameters become much smaller than in the preceding column. The crisis dummy continues to have a significant positive impact on the premium and, in addition, now it is found to have a significant positive impact on the conditional variance as well. There continues to be strong evidence of EGARCH effects, but the estimates do not suggest any asymmetric effects of disturbances anymore. Finally, the Q statistics do not reveal any symptoms of autocorrelation.

Table 3 turns 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 table, we introduce also the term premium of U.S. interest rates of similar maturity, to provide a benchmark for the term premium generally demanded by investors.

Like in the previous table, columns 1 to 5 report OLS regressions, while columns 6-7 report EGARCH estimates, using the same array of specifications as before. Column 1 presents the basic specification. We find that the foreign reserves to deposits ratio exerts a significant positive effect on the term premium, suggesting that the announcement of higher reserves reduces more the short-term NDF premium than the longer-term one. This likely reflects the fact that higher reserves lower the perceived probability of *immediate* devaluation relative to the probability of *eventual* devaluation. On the other hand, the liquidity ratio of banks carries a negative sign, which suggests that banks’ decision to hold larger cash reserves relates more to perceived short-term risks

than long-term ones. The remaining coefficient estimates are insignificant. The explanatory power of the equation is quite high, as reflected by its R-squared of 0.46, and the residuals show no signs of serial correlation.

Column 2 uses the Goldman Sachs misalignment proxy. Like in the regressions of the 1-month premium, its coefficient estimate is positive but highly imprecise. Column 3 disaggregates foreign reserves into hard-currency and public-debt assets. Both carry significant positive coefficients, but that of bond reserves is much smaller and significant only at the 10 percent level. This suggests that the impact just described of foreign reserves on perceived devaluation probabilities at different horizons is mostly due to hard-currency reserves.

Column 4 adds to the basic specification the risk rating of foreign-currency Argentine debt. Like with the 1-month premium, the main consequence is to render foreign reserves insignificant, confirming the interpretation given earlier that risk ratings are strongly affected by foreign reserve holdings. Column 5 adds the internal and external shock dummies. Both carry significantly negative coefficients, in accordance with the fact noted earlier that the term structure tends to become inverted at times of crisis. Introducing the dummies also causes some changes in other parameters. Most notably, the high-yield spread becomes significant at the 10 percent level with a negative sign, while foreign reserves become insignificant.

Columns 6 and 7 report EGARCH estimates, restricting as before the lag length of the domestic financial ratios in the estimated specifications – in order to conserve sample size – and combining the two crisis dummies into a single one. In column 6, the crisis dummy affects only the conditional mean of the term premium. Like in the OLS

estimates of column 5, the dummy carries a negative and significant coefficient. The sign pattern of the remaining coefficients is similar to that in column 5. Now, however, all regressors, except for the high-yield spread, carry significant parameter estimates – positive in the case of the U.S. term structure, the EMBI spread and the foreign reserve ratio, and negative for the liquidity ratio of banks. There is strong indication of EGARCH effects, including significant asymmetry that results in positive disturbances increasing the conditional variance more than negative ones. The Q statistics do not reveal residual autocorrelation. However, the autoregressive parameter in the variance equation is close to unity, suggesting that the variance process is close to an integrated EGARCH (IEGARCH).

Column 7 adds the crisis dummy also in the conditional variance equation. It is found to exert a positive and highly significant effect, confirming the finding in Table 2 above that volatility of the term premium rises at times of major shocks. The remaining estimates show very little change relative to those in column 6, and they all continue to be highly significant with the exception of the high-yield spread. We again find a strongly asymmetric impact of disturbances on the conditional variance, but now there is much less evidence of IEGARCH effects. The residuals display no symptoms of autocorrelation.

V. 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 in 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 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.

Second, political and economic events seem to be important factors in the behavior of currency premia. The currency premium in Argentina increased during the Mexican, Asian, Russian, and Brazilian 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 follow simple rules.²² 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.²³

Third, the yield curve of the currency premium 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, and/or may anticipate an overshooting of the exchange rate after the collapse. Furthermore, fluctuations in the term structure might also reflect different liquidity in the short- and long-term markets. These fluctuations in term premia imply that one needs to proceed with care when comparing interest rate differentials, currency premia, and country premia on assets of different maturities. A remaining

²² See Frankel, Fajnzylber, Schmukler, and Servén (2001).

question is whether this seemingly predictable behavior of term premia generates opportunities for arbitrage. Informal evidence suggests that it certainly prompts investors to take speculative bets.

Fourth, 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 and its term structure. Risk related to EMBI spreads, as well as that captured by standard risk ratings, have in most cases a positive effect on currency premia. Reserves – especially hard-currency reserves, more than government-bond reserves – have a negative impact on currency premia, 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 negatively the term premium. Finally, adverse domestic and external events that threaten the sustainability of the convertibility system raise the currency premium and tend to invert its term structure.

In this paper we have made some progress towards identifying the regularities of the currency premium and understanding its determinants. It would be useful to know if 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.

²³ See Ganapolsky and Schmukler (2001).

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Figure 1
Currency Premia under Currency Boards

The figure shows daily values of currency premia in Argentina (top panel) and Hong Kong (lower panel). The currency 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 premium for Hong Kong is computed from the forward discount -- the forward exchange rate minus the spot exchange rate, using 1-month contracts. The sample for Argentina covers the period 4/1/93 - 9/25/01, for Hong Kong it covers the period 1/4/93 - 9/25/01. All rates are in basis points, annualized, and continuously compounded.

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

The table shows summary statistics of daily data on the currency premium in Argentina and Hong Kong for different samples. The currency 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 premium for Hong Kong is computed from the 1-month forward discount. 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) changes of finance minister, and (viii) cut of international credit. The crisis periods for Hong Kong are: (i) The Mexican crisis, (ii) the financial distress in S. Korea, (iii) the attacks on the Thai baht and the four attacks on the Hong Kong dollar. See text for a description of the events. All rates are in basis points, annualized, and continuously compounded.

	<i>Dates</i>	<i>Number of Observations</i>	<i>Mean</i>	<i>Median</i>	<i>Standard Deviation</i>	<i>Min</i>	<i>Max</i>
Argentina							
Time Deposit Rates (deposits up to 2 months)							
Total	04/01/93 - 06/05/01	2,121	211	148	204	1	1,986
Tranquil Periods (after the Mexican Crisis)		1,228	126	98	97	1	812
Crisis Periods		446	383	252	333	25	1,986
Mexican crisis	01/10/95 - 04/10/95	63	603	520	243	264	1,316
Attack on the Hong Kong dollar	10/29/97 - 11/26/97	21	223	223	90	83	393
Russia's default	08/19/98 - 10/16/98	42	201	193	69	65	405
Devaluation of the Brazilian real	01/13/99 - 02/12/99	23	210	206	56	97	315
Financial Times article and elections	05/17/99 - 12/17/99	149	186	155	74	88	397
Vice president resigns	10/06/00 - 12/29/00	56	216	220	90	25	397
Changes of finance minister	03/16/01 - 05/18/01	38	548	480	252	202	1,308
Cut of international credit	07/10/01 - 09/25/01	54	1,005	940	359	441	1,986
Hong Kong							
Forward Rates							
Total	01/04/93 - 06/05/01	2,240	58	12	165	-111	2,840
Tranquil Periods		1,908	15	6	53	-111	325
Crisis Periods		332	301	217	313	-47	2,840
Mexican crisis	01/10/95 - 04/10/95	62	73	38	106	-47	341
Early signs of financial distress	01/27/97 - 02/21/97	19	50	9	112	-19	376
Attack on the Thai Baht	05/14/97 - 7/24/97	51	182	101	163	23	621
1st Attack on the Hong Kong dollar	08/15/97 - 12/15/97	87	386	225	398	70	2,840
2nd Attack on the Hong Kong dollar	01/05/98 - 02/04/98	22	598	491	293	147	1,165
3rd Attack on the Hong Kong dollar	05/27/98 - 07/06/98	29	418	348	205	212	1,119
4th Attack on the Hong Kong dollar	07/10/98 - 10/06/98	62	426	306	272	178	1,309

Figure 2
Term Structure of the Currency Premium

The figure shows the term structure of the currency premium in Argentina (top panel) and Hong Kong (bottom panel), calculated as the difference between the 12-month and the 1-month currency premium. 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. The Hong Kong forward rates are taken from Bloomberg. The Argentine NDF rates were obtained from Deutsche Bank and Bloomberg. All rates are annualized, in basis points, and continuously compounded.

Appendix Table 1
Data Description

	<i>Description</i>	<i>Maturity</i>	<i>Sample</i>	<i>Source</i>
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	9/9/98-9/25/01 (1-month) 10/20/97-9/25/01 (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 - 9/25/01	Bloomberg
Interbank offer rates in pesos and dollars (BAIBOR)	Annualized rate	1 and 12 months	4/21/97 - 9/25/01	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 - 9/25/01	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 - 9/25/01	Bloomberg (original source: Central Bank of Argentina)
Bond reserves of the central bank	Reserves in Argentine government bonds, (U.S. dollar, billions)	-	12/29/1994 - 9/25/01	Bloomberg (original source: Central Bank of Argentina)
Hard-currency reserves	Reserves held in hard currency and short- and long-term deposits (U.S. dollar, billions)	-	12/29/1994 - 9/25/01	Bloomberg (original source: Central Bank of Argentina)
Total deposits of the financial system	Total Argentine bank deposits (U.S. dollar, millions)	-	12/29/1994 - 9/25/01	Bloomberg (original source: Central Bank of Argentina)
Total cash holdings of the financial system	Cash holdings in local and foreign currency (U.S. dollars, millions)	-	12/29/1994 - 9/25/01	Bloomberg (original source: Central Bank of Argentina)
Hong Kong data				
Deliverable forward exchange rate (FWD)	Hong Kong dollars per U.S. dollar	1 and 12 months	1/4/93 - 9/25/01	Bloomberg
Spot exchange rate	Hong Kong dollars per U.S. dollar	-	1/4/93 - 9/25/01	Bloomberg
Interbank rate in Hong Kong dollars (HIBOR)	Annualized rate	1 and 12 months	1/4/93 - 9/25/01	Hong Kong Monetary Authority
International data				
U.S. Federal Funds rates (FFR)	Annualized rate	1 month	1/4/93 - 9/25/01	Bloomberg
U.S. Deposit rates	Annualized rate	1 month	9/25/96-9/25/01	Bloomberg
U.S. Treasury bill rates	Annualized rate	3 and 12 months	1/4/93 - 9/25/01	Bloomberg
U.S. dollar LIBOR	Annualized rate	1 and 12 months	1/4/93 - 9/25/01	Bloomberg
High-yield spread	Spread of Moody's junk bond index over the U.S. 30-year government bond yield	-	1/4/93 - 9/25/01	Bloomberg
GS misalignment measure	Estimated equilibrium exchange rate from trade-weighted real exchange rates		9/9/98-9/25/01	Goldman Sachs
Average foreign currency credit rating	Average risk ratings of the three leading agencies: Moody's, Standard and Poor's, and Fitch-IBCA	-	1/4/93 - 9/25/01	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 - 9/25/01	JP Morgan