

**Verifiability:
A Rationale for the Failure of Intermediate Exchange Rate Regimes⁺**

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Abstract

This paper offers a possible theoretical rationale – currently lacking -- for the proposition that intermediate exchange rate regimes are no longer viable. According to this proposition, countries are being pushed to the “corners,” the extremes of either free floating or firm fixing. We introduce the notion of *verifiability*, by which we mean the ability of a market participant to infer statistically from observed data that the exchange rate regime announced by the authority is in fact in operation. Verifiability is a means to credibility. Our point is that a simple regime may be more verifiable by market participants than a complicated intermediate regime. We study the verifiability of exchange rate regimes by analyzing the case of Chile and by performing Monte Carlo simulations. Simple pegs and basket pegs are relatively easy to verify. As the case of Chile helps illustrate, a band around a peg makes the verification more difficult. Under a narrow band the weights on the central parity can be estimated correctly. However, wider bands make impossible the verification of the central parity. The amount of data that would be required may well exceed the length of the time period during which a given regime is typically maintained. The Monte Carlo exercise shows that the amount of information necessary to verify the exchange rate regimes increases with the complexity of the regime, including the width of the band and the number of currencies in the basket.

JEL Classification Codes: F31, F32, F33, F36

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I. Introduction

The choice of exchange rate regime – floating, fixed, or somewhere in between – is an old question in international monetary economics. But the steady increase in magnitude and variability of international capital flows has complicated the question. This is particularly the case for the developing countries that in the 1990s became full-fledged participants in international financial markets.

A major new element in the debate is the proposition that emerging market countries are, or should be, abandoning basket pegs, crawling pegs, bands, adjustable pegs, and various combinations of these. The currently-fashionable view is that countries are being pushed to the “corners,” the extremes of either free floating or firm fixing. The intermediate regimes are said to be no longer viable. This proposition is variously called the hypothesis of the vanishing intermediate regime, the missing middle, or the corners solution. Its life history has gone from birth to conventional wisdom in a remarkably short period of time.

The motivation of this paper is the observation that, as fashionable as this proposition has become, few of its proponents, if any, have offered an analytical rationale for it, let alone a fully worked out theoretical model. Our aim is to offer a possible theoretical rationale. We seek to introduce the notion of *verifiability*, and to suggest that a simple peg or a simple float may be more verifiable by market participants than a more complicated intermediate regime. Verifiability can be thought of as a concrete instance of the more general principle of “transparency” that is so often invoked in recent discussions of the new international financial architecture but so seldom made precise.

Consider the exchange rate regime that Chile has had for most of the last 20 years: a band around a central parity that itself is a basket with a rate of crawl. So far as existing theory is concerned, the complexity of this arrangement has no implications for its credibility. But, in truth, when a central bank announces a regime of this type, the public has no way of verifying quickly, by observing the exchange rate, whether the central bank is doing what it claims to be doing.

A central bank does not earn credibility merely by announcing a monetary regime with a nominal anchor such as the exchange rate, even if its intentions are sincere. The public will judge credibility from data available to it. If the announced exchange rate regime is a simple dollar peg, a market participant need only check that the exchange rate today is the same as the exchange rate yesterday, in order to verify that the central bank is indeed following its announced policy. If the announced regime is a pure float, a participant can essentially check every month whether the central bank has intervened in the market by seeing whether its reserve holdings have changed. Under the basket band, by contrast, the market participant needs more months of data in order to be able to verify that the central bank is indeed implementing the announced policy. How many months of data he or she needs is the central analytical exercise of this paper.

We are not claiming that verifiability is necessarily the complete story behind the purported non-viability of intermediate regimes. And we are certainly not claiming that it

is the only criterion, or even the most important criterion, in the larger debate about fixed and floating exchange rate regimes. Many other factors, whether from the traditional optimum currency area literature or the newer criteria associated with credibility and financial markets, need to be taken into account.¹ Our goal is rather to offer an attempt at what, so far as we are aware, may be the first explicit analytical rationale for the proposition that intermediate regimes are less viable than the corner regimes.

In this paper, we study the verifiability of exchange rate regimes by analyzing the case of Chile and by doing Monte Carlo simulations. The case of Chile shows, as expected, that simple pegs and basket pegs are easy to verify. A band around a peg makes the verification more difficult. Under a narrow band the weights on the central parity can be estimated fairly well, with 50 days of data.² Wider bands, however, make impossible the verification of the central parity. More precisely, verification would require many years of data, in excess of the length of the time period that a given exchange rate regime typically lasts. The Monte Carlo exercise shows the role of a number of factors in determining verifiability: the band size, number of currencies in the basket, the rate of crawl, sample period, periodic adjustments of the central parity. The results confirm the intuition that the amount of information necessary to verify the exchange rate regimes increases with the complexity of the regime.

The rest of the paper is organized as follows. Section II introduces the analytical framework used throughout the paper to verify exchange rate regimes. Section III presents estimations for the case of Chile. Section IV performs Monte Carlo exercises to study the verification time under simulated models. The Appendix describes in detail the recent history of the Chilean exchange rate policy.

II. The Corners Hypothesis

Intellectual Origins

What is known about the origins of the hypothesis of the vanishing intermediate regime? The original reference is believed to be Eichengreen (1994). The context was not emerging markets, but the European Exchange Rate Mechanism. The ERM crisis of 1992 and band-widening of 1993 suggested to some that a gradual transition to European Economic and Monetary Union, where the width of the target zone was narrowed in steps, might not be the best way to proceed after all. (Crockett, 1994, made the same point.) Obstfeld and Rogoff (1995) concluded, “A careful examination of the genesis of speculative attacks suggests that even broad-band systems in the current EMS style pose difficulties, and that there is little, if any, comfortable middle ground between floating rates and the adoption by countries of a common currency.” The lesson that “the best

¹ Two recent reviews are Larrain and Velasco (1999) and Frankel (1999).

² Even 50 days may be too long, however, in the midst of a full-fledged speculative attack, which is the circumstance in which intermediate regimes have been abandoned in recent years. In the midst of a currency crisis, the central bank needs to regain the confidence of market participants in a matter of days, not a matter of months.

way to cross a chasm is in a single jump” was seemingly borne out subsequently, by the successful leap from wide bands to EMU in 1998-99.

After the East Asia crises of 1997-98, the proposition was applied to emerging markets. In the effort to “reform the international financial architecture” so as to minimize the frequency and severity of crisis in the future, the proposition was rapidly adopted by the international financial establishment as the new conventional wisdom.

For example, Summers (1999a)³:

“There is no single answer, but in light of recent experience what is perhaps becoming increasingly clear -- and will probably be increasingly reflected in the advice that the international community offers -- is that in a world of freely flowing capital there is shrinking scope for countries to occupy the middle ground of fixed but adjustable pegs. As we go forward from the events of the past eighteen months, I expect that countries will be increasingly wary about committing themselves to fixed exchange rates, whatever the temptations these may offer in the short run, unless they are also prepared to dedicate policy wholeheartedly to their support and establish extra-ordinary domestic safeguards to keep them in place.”

Other high-profile examples include Eichengreen (1999, p.104-105), Minton-Beddoes (1999) and Council on Foreign Relations (1999, p.87). The International Monetary Fund has now agreed that countries that get into trouble by following an intermediate regime will in the future not be bailed out, though it qualified the scope of the generalization a bit, for example, by allowing a possible exception for “systemically” important countries.

It may be that the *Economist* (1999, p.15-16) is right that “Most academics now believe that only radical solutions will work: either currencies must float freely, or they must be tightly tied (through a currency board or, even better, currency unions). But the proposition remains to be modeled, let alone proven.

What do countries actually do?

Out of 185 economies, the IMF (April 1999) classifies 48 as independently floating and 45 as following rigid pegs (currency boards or monetary unions, including the CFA franc zone in Africa). This leaves 92 following intermediate regimes – half of the total (of which 30 follow conventional pegs against a single currency).

Most of those listed as floating in fact intervene in the foreign exchange market frequently. Only the United States floats so purely that intervention is relatively rare.

At the other end of the spectrum, most of those classified as pegged have in fact had realignments within the last ten years. Obstfeld and Rogoff (1995) report that only

³ Other high-profile examples include Eichengreen (1999, p.104-105), Minton-Beddoes (1999) and Council on Foreign Relations (1999, p.87).

six major economies with open capital markets, in addition to a number of very small economies had maintained a fixed exchange rate for five years or more, as of 1995. Klein and Marion (1997) report that the mean duration of pegs among Western Hemisphere countries is about 10 months. The implication is that conventional pegs should be called “adjustable pegs,” and classified as intermediate regimes.

Only 37 countries have altogether given up an independent currency as legal tender: the euro-11, the 14 members of the CFA Franc Zone⁴, Panama, San Marino, and some tiny island states. Of these, only the euro-11 have given up national currencies recently. True, eight economies have adopted currency boards: Hong Kong (1983), Argentina (1991), Estonia (1992), Lithuania (1994), Bulgaria (1997), Bosnia (1998) and two smaller countries. (The latter two are Brunei and Djibouti. Montenegro is now evidently adopting a currency board too, or even declaring marks legal tender.) That adds up to 20 countries that have chosen ultra-fixed exchange rate arrangements in the past decade. But this does not constitute evidence that the heralded world trend toward a smaller number of currencies has begun. The missing fact is that -- as the result of the breakup of the Soviet Union and of Czechoslovakia and Yugoslavia -- roughly as many independent currencies have been created in the 1990s as have disappeared. One might assert a sort of Markov stasis, in which independent currencies are always being created and disappearing, but the overall pool remains roughly steady.

Most countries still choose something in between rigid fixity and free float. The intermediate regimes in the IMF classification scheme break down as follows. In addition to the 30 pegged to a single currency, there are 13 pegged to a composite, 7 crawling pegs, 8 horizontal bands, 9 crawling bands, and 25 managed floats. These countries may have good reasons for their choices.⁵ Close to the center of the economists’ creed is that interior solutions are more likely to be optimal -- for the interesting questions -- than corner solutions.

But it is true that for the middle-income emerging market countries, all of which have been exposed to substantial financial volatility in the period in recent years, the casualties among intermediate regimes have been high. Mexico, Thailand, Korea, Indonesia and Brazil had not in fact been following explicit tight dollar pegs when they were hit by speculative crises and were forced to move in the direction of floating. Each had a sort of basket or band that they were forced to abandon.⁶ At the same time, Hong Kong in Asia and Argentina in Latin America, the two countries with currency boards, were the two that got through the period successfully, judged by the (very particular) criterion of avoiding being forced into increased exchange rate flexibility. As a statement of observed trends, at least, the set of emerging market countries in the late 1990s does seem to bear out the claimed movement toward the corners. The countries that have

⁴ Even the francophone countries of Africa finally devalued against the French franc in 1994 (though they have retained their currency union among themselves).

⁵ The data pertain to April 4, 1999. The source is International Financial Statistics, September 1999. Subsequently, Colombia and Chile abandoned their crawling bands.

⁶ Even in the case of Thailand, where the baht had been *de facto* linked closely to the dollar in the last two years before the crisis of July 1997, the official policy was still a basket peg.

abandoned band arrangements in recent years include the Czech Republic (May 27, 1997), Indonesia (Aug. 10, 1997), Russia (Aug. 27, 1998), Brazil (Jan. 15, 1999), Ecuador (Mar 4, 1999), Chile (Sept 3, 1999) and Colombia (Sept. 26, 1999).⁷ While most of these policy changes took place under great pressure, Chile was not facing tremendous speculative pressure when it made its recent switch, and Indonesia abandoned the bands before the full crisis hit. (This move won praise at the time. Even though the country was soon thereafter hit with the worst of the Asian crises, commentators today tend to include Indonesia on the list of data points that is supposed to demonstrate the superiority of the floating option over the band option.⁸)

It seems intuitively right that these countries, facing finicky international investors and rapidly disappearing foreign exchange reserves, had little alternative but to abandon their pegs and baskets and bands and crawls and move to a float, unless they were prepared to go to the opposite corner. But what is the rationale for this proposition?

Lack of theoretical foundations

What is the analytical rationale for the hypothesis of the disappearing intermediate regime (or the “missing middle”)? Surprisingly, none currently exists, to our knowledge.

At first glance, it appears to be a corollary to the principle of the Impossible Trinity.⁹ That principle says that a country must give up one of three goals: exchange rate stability, monetary independence, and financial market integration. It cannot have all three simultaneously. If one adds the observation that financial markets are steadily becoming more and more integrated internationally, that forces the choice down to giving up on exchange rate stability or giving up on monetary independence. But this is not the same thing as saying one cannot give up on *both*, that one cannot have half-stability and half-independence. There is nothing in existing theory, for example, that prevents a country from pursuing a target zone of moderate width. The elegant line of target-zone theory begun by Krugman (1991) always assumed perfect capital mobility. Similarly, there is nothing that prevents the government from pursuing a managed float in which half of every fluctuation in demand for its currency is accommodated by intervention and half is allowed to be reflected in the exchange rate. (To model this, one need only introduce a “leaning against the wind” central bank reaction function into a standard monetary model of exchange rate determination.) And there is nothing that prevents a

⁷ Goldman Sachs.

⁸ The conventional wisdom now is that it is far worse to be forced to abandon an exchange rate target late into a speculative episode than early. Indonesia is one counterexample, a country that abandoned early, and suffered a sever crisis. Brazil is another counterexample: it clung to its target long after speculative outflows began to surge in August 1998, and yet when it finally devalued in January 1999, adverse effects on the economy were very mild compared, for example, to its neighbor Argentina.

⁹ Summers (1999b, p. 326) is explicit: “...the core principle of monetary economics is a trilemma: that capital mobility, an independent monetary policy, and the maintenance of a fixed exchange rate objective are mutually incompatible. I suspect this means that as capital market integration increases, countries will be forced increasingly to more pure floating or more purely fixed exchange rate regimes.”

country from pursuing a peg that is abandoned whenever there is a shock large enough to use up half its reserves.

Another justification that has been offered is that when a government establishes any sort of exchange rate target, as did the East Asian countries, its banks and firms foolishly underestimate the possibility of a future break in the currency value.¹⁰ As a result, they incur large unhedged dollar liabilities abroad. When a devaluation occurs, their domestic-currency revenues are inadequate for servicing their debts, and so they go bankrupt, with devastating consequences for the economy. “It follows that in a world of high capital mobility there are only two feasible approaches to exchange rate policy. One is not just to peg the exchange rate, but to lock it in – the Argentine strategy....The vast majority of countries will ... have to follow the other alternative of allowing their currencies to fluctuate. If the exchange rate moves regularly, banks and firms will have an incentive to hedge their foreign exposures...” (Eichengreen, 1999, p.105).

There is little doubt that the focus on unhedged foreign-currency debt describes accurately why the 1997-98 devaluations were economically devastating to East Asia. But the argument, as stated, has some weaknesses. First, it appears to depend on irrationality on the part of banks and firms. Second, it appears to imply that a country would be better off by gratuitously introducing extra noise into the exchange rate, to deter borrowers from incurring unhedged dollar liabilities. This seems unlikely to be right. Third is the point emphasized by Ricardo Hausmann: because foreigners are unwilling to take open positions in the currencies of emerging-market countries, the admonition to avoid borrowing in dollars is to some extent an admonition to avoid borrowing at all. (An admonition to hedge the dollar exposure is not helpful; someone has to take the other side of the futures contract, and this will be difficult in the aggregate if foreigners are unwilling to take the open position.) It may well be that this is the right road to go down, that exchange rate volatility is a way to put some sand in the wheels of the excessive capital movements, and that a lower volume of total debt is a good outcome. But if this is the argument, the proponents should be explicit about it. In any case, it seems doubtful that this argument could be captured by conventional models.

A third possible justification is that governments that adopt an exchange rate target, and sometime later experience a major reversal of capital inflows, tend to wait too late before abandoning the target. As of 1998, we thought we had learned that the one thing an emerging-market government can do to minimize the eventual pain from a currency crisis is to try to devalue early enough (or else raise interest rates early enough, as would happen automatically under a currency board – anything to adjust, rather than try to finance an ongoing deficit). Mexico, Thailand and Korea made the mistake of waiting too long, until reserves ran very low, so that by the time of the devaluation there was no good way out, no combination of interest rates and exchange rate that would

¹⁰ The version of this argument in Eichengreen (1999, p.104) overstates the extent to which the East Asians had “a stated commitment to the peg,” as most commentators have done as well. In fact few of the East Asian countries had explicit dollar pegs.

simultaneously satisfy the financing constraint externally and prevent recession domestically. But exiting from an exchange rate target can be difficult politically. The lesson is drawn that, to avoid this difficulty, governments should either adopt a rigid institutional fixed-rate commitment (such as the currency boards of Hong Kong and Argentina), or, if not prepared to do that, abandon the peg early.¹¹

On this basis, when Brazil in the Fall of 1998 delayed the seemingly inevitable jettisoning of the *real* target, many thought this would be a repeat of the earlier mistakes. Instead, when the devaluation finally came in January 1999, Brazil's trade balance improved sharply, the lack of confidence subsided, and output and employment subsequently performed far better than in neighboring Argentina. Thus it is more difficult to generalize from recent experience than widely believed. Furthermore, if we are to use government reluctance to exit a target arrangement as the basis of a model of the unviability of intermediate regimes, it seems that we would again require some sort of irrationality (or political constraints¹²) on the part of policy-makers.

Thus, each of the three arguments offered -- the impossible trinity, the dangers of unhedged dollar liabilities, and the political difficulty of exiting -- contains some important truth. But none seems able to stand as a theoretical rationale for the superiority of the corner solutions over the intermediate regimes. Is the corners hypothesis, then, just a misplaced manifestation of the temptation to believe that the grass is always greener somewhere else?

III. Verifiability

The idea behind verifiability is that the government's announcement of an exchange rate regime is more likely to be credible if market participants can check for themselves from observable data that the announced regime is in fact in operation. This process of verification can be modeled along the lines of the process of statistical inference familiar to econometricians. We are not suggesting that market participants will necessarily run OLS regressions literally, but rather that they must do something similar implicitly.

In this paper we will concentrate on the case of the basket peg with a band, and perhaps with a crawl. If a country follows a precise basket peg, with no band, the problem of statistical inference is of limited interest. In that case, the announcement of a basket of N major currencies (with unannounced parameters) can be verified with $N+2$ observations. But in practice there is almost always some range of variation in the observed exchange rate data, even if it is only within a narrow bid-ask spread quoted by

¹¹ Even then we had a counter-example: Indonesia had widened the band right away in 1997, and yet that didn't save it. But one could argue that political instability would have done Indonesia in no matter what. Taiwan devalued promptly, and suffered less than the others.

¹² Governments may have an incentive to postpone devaluations until after elections. See Ernesto Stein and Jorge Streb (1998, 1999).

the banking system, or within the +/- 1 percent range that constituted a fixed exchange rate under the rules of the Bretton Woods system. Then the problem of statistical inference is not trivial. For bands of substantial width, the statistical inference can in fact be difficult, as we shall see. This is all the more true if one allows for the ever-present possibility of shifts in the parameters -- basket weights, band width, rate of crawl, or level of parity -- or changes in the regime altogether, especially if some of these shifts are not announced.

We will begin with an analysis of the actual basket band followed by Chile during most of the 1990s, and then move on to Monte Carlo results. [We hope also to study other currencies, and perhaps eventually to derive some purely analytical results.] If the currency in question is in truth following a basket band, the question of interest is how many data are necessary, i.e., how much time must elapse, in order to verify that the data support the hypothesis. In general, we will consider an anchored exchange rate regime to have been verified if it passes three tests: (1) we can find statistically significant basket parameters, i.e., can reject the hypothesis that the currency is behaving like any "random" currency, (2) we fail to reject the hypothesis that the exchange rate is following a basket peg, (3) we have reason to believe that the second test has power to reject the null hypothesis, in that it succeeds in rejecting when applied to a times series of equal length for which the null hypothesis is false. In cases where the weights are publicly announced, then we may also apply related test criteria: (4) we fail to reject that the exhibited weights are the same as those announced, and (5) we do reject that the exhibited weights are equal to other possible arbitrary values, such as the weights on the SDR or 1/3,1/3,1/3 on the three big currencies. We want to see how the ability to confirm the announced nominal regime statistically is affected by the width of the band, by the presence of more than one foreign currency in the basket, by the presence of a non-zero rate of crawl, by the government's decision whether to announce these parameters, and by the frequency of changes in the parameters.

Throughout, we will focus on 95% significance levels. If the time sample needed for a currency to pass these tests at 95% significance levels is long (relative, for example, to the average length of time that these regimes tend to last), then we pronounce the regime not verifiable. If it is not verifiable, we suspect that the country cannot reap the credibility gains that an anchored exchange rate regime theoretically offers – credibility in the eyes of workers and producers who set wages and prices, and in the eyes of speculators who have the ability to attack the central bank's reserves and bring about a crisis. Such a regime may not be viable. Viability requires verifiability.

The goal of our paper is to study how long it takes for financial markets to learn from observable data the rules guiding the intervention behavior of monetary authorities in the foreign exchange markets. To perform both the analytical and empirical analysis, we need a basic framework and testing procedure. This section introduces the analytical framework used throughout the paper to verify exchange rate systems.

III.a Basic Framework

We assume that the exchange rate for a given small country is given by a geometrical average of N foreign currencies, with a possible rate of crawl d and an error term. The log exchange rate is:

$$\log s_t = c + \log(1 + d) + \frac{1}{N} \sum_i w_i \log s_{i,t} + \log \varepsilon_t . \quad (1)$$

s_t is the spot exchange rate of the domestic currency with its value measured in terms of a numeraire that we will explain momentarily . $s_{i,t}$ are the spot exchange rates of major “strong currency countries” with the values measured vis-à-vis the same numeraire . As major currencies, we use the U.S. dollar, the Japanese yen, the Deutsche mark, the French franc, and the British pound. d is the rate of crawl, which for now is assumed to be fixed during a given sample period. (One alternative would be to use past domestic or future inflation rates relative to international inflation rates, where the authorities are believed to be following an indexation policy.) w_i are the weights given to the currencies included in the basket.

This general case captures many possible regimes, including simple pegs, basket pegs, crawling pegs, crawling baskets, target zones, certain forms of managed floating, and free floating. In the case of a precise basket peg, the error term vanishes, and an OLS regression can be expected to have an R² near 1. (A dollar peg is of course the special case where the weight on the dollar is one and on other currencies zero.) For most currencies, the error term will be important. In the case of a pure float, the error term may constitute the entire variance of the exchange rate, and the other parameters may be equal to zero. We use daily data in our empirical research, both for estimation and Monte Carlo simulations.

The question of what to use as the numeraire to measure the values of the domestic and foreign currencies is a surprisingly subtle one. In the case of precise basket pegs (or dollar pegs), the choice of numeraire makes no difference, so long of course as the same one is used for both dependent and independent variables alike; the correct weights should emerge, with a perfect statistical fit, regardless of the numeraire. If equation (1) holds in terms of numeraire x , then it also holds after multiplying through by exchange rate y/x . But in the general case, the choice of numeraire will make a difference. Past studies have used a variety of different numeraires; they include the consumer basket of domestic goods (Frankel, 1993, which emphasized Asian currencies), the SDR (Frankel and Wei, 1995, which emphasized policies of European currencies), and the Swiss franc (Frankel and Wei, 1994 and Benassy-Quere, 1999).

Upon further reflection, these measures are not quite right. We wish to consider regimes where the central bank monitors a central parity, but routinely allows appreciations or depreciations relative to that parity in response to such factors as inflation, unemployment, trade deficits or surpluses, various market pressures and so on. These factors are only partially accommodated under an intermediate regime such as a

band or managed float, but they have a role nonetheless. We have not yet chosen to model explicitly these factors; they are comprised by the error term. We are assigning them a log normal distribution. The authorities are presumed to be trading off the long-term credibility benefits of sticking relatively close to their central nominal parity against the monetary-independence benefits of responding to short-term developments. But in framing this tradeoff, there is no reason for them to think of the departure above or below the central parity in terms of dollars or a basket of goods, and still less reason to think in terms of Swiss francs. The most useful way to phrase these appreciations and depreciations is, rather, in terms of an effective exchange rate, that is, a weighted average of trading partners' currencies.

Our central results are based on measuring values of currencies in terms of a weighted basket of the five major currency countries. One possible set of weights is the bilateral trade shares of the smaller country in question. This has a drawback: it leaves out the role of all the other bilateral trade partners, as well as third-country markets and competitors. But most of those are linked to some combination of the major currencies. Here we adopt the simple approach of using the five countries' weights in gross world production. In this way it is hoped that, for example, the large weight of the US will roughly reflect the importance of dollar-linked countries in the trade of Chile or Indonesia beyond the share of the US in bilateral trade of those two countries. (A second advantage of using GDP weights is that one need not obtain the full set of bilateral trade data and recompute a new set of weights for each country. But using bilateral trade weights is a possible extension for future research.) To repeat, our choice of numeraire is the output-weighted basket of the five major currencies.

Equation (1) captures different exchange rate regimes.

Simple Pegs, Basket Pegs, Crawling Pegs, Crawling Baskets:

In this case, the value of the currency follows the exchange rates of the currencies to which it is pegged, plus the crawling rule, and a stochastic error. The error is the error allowed by the government when setting the exchange rate. The error term is: $\log \epsilon_t$ iid $N(0, \sigma^2)$. In the case of simple pegs, $N=1$. Under basket pegs, $N>1$. Crawling pegs imply $d>0$. Under crawling baskets, $N>1$ and $d>0$. The independence assumption is certain to fail in a time series for the level of the exchange rate. A simple way of allowing for this is to work with first differences. We also try a more sophisticated specification, however, an error-correction model.

Target Zones:

Beyond the special case of pegs is the broader case of bands or target zones. There is a central parity that could be a single peg or a basket peg. In addition, there is a band around the central parity. The exchange rate fluctuates inside the band. Whenever it hits the boundary, the government intervenes to keep the exchange rate inside the band. In some cases, governments make intra-band interventions as well.

In a target zone, the observed spot exchange rate s_t^* behaves as follows:

$$s_t^* = \begin{cases} -b & \text{if } s_t < -b \\ b & \text{if } s_t > b \\ t & \text{otherwise} \end{cases}$$

where s_t is defined by equation (1) above and b is the upper bound of the band. We will assume that inside the band, the exchange follows $\log s_t = \rho \log s_{t-1} + \log u_t$, such that $\log u_t \sim N(0, \sigma^2)$. If the floating exchange rate is a random walk, $\rho=1$. If not $\rho < 1$.

We will concentrate on the random walk case, since most exchange rate time series cannot reject the unit root hypothesis. In reality, the distribution is likely to be somewhat more complicated than this. Even under two simplifying assumptions made by Krugman (1991), in a famous article that generated a sub-field of research on target zones -- that the band is 100% credible and that the authorities intervene only at the boundaries -- the distribution is not normal, but rather follows a particular S-shape.¹³ But extensive empirical investigation of the European Exchange Rate Mechanism in the 1980s and early 1990s established that the spot rate does not in fact obey the predicted distribution. One reason is clearly that speculators did not have 100% faith that the target zones would prevail. This imperfect credibility was in the event justified by realignments in the early 1980s, and especially by the ERM crises of 1992-93. It is also very relevant for the present exercise, which is entirely based on a starting point that assumes imperfect credibility. (Another explanation for why the ERM data did not fit the Krugman distribution was the prevalence of intra-marginal intervention.) One extension for further research would be to use statistical distributions implied by more sophisticated versions of the target zone theory. Another would be to take the observed statistical distribution from historical episodes such as the ERM currencies in the 1980s or 1990s. But to start with we assume the log normal distribution indicated.

Managed Floating and Free Floating

There are many possible patterns of exchange rate intervention. Our basic framework allows us to only test the cases when d or w_i are different from 0. In other words, the government is using some form of nominal anchor or crawling peg rule to guide its operations. All other forms of intervention are not nested in our specification. Therefore, we would not be able to reject them. Pure floating takes place when $d=0$ and $w_i=0$.

III.b Testing Strategies

Hypothesis Testing

¹³ When the spot rate draws close to one edge, speculators are aware that there is a limit on how far it can continue to move in that direction. The expected value will show a regression back toward the central parity. As speculators respond to that expectation, they will push the spot rate away from the margin, even without any intervention

In this paper, we want to determine how verifiable different exchange rate regimes are. We need to establish what tests financial markets perform to learn about the monetary authorities' actions. There are many testable hypotheses. We focus on five cases. In each case, we measure the "verification time," defined as the elapse of time (usually measured in days) necessary to reach the judgment that the data are consistent with, and support, the hypothesis that the exchange rate is following a band around a basket peg.

Test 1 (T1): The first case tests whether the government is following some sort of nominal anchor and whether the rate of crawl is zero. We assume that market participants do not know what the government is doing or they do not believe the announced exchange rate regime. The null hypothesis is that the exchange rate follows a random walk with no drift. Therefore, we think of market participants as testing if all the weights on the strong currencies are jointly equal to zero. In other terms,

$$\begin{aligned} \text{H0: } & w_I = 0 \dots \text{ and } \dots w_N = 0 \text{ and } d=0 \\ \text{HA: } & w_I \neq 0 \dots \text{ or } \dots w_N \neq 0 \text{ or } d \neq 0. \end{aligned}$$

Test 2 (T2): The second case is a slight modification of the base case. In this case, market participants only test whether the weights are equal to zero. The null and alternative hypotheses are:

$$\begin{aligned} \text{H0: } & w_I = 0 \dots \text{ and } \dots w_N = 0 \\ \text{HA: } & w_I \neq 0 \dots \text{ or } \dots w_N \neq 0. \end{aligned}$$

Test 3 (T3): We complement T2 with another test. To show that T2 has size we replace the dependent (LHS) variable by a white noise. In this case, we expect to fail to reject the null hypothesis specified in T2.

$$\begin{aligned} \text{H0: } & w'_I = 0 \dots \text{ and } \dots w'_N = 0 \\ \text{HA: } & w'_I \neq 0 \dots \text{ or } \dots w'_N \neq 0, \end{aligned}$$

such that w'_i are the weight.

Test 4 (T4): In the third case, market participants test whether the observed weights are equal to the announced weights. Conditional on the announcement being true, we expect that this null will not be rejected. The null and alternative hypotheses are as follows,

$$\begin{aligned} \text{H0: } & w_i = \text{announced weights} \\ \text{HA: } & w_i \neq \text{announced weights.} \end{aligned}$$

Test 5 (T5): T4 might raise a problem. T4 might fail to reject the null if, for example, we work with a short time sample. Market participants know instinctively that a failure to reject the regime is an impressive finding only when that test would be capable of rejecting the regime in the case where it was false. In other words, we want the test to have power. To show that T4 has power, we complement the above test with another experiment in which the same test is capable of rejecting the null hypothesis. To do this, we switch the LHS variable by a white noise. The hypotheses tested are:

H0: $w'_i =$ announced weight on currency i
 HA: w'_i announced weights on currency i .

General Criterion: As a general criterion we report the time to reject T2 and T5 and, at the same time, fail to reject T3 and T4.

Estimation Procedures:

A variety of estimation/testing procedures are potentially applicable. We undertake both a “naïve” and a “sophisticated” estimation procedure.

The “naïve” estimation consists of computing ordinary least squares (OLS) regression estimates of equation (1) for all models, regardless of the exchange rate regime in place. The naïve estimation assumes that errors in equation (1) are *iid* $N(0, \sigma^2)$. We perform two naïve estimations, one with the variables in levels and one with the variables in first differences. The first one assumes that the government links the level of the domestic exchange rate with levels of the major currency exchange rates. A deviation in one period will tend to be fully corrected in the next. The second one assumes that the government changes the current exchange rate when it sees change in the major currencies, but does not necessarily correct past deviations.

The “sophisticated” estimation takes into account the statistical properties of the exchange rate regime. For simple pegs and basket pegs, we assume that financial markets estimate error-correction models (ECMs). In fact, we also use ECMs to estimate simple and basket pegs with bands. These models simultaneously estimate the long-term and short-term relationship of the domestic exchange rates. The long-term relationship links the level of the domestic exchange rate with the level of the strong currency exchange rates. The domestic exchange rate adjusts in the short-term to deviations from the long-term relationship. The ECM is estimated by the following equation, which yield estimates of w_i to test cases 1-5:

$$\log s_t = c + \gamma \log s_{t-1} - \log(1 + d) + \sum_{i=1}^N w_i \log s_{i,t-1} + \sum_{h=1}^L \beta_h \log s_{t-h} + \sum_{i=1}^N \sum_{h=1}^L \beta_{i,h} \log s_{i,t-h} + \log \varepsilon'_t \quad (2)$$

In the case of target zones, the error term is truncated at $CP_t + b$ and $CP_t - b$. CP_t is the central parity of the band; b is half the band width. The central parity is given by:

$$CP_t = c + \log(1 + d) + \sum_{i=1}^N w_i \log s_{i,t}.$$

A sophisticated estimation would involve specifying the correct likelihood function. The log change of the exchange rate, conditional on the information set I_t , has the following truncated normal distribution:

$$f(\log s_t | I_t) = \frac{\phi \frac{\log s_t}{\sqrt{\sigma_t^2}} - \frac{1}{\sqrt{\sigma_t^2}}}{\frac{U_{t-1}}{\sqrt{\sigma_t^2}} - \frac{L_{t-1}}{\sqrt{\sigma_t^2}}}$$

In other terms, $f(\log s_t | I_t) = TN(\mathbf{0}, \sigma_t^2, U_t, L_t)$. U_t (L_t) is the maximum (minimum) possible change in the exchange rate, which takes the exchange rate to the upper (lower) side of the band. At every point in time, $U_t = CP_t + b \cdot \log s_t$ and $L_t = CP_t - b \cdot \log s_t$. The information set is given by $I_t = \{s_t, s_{it}, t\}$. The parameter vector to estimate is $\theta = (c, d, w_1, \dots, w_N, \sigma^2)$. The band width ($2 \times b$) is assumed to be known.

The target zones literature has used this type of models, to estimate the s-shape properties of exchange rates under the assumptions of no infra-margin intervention and perfect credibility. The empirical literature on target zones, such as Bekaert and Gray (1999), assumes that the central parity and band width are known and proceed to estimate how macroeconomic fundamentals affect the exchange rate. For the purpose of this paper, we would need to estimate the central parity of a target zone. We do not know the position of the spot exchange rate inside the band. There are many combinations of the parameters that might give us a solution to the problem. Future extensions of this work might find a model that estimates the weights in the central parity. The mere application of the available models does not yield an easy answer to the verifiability problem, and requires a large amount of information to converge to possible solutions.

IV. The Case of Chile

To provide a background and motivate our Monte Carlo results below, we first focus on the particular case of the Chilean peso. We select the case of Chile because during most of the 1990s it provided a relatively transparent example of a basket peg with a band. The parameters configuring the basket peg and the band width were publicly announced. Thus, if we conclude that the Chilean exchange rate regime was not verifiable, such a conclusion is likely to apply even more strongly to other countries in Latin America or Asia, where governments often have not announced explicit regimes or the parameters in them, or in some cases have not for long abided by the regime they announced.

IV.a Data Description

A number of successive exchange rate regimes have been in place in Chile since the early 1980s. In 1982, Chile had a crawling peg vis-à-vis the U.S. dollar, with daily devaluations following the difference between domestic and external inflation. The peg to the dollar continued until 1992, with bands of varying width around the central parity and with realignments of the central parity. In 1992, the government decided to adopt a target zone around a basket peg. The weights in the central parity changed over time and there

were realignments, but the central parity was always tied to the U.S. dollar (US\$), the Deutsche mark (DM), and the Japanese yen (JY). In September 1999, the central bank decided to float the peso. A full chronology of the exchange rate system in Chile is displayed in Table A.1 in the appendix.

We analyze the case of Chile by looking at seven sub-periods, selected on the basis of a minimum duration (specifically, those comprising at least 249 daily observations, amounting to approximately one year). The first three sub-periods involve a peg to the U.S. dollar with a band. The last four involve a basket peg with a band. For each of the seven sub-periods, Table IV.1 lists the announced weights in the central parity, and the band around the central parity. Figure IV.1 summarizes the main aspects of the evolution of the exchange rate regimes in Chile. The figure shows that the trend of the peso has been to depreciate over time, with significant appreciations and depreciations on several occasions. Figure IV.2a displays the observed exchange rate and shows how it fluctuates within the band, as well as the gradual widening of the latter. This is further illustrated in Figure IV.2b, which shows the relative position of the exchange rate vis-à-vis the lower and upper band. It is apparent that in some periods, like 1991-92, the exchange rate is close to the lower band. In other periods, like 1994-95, the exchange rate fluctuates farther inside the band.

[Table IV.1: Exchange Rate Regimes in Chile]

[Figure IV.1: The Chilean Exchange Rate Arrangements]

[Figure IV.2a: Chilean Spot Exchange Rate and Exchange Rate Band]

[Figure IV.2b: Relative position of the Chilean Exchange Rate inside the band]

The “Dolar Acuerdo” or Central Parity:

On July 3, 1992, the Chilean central bank established a basket of 3 foreign currencies, the US\$, the DM, and the Japanese Yen with weights of 50%, 30% and 20%, respectively. The so-called “dolar acuerdo” (or central parity given by the basket rule) is computed as a function of two bilateral exchange rates. This rule establishes that the peso/US\$ exchange rate is a function of the peso/DM and the peso/JY exchange rates.

The Chilean exchange rate vis-à-vis the US\$ is calculated using the formula:

$$X_t = C_t/C_0 * X_0 * 1/(w_1 + w_2 D_0/D_t + w_3 J_0/J_t)$$

As this is not a linear function of the parameters, a more convenient representation is:

$$(X_0/X_t) = w_1 (C_0/C_t) + w_2 (D_0/D_t)(C_0/C_t) + w_3 (J_0/J_t)(C_0/C_t) \quad (3)$$

where,

C_t : Value of Basket at time t (in \$)

C_0	:	Value of Basket at the beginning of the period (in \$)
X_t	:	Exchange rate of Chilean \$ vis-à-vis the US\$ at time t
X_0	:	Exchange rate of Chilean \$ vis-à-vis the US\$ at time 0
w_1, w_2, w_3	:	weights in the basket
D_t	:	Exchange rate of Chilean \$ vis-à-vis the DM at time t
D_0	:	Exchange rate of Chilean \$ vis-à-vis the DM at time 0
J_t	:	Exchange rate of Chilean \$ vis-à-vis the JY at time t
J_0	:	Exchange rate of Chilean \$ vis-à-vis the JY at time 0.

The Chilean authorities used to report daily the “dolar acuerdo” or central parity. This central parity is determined ex-ante by the announced weights of the peg. The central bank just computes the central parity according to the spot exchange rate of the strong currencies. The actual Chilean peso could not be outside a predetermined distance of the central parity if the band was not to be violated. As already noted (see Table IV.1), the central parity is a simple peg during the first three periods we analyze and a basket peg during the last four periods.

As a benchmark, we apply the same tests mentioned above to the central parity. This helps us determine the effect of the width of the band on our verifiability assessment, since the tests on the central parity amount to testing the identifiability of a zero-width band. In addition, the case of Chile also helps us determine the effect of one versus more currencies in the basket, as the central parity in the first three periods contains only one currency (the US\$), while the last three periods involve three currencies.

The Construction of the Numeraire

All exchange rates are measured relative to a numeraire. As explained above, the numeraire is based on a weighted-basket of major currencies. The weights are based on the 1991 GDP shares of 5 countries: U.S., France, Germany, Japan, and U.K. The shares are 39.2%, 9.2%, 14.3%, 31%, and 6.4% respectively. Specifically, we use the GDP at market prices (constant 1995 US\$) obtained from the World Bank World Development Indicators.

The above equation is rewritten and expressed in terms of the numeraire. The equation we estimate is the following:

$$s_t = C + w_{US\$} s_{US\$,t} + w_{DM} s_{DM,t} + w_{JY} s_{JY,t} + v_t \quad (4)$$

The exchange rates are defined as follows:

s :	Spot exchange rate between the Chilean peso and the numeraire (US\$/N)
$s_{US\$}$:	Spot exchange rate between the U.S. dollar and the numeraire (US\$/N)
s_{DM} :	Spot exchange rate between the Deutsche mark and the numeraire (DM/N)
s_{JY} :	Spot exchange rate between the Japanese yen and the numeraire (JY/N).

The exchange rates, both of the major currencies and the Chilean peso, are calculated as the number of units of the currency necessary to purchase a geometrically weighted basket of strong currencies. Table IV.2 reports the summary statistics of the currencies under consideration.

[Table IV.2: Strong Currencies]

IV.b Results

All estimations and tests are performed using each of three series as dependent variable: the actual peso exchange rate, a randomly-generated series, and the daily announced central parity. The estimations are reported on each of the seven exchange rates regimes. We focus on three types of results: point estimates of the weights conforming the central-parity basket; Wald tests of the hypotheses that the estimated coefficients equal those announced by the authorities or, alternatively, equal zero; and stability of the estimated parameters (when using the actual exchange rate as dependent variable).

We first review the point estimates of each model's parameters at sample sizes of 50 and 100 observations. These estimates tell us how well can market participants estimate the weight of the central parity when the regimes are 50 and 100 days old. We perform this exercise using three kinds of estimates: static OLS on the level data, static OLS on the first-differenced data, and long-run estimates obtained from an error-correction specification.

The results are displayed in Table IV.3, which presents both the point estimates of the US Dollar weight and their reported standard errors. (To save space, we do not report the point estimates of the other currencies' weights.) When using the central parity as dependent variable, the estimates of the US Dollar weight converge to the announced values fairly quickly, especially in the single-peg sub-periods 1-3. However, in the multiple-peg sub-periods 4-7, some of the level-based and, especially, the first-differenced estimates still remain far from the announced values after 100 observations.

Next, when using the randomly-generated series as dependent variable, we find that the coefficient estimates are almost invariably small relative to their reported standard errors. The error-correction estimates are fairly close to zero in most cases, but some of the level and difference estimates are large in absolute magnitude.

Perhaps more importantly, when using the actual exchange rate as dependent variable, a contrast emerges between sub-periods 1-3 and 4-7. In the former sub-periods, the error-correction estimates approach the announced value rather quickly – by observation 50, they are not more than 5% apart from it. The first-difference estimates are farther away, but not significantly so according to their computed standard errors. (In turn, the level estimates remain far from the announced values judged by their standard errors, but the latter are almost certainly understated).

In contrast, for periods 4-7 none of the estimates appears close to the announced values. Indeed, several point estimates are negative and large, and precision is in general much poorer according to the reported standard errors. Thus, the conclusion is that in sub-periods 4-7 none of these simple estimators comes close to the true basket weights, even after a reasonably large number of observations.

[Table IV.3: Point Estimates]

We next turn to formal hypothesis tests on the parameter estimates. Specifically, we test the null hypotheses that (a) the estimates of the weights on the various currencies are jointly different from zero (Test 2 above) and (b) the estimates equal the announced weights. We perform these tests only for the first difference and error-correction estimates, given that the computed covariance matrix of the level estimates is likely to be grossly inconsistent. Finally, we report the tests only for the estimates obtained using as dependent variable the actual exchange rate and the randomly generated series;. (Comparable tests using instead the central parity yielded trivial results – rejection of the zero-weights and non-rejection of the announced weights in every sub-period and for every sample size.)

Figures IV.3 and IV.4 report marginal significance levels for the null of zero weights, corresponding to the first difference and error-correction estimates respectively. The graphs plot the p-values against sample size for each of the seven sub-periods under consideration. It is apparent that the null can be rejected even at small sample sizes in the case of the actual exchange rate – with the exception of a couple of brief intervals when using the error-correction estimates – and cannot be rejected in the case of the randomly-generated series – again excepting a brief stretch in sub-period 2 when using the error-correction parameters.

[Figure IV.3: p-values—Test 2 & 3 (H_0 : Weights=0) – First differences]

[Figure IV.4: p-values —Test 2 & 3 (H_0 : Weights=0) - Error-Correction]

[Figure IV.7: Parameter Instability—OLS (fd or levels)]

Next, Figures IV.5 and IV.6 report marginal significance levels for the null that the estimates equal the announced weights for each regime. Thus the goal is now to fail to reject the null hypothesis. Here both figures reveal a stark contrast between sub-periods 1-3 and 4-7. In the case of the first-differenced estimates, the null cannot be rejected in the former sub-periods (for the case of the actual exchange rate series), but is thoroughly rejected in the latter at any sample size. Interestingly, in these latter periods it proves more difficult to reject the same hypothesis for the case of the randomly-generated series. In turn, the error-correction estimates from the actual exchange rate series yield a broadly similar picture: they also reject the null in sub-periods 5-7 (except for some brief intervals), and fail to reject in sub-periods 1-4. However, this latter result is achieved after a considerable stretch of consecutive rejections, especially in sub-periods 3 and 4 (and to a more limited extent in period 2 too). Finally, for the randomly-generated series

the error correction estimates clearly reject the announced weights for every sample size and sub-period.

On the whole, these results strongly suggest that the widening of the band, as well as the adoption of multiple instead of simple pegs – the two features that characterize the evolution of Chile’s exchange regime between sub-periods 1 and 7 -- both appear to make more difficult the verification of the announced regime using simple econometric estimates.

[Figure IV.5: p-values—Test 4 & 5 (H0: Weights=Announcement) - First differences]

[Figure IV.6: p-values—Test 4 & 5 (H0: Weights= Announcement) - Error-Correction]

As a final check, we turn to the stability of the various estimates. Figures IV.7 and IV.8 respectively present the first-difference and error-correction estimates of the U.S. dollar weight, as well as their 95% confidence regions, at each sample size and for each sub-period. Again there is a contrast between the simple peg and multiple peg regimes, especially in the case of the error-correction estimates in Figure IV.6. Under the simple peg regimes, the error-correction estimates appear fairly concentrated around the announced values. The third sub-period is a bit different in that the estimate remains consistently below (although close to) the announced value in the first part of the sample, so that the confidence region includes the announced central parity only in the second part of the sample. In contrast, the estimates for sub-periods 4-7 are much more unstable and imprecise (note the larger vertical scale used in these graphs). In periods 4 and 6, they eventually center on the announced weights, but their dispersion renders them of little informational value.

[Figure IV.7: Parameter Instability—First differences]

[Figure IV.8: Parameter Instability—Error-Correction]

By way of summary of our results, we present in Table IV.4 a rough and somewhat subjective estimate of “verification time” – that is, the sample size required to reject *irreversibly* the (false) null hypothesis that the currency weights are zero, or to *irreversibly* stop rejecting the (true) null that the currency weights equal their announced values. By “irreversibly” here we mean that the test outcome is not reversed at larger sample sizes. If at no sample size is this irreversible outcome obtained, we enter an “N” (short for “Never”) in the corresponding column in the table. The table presents this information for each sub-period, using both the first-difference and error-correction estimates. Finally, we also note in the table their overall precision, defined as high if the confidence region extends no farther than 25 percent above/below the parameter’s true value, and as low otherwise.

The top panel corresponds to the first-difference estimates. In this specification, the null of zero weights can be rejected at any sample size; hence the first column in the

table is all ones. However, the announced weights are rejected throughout in sub-periods 4-7 (and never rejected in sub-periods 1-3), hence the “N”s in the bottom half of the second column. Finally, precision of the estimates is low across all subperiods.

In the case of the error-correction estimates, the null of zero weights can be rejected from the start only in sub-periods 2 and 3. In sub-period 6, it cannot be rejected even with the full sample. Likewise, it takes some time to stop rejecting the announced weights – from a moderate sample size of 40 in sub-period 1, to over 200 observations in sub-periods 3-4. In the last three sub-periods, the estimates never converge to the announced values. Precision of the estimates is quite good in the first three sub-periods, and quite poor in the last four.

[Table IV.4: Chilean Exchange rate Regime Verification time]

V. Monte Carlo Simulations

We turn to the Monte Carlo simulations, which offer a more general testing ground for verifiability of intermediate regimes. For our experiments, we generate 1,000 samples according to the simple model described by equation (1), using for the baskets actual data on the exchange rates of the major currencies (valued in terms of the GDP-weighted numeraire). We use daily data between February 1986 and September 1999. The parameters of the data-generating process are c (level of exchange rate), d (yearly rate of crawl), $w_1...w_3$ (weights on US\$, DM, and JY), σ (standard deviation of the error term), and t_0 (initial observation). In the Monte Carlo simulation, the log error term is generated as *i.i.d* normal with mean zero. Based on this basic framework, we study the effect of different model specifications on the amount of time to reject our proposed null hypotheses.

V.a Role of Band Size

Clearly, it should be harder to verify a basket regime with a wide band than one with a narrow band, and harder to verify a basket regime with a loosely managed float (i.e., a small tendency to intervene when the exchange rate drifts from the parity) than another with a tightly managed float (a strong tendency to intervene). To verify the role of band size in determining the amount of information needed to reject the proposed null hypotheses, we generate sets of 1,000 samples, according to equation (1). Each set has a different standard deviation of the underlying disturbance (σ), representing different band sizes.

For each sample, we calculate the number of observations necessary to obtain 10 rejections of the null hypothesis that both the weights and the rate of crawl are zero (Test 1), and the null hypothesis that the weights are zero (Test 2). We label these sample sizes VT1 and VT2, respectively, where VT stands for “verification time”.

For this exercise, we generate the samples using a level parameter equal to 1, a rate of crawl of 1% per year, and equal weights for all major currencies, and starting from observation 1 (2/24/1986). We let the standard deviation vary from 1 percent to 10 percent. In this regard, recall that 2% was the width of Chile's band from mid-1985 to 1987, and 10% was the width of the band during the period 1992-97. For purposes of comparison, 2_ percent was the width of the ERM target zone followed by many European countries up until 1992 (and still followed today by Denmark), 6 percent is the width of the ERM target zone followed by Italy and the United Kingdom up to 1992, and 15 percent is the width of the ERM zone for France and others from 1992 until the beginning of EMU in January 1999.

The results appear in Figure V.1. The graphs plot the quantiles of VT1 and VT2 against the standard error () used to generate the samples. Each line corresponds to one quantile, and depicts the number of observations needed to achieve rejection of the null hypothesis (at the 5 percent level) in x% of the 1,000 samples – where x is the quantile in question.

As expected, the graphs show that, for both tests, the number of observations needed to reject the null of zero weights and rate of crawl in any given percentage of the samples rises steadily with . This is reflected by the fact that the lines corresponding to the various quantiles have positive slopes. In other words, wider bands make it more difficult for investors to reject specific hypotheses concerning the weights of the central parity – they need more time to get an accurate assessment of the parameter values. And the additional time needed is not negligible. For test 2, for example, the number of observations needed to reject the null in 50% of the samples ranges from under 100 days for an (old-) EMU-sized band (2% width) to over 500 for a Chilean-sized one (10% width).

[Figure V.1: Role of Band Size]

V.b Role of Number of Currencies in Basket

Intuitively, the larger the number of unknown parameters that need to be estimated, the harder it should be to verify that the data match the announced policy regime. This applies not only to the number of currencies in the basket, but also to the presence of a non-zero rate of crawl.

To verify this assertion, we next examine the impact of different basket sizes on the amount of information needed to reject the nulls underlying tests 1 and 2. For this purpose, different numbers of currencies were included in the Data Generating Process (DGP). We construct a simple peg (the U.S. dollar), a two-currency basket (the U.S. dollar and the Deutsche mark), and a three-currency basket (the dollar, the Deutsche mark, and the Japanese yen). In each basket the currencies are equally weighted. The other assumptions are like in the previous exercise.

The results are portrayed in Figure V.2. To avoid cluttering the pictures, only the medians of VT1 and VT2 (defined as before) are presented. They are plotted against alternative values of the standard deviation of the random disturbance assumed in the simulation.

As expected, increasing the number of currencies in the basket shifts the quantile lines upward, reflecting the fact that for any given value of the standard deviation more observations become necessary to reject the null hypotheses. As before, the increase in information requirements is sometimes substantial. For example, with a band width of 10 percent (as observed in Chile in recent times), moving from a single to a 3-currency basket raises the 50-percent quantile of Test 2 by over 200 observations – implying that an extra year of data becomes necessary to reject the null hypothesis.

[Figure V.2: Role of Number of Currencies in Basket]

V.c Role of Rate of Crawl

What about the rate of crawl? Intuitively, its value should have little consequence for Test 2, which is concerned only with the basket weights. However, for Test 1 it can make a big difference – rates of crawl farther away from zero must help reject the null hypothesis more quickly, since the latter involves a zero rate of crawl.

This is verified in Figure IV.3, which shows the effects of different rates of crawl on the verification time, as reflected by the 50-percent quantile of VT1 and VT2. For a given value of σ , we generate different samples assuming increasing rates of crawl. As expected, VT1 (measured by the left scale) declines steadily as the rate of crawl rises away from zero, while VT2 (measured by the right scale) shows only modest variation.

[Figure V.3: Role of Rate of Crawl]

V.d Role of Period

The power of these tests depends on the precision of the parameter estimates, itself given by the noise-to-signal ratio -- or the relative size of the variances of the dependent and independent variables. When the variance of the dependent variable is large relative to the variance of the independent variable, the estimates are imprecise and it is difficult to reject a given null hypothesis. Since these relative variances are not constant over time, the verifiability of a given model may depend on the specific time period over which it is observed.

This can be assessed using data from different time periods to carry out the tests T1 and T2. Since our experiments use actual data on the hard currencies, any differences in VT1 and VT2 across replications using hard-currency data from different time periods

should be attributed to changes over time in the variance-covariance matrix of the hard currencies.

The results of such an experiment are reported in Figure V.4, which shows the median values of VT1 and VT2 obtained when the simulations use hard-currency data from different periods in 1986-96, and assuming a three-currency basket with equal weights.

To facilitate the interpretation of the results, we also show in the figure a measure of the variance of the hard currencies – specifically, the inverse of the average of their standard deviations. As the graph shows, variability of the hard-currency exchange rates was particularly high in the first and fourth periods considered. This results in a clear reduction in VT1 and VT2 in such periods, relative to the rest.

[Figure V.4: Role of Period]

V.e Role of Periodic Adjustments

In the real world, verification of basket pegs is often complicated enormously by frequent changes in the weights or other parameters governing the peg, either in a systematic effort to track actual bilateral trade weights or on a more ad hoc basis. If these changes happen often enough, it may become very hard for market participants to reach an accurate assessment of the rule governing the exchange rate.

Indeed, if we allow for periodic adjustments in the crawl rate and/or the basket weights, and gradually let the adjustments become more frequent, at some point the interval between adjustments will become shorter than the regime's verification time, as defined earlier. In such conditions, it becomes impossible for market participants to ever verify the exchange rate regime – they can't catch up with the moving target.

In future revisions we plan to examine the effects of various types of readjustments -- affecting basket weights, speed of crawl, or band-widths. The simplest exercise would be to assume that the date of a potential realignment is known, and to use breakpoint tests to see whether it has in fact taken place. A more difficult exercise is to assume one realignment at some unknown point during the sample period, and to use statistical techniques to estimate the date at which it seems to occur. Still more complicated techniques would be needed to allow for an unknown number of shifts, occurring at unknown dates. In each case, the central question of interest would be how the changes in parameters decrease the verifiability of the basic regime.

VI. Summary of Conclusions

The new conventional wisdom is that intermediate exchange rate regimes, such as baskets, crawls, and bands, are no longer viable. According to this proposition, countries

are being pushed to the “corners,” the extremes of either free floating or firm fixing. We have argued that a theoretical rationale for this proposition is currently lacking; none of the candidates offered -- the impossible trinity, the dangers of unhedged foreign liabilities, or government reluctance to abandon ship in time -- is quite up to the job. We offer such a rationale, by introducing the notion of *verifiability*. By verifiability we mean the ability of a market participant to infer statistically from observed data that the exchange rate regime announced by the authority is in fact in operation. Verifiability is an instance of transparency, a means to credibility. Our point is that a simple regime such as a clear dollar peg or free float may be more verifiable by market participants than a complicated intermediate regime.

We begin the analysis with the case of Chile, which has followed various combinations of basket pegs, crawls, and bands, over the last two decades. From 1982 to 1992, when the band was relatively narrow and the peg was simply to the dollar, 50 observations is generally a big enough sample to achieve some sort of statistical verification. But from 1992 to 1999, when the band was relatively wide and the peg was to a basket of currencies, verification was not possible. On the whole, the results suggest that the widening of the band, as well as the adoption of multiple instead of simple pegs - - the two features that characterize the evolution of Chile’s exchange regime over this period -- both make more difficult the verification of the announced regime by means of simple econometric estimates.

We continue the analysis by means of Monte Carlo tests. We began with the effect of the width of the band on verifiability. As expected, when the range of variability is small, the number of observations needed to reject that the weights and the rate of crawl are zero is relatively small. For larger variances, the number of observations needed to reject the null hypothesis increase. The number of observations needed to differentiate the crawling basket from a random currency in at least half of the samples is under 100 days when the band width is 2%, as it was for Chile from 1985 to 1987, but is over 500 days when the band width is 10 percent, as it was for Chile from 1992 to 1998. In other words, wider bands make it more difficult for investors to verify the regime.

Second, we looked at the role of the number of currencies in the basket. Moving from a single-currency parity to a 3-currency basket increases the amount of data needed to distinguish the basket from a random currency by an extra year’s worth of observations (assuming a 10 percent band, and again using the criterion of finding statistically significant weights at least half the time).

If we are right that it is hard for a central bank to establish credibility for its proclaimed monetary regime without verifiability, then our results confirm that complicated combinations of baskets, crawls, and bands, are less likely to satisfy skeptical investors than are simpler regimes. We thus offer a rationale for the hypothesis of the vanishing intermediate exchange rate regime. If it is not verifiable, it may not be viable.

References

Bekaert, Geert and Stephen Gray, 1998, "Target Zones and Exchange rates: An Empirical Investigation," *Journal of International Economics*, v45 n1 June 1998, pp. 1-35.

Benassy-Quere, Agnes, 1999, "Exchange Rate Regimes and Policies: An Empirical Analysis," in Exchange Rate Policies in Emerging Asian Countries, edited by Stefan Collignon, Jean Pisani-Ferry, and Yung Chul Park (Routledge: London), 40-64.

Council on Foreign Relations, 1999, Safeguarding Prosperity in a Global Financial System: The Future International Financial Architecture, published by Institute for International Economics, Washington, DC, 1999.

Crockett, Andrew, 1994, "Monetary Policy Implications of Increased Capital Flows," Changing Capital Markets: Implications for Monetary Policy, Symposium sponsored by Federal Reserve Bank of Kansas City, Jackson Hole, August 1993.

The Economist, "Global Finance: Time for a Redesign?" January 30, 1999, p. 1-18.

Edwards, Sebastian and Miguel Savastano, 1999, "Exchange Rates in Emerging Economies: What Do We Know? What Do We Need to Know?" NBER Working Paper No. 7228, July.

Eichengreen, Barry, 1994, International Monetary Arrangements for the 21st Century, Brookings Institution, Washington DC.

Eichengreen, Barry, 1999, Toward a New Financial Architecture: A Practical Post-Asia Agenda, Institute for International Economics, Washington, DC.

Ffrench-Davis, Ricardo, Manuel Agosin, and Andras Uthoff, 1995, "Capital Movements, Export Strategy and Macroeconomic Stability in Chile," in Ricardo Ffrench-Davis and Stephany Griffith-Jones, Coping with Capital Surges: The Return of Finance to Latin America, Lynne Reiner Publishers, Boulder, 99-144.

Frankel, Jeffrey, 1993, "Is Japan Creating a Yen Bloc in East Asia and the Pacific?" in Regionalism and Rivalry: Japan and the U.S. in Pacific Asia, edited by Jeffrey Frankel and Miles Kahler, University of Chicago Press, Chicago, 1993, 53-85.

Frankel, Jeffrey, 1999, "No Single Exchange Rate Regime is Right for All Countries or at All Times," Graham Lecture, Princeton University Press. NBER Working Paper No. 7338.

Frankel, Jeffrey, and Shang-Jin Wei, 1994, "Yen Bloc or Dollar Bloc? Exchange Rate Policies of the East Asian Economies" in Macroeconomic Linkages: Savings, Exchange Rates, and Capital Flows, *NBER - East Asia Seminar on Economics, Volume 3*, Takatoshi Ito and Anne Krueger, editors, University of Chicago Press, 1994.

Frankel, Jeffrey, and Shang-Jin Wei, "Emerging Currency Blocs", in The International Monetary System: Its Institutions and its Future, edited by Hans Genberg, Springer, Berlin, 1995, 111-143.

Hausmann, Ricardo, Michael Gavin, Carmen Pages-Serra, and Ernesto Stein, 1999, "Financial Turmoil and the Choice of Exchange Rate Regime," InterAmerican Development Bank.

Hussey s. and F. Morandé, 1996, "La Banda Cambiaria en Chile," in Análisis Empírico del Tipo de Cambio in Chile," Morandé and Vergara editors, CEP-ILADES.

Klein, Michael, and Nancy Marion, 1997, "Explaining the Duration of Exchange-Rate Pegs," *Journal of Development Economics*, December , vol. 54, no. 2, pp. 387-404.

Krugman, Paul, 1991, "Target Zones and Exchange Rate Dynamics," *Quarterly Journal of Economics* CVI, 669-682.

Larrain, Felipe, and Andres Velasco, 1999, "Exchange Rate Policy for Emerging Markets: One Size Does Not Fit All," July, forthcoming, Essays in International Finance, Princeton University Press.

Lowell, Julia, 1992, "Do Governments Do What They Say (And Do We Believe Them)? Two Essays on National Debt and Exchange Regime Policies," PH.D. dissertation, Department of Economics, University of California, Berkeley.

Minton-Beddoes, Zanny, 1999, "From EMU to AMU? The Case for Regional Currency Blocs," *Foreign Affairs*.

Obstfeld, Maurice, and Kenneth Rogoff, 1995, "The Mirage of Fixed Exchange Rates," NBER Working Paper No. 5191.

Stein, Ernesto and Jorge Streb, 1998, "Political Stabilization Cycles in High Inflation Economies," *Journal of Development Economics*, 56, 159-180, June.

Stein, Ernesto and Jorge Streb, 1999, "Elections and the Timing of Devaluations," working paper, InterAmerican Development Bank.

Summers, Lawrence, 1999a, testimony before the Senate Foreign Relations Subcommittee on International Economic Policy and Export/Trade Promotion, January 27.

Summers, Lawrence, 1999b "Building an International Financial Architecture for the 21st Century," *Cato Journal*, 18, no. 3, 321-330.

Takagi, Shinji, 1988, "A Basket Policy: Operational Issues for Developing Countries" *World Development*, 16, no. 2, 271-79.

Williamson, John, 1996, The Crawling Band as an Exchange Rate Regime: Lessons from Chile, Colombia, and Israel, Institute for International Economics, Washington DC.

Vergara, Rodrigo, 1994, "Política Cambiaria en Chile: Experiencia de una década," *Estudios Públicos*, N°56.

Appendix

Table A.1: Exchange Rate Policy in Chile

Date	Policy
September, 1982	<ul style="list-style-type: none"> • Daily devaluations in line with domestic inflation in the preceding month minus an estimate of external inflation
August 1, 1984	<ul style="list-style-type: none"> • a band of +/- 0.5%
June, 1985	<ul style="list-style-type: none"> • widening to 2%
January 5, 1988	<ul style="list-style-type: none"> • widening to 3 %
June 6, 1989	<ul style="list-style-type: none"> • widening to 5% • accelerate the rate of real depreciation, which was achieved by reducing the estimate of international inflation • adjustment of central parity: previous month inflation minus estimated international inflation
April 3, 1991	<ul style="list-style-type: none"> • 2% revaluation of central parity
January 23, 1992	<ul style="list-style-type: none"> • band widened to 10% (from +/-5%) • discrete 5% revaluation of central parity
March, 1992	<ul style="list-style-type: none"> • managed floating is authorized
July, 1992	<ul style="list-style-type: none"> • central parity: 50% U.S. dollar, 30% Deutsche mark, 20% Japanese yen
November, 1994	<ul style="list-style-type: none"> • central parity: 45% U.S. dollar, 30% Deutsche mark, 25% Japanese yen
November 30, 1994	<ul style="list-style-type: none"> • 9.66% revaluation of central parity
December, 1995	<ul style="list-style-type: none"> • 2% revaluation • 2% annual revaluation
January 21, 1997	<ul style="list-style-type: none"> • 4% revaluation of central parity • new band: +/- 12.5% • new weight: 80% U.S. dollar, 15% Deutsche mark, 5% Japanese yen
June 25, 1998	<ul style="list-style-type: none"> • 2% annual revaluation • new asymmetric band: +2%, -3,5%
September 16, 1998	<ul style="list-style-type: none"> • new band: +/- 3.5% • between September 17 and December 31, 1998 the band will be widened progressively until it accumulates and additional 1.5% in each extreme , such that by the end of the year the band would be +/- 5% • new estimates of annual international inflation from 2.4% to 0% for the rest of the year • the relevant internal inflation rate is the inflation target and not past inflation

December 23, 1998	<ul style="list-style-type: none"> • new band: +/-8% • no change in other parameters (central parity adjusts only with internal inflation and the band continue widening daily by 0,013575%)
January 1, 1999	<ul style="list-style-type: none"> • Deutsche mark is replaced by the euro, with the same weight
September 2, 1999	<ul style="list-style-type: none"> • free floating with managed intervention only in exceptional cases • release of new information regarding interventions in the foreign exchange markets