

Estimating Temporary and Permanent Components of Currency Risk with an Extension of the Dornbusch Model

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Abstract. International currency risk premiums on low-credibility currencies are not well measured without a theory simply as differences in real interest rates. At the same time, when measured by reference to a theory, they typically appear as large and volatile unexplained residuals whose behavior is difficult to rationalize. This short article suggests a workable compromise under which both permanent and temporary components of currency risk premiums can be inferred from an intertemporal UIP model of maintained asset market equilibrium when factor and product prices are sticky. The strength of the model is demonstrated by showing that the measure of the surge in currency risk obtained for the crisis that started in Mexico in December 1994 bids fair to explain financial and economic declines that actually occurred.

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I. Introduction

There are two prominent approaches to deducing the risk premiums of onshore claims denominated in a low-credibility local currency, such as Mexican peso, as opposed to U.S. dollar or other leading denominations that are in wide international use. These two approaches -- one based on the International Capital Asset Pricing Model, ICAPM, and the other based on Uncovered Interest Parity, UIP -- may have had scant success in accounting for observed time series of interest and exchange relations (Isard, 1997, p. 142; Meese and Rogoff, 1988; Engel, 1996.¹ Hence the main use of these model approaches may have been to identify large unexplained residuals or “puzzles” for further analysis of their possible causes and significance for policy (e.g., Edwards, 1999). Derived from the ICAPM, this residual is a measure of abnormal returns such as the “Jensen alpha.” Under UIP, the unexplained extra return supposedly required as a net risk premium on the less credible currency is backed out as a forcing variable that makes UIP hold precisely with risk-adjusted interest rates.

Isard (1997) and Engel (1996) have further concluded that these and related models have difficulty supporting observed variations in risk premiums with plausible variance-covariance configurations. Deducing such variations with a workable model is the task of this paper. The approach chosen, intertemporal UIP, provides much more coherence than snapshots of interest rate spreads, that are still commonly used to read off risk premiums directly, can provide.

Although strong faith in UIP is not justified empirically, consistent conjectures based on a macro-model that maintains the UIP relation ex ante up to any horizon capture the development of currency risk premiums during a major crisis in a way that is consistent with the continuous maintenance of asset-market equilibrium given the latest state of information. This short article seeks to extend and then to apply this approach by relying on Meese and Rogoff's (1988) generalization of the Dornbusch (1976) model. The essential insight provided by that model is that, with price stickiness in factor and product markets, it is not correct to attribute international differences in real interest rates exhaustively to a variety of risk factors, such as political and currency risk. Rather, risk-adjusted differences in real interest rates may persist for years, though not indefinitely, after shocks to equilibrium in product or factor markets. If those differences are expected to decline sufficiently rapidly as sticky prices adjust, they can be compensated by a series of prospective changes in the real exchange rate. To be rationally expected in a bubble-free environment, these changes would have to lead that rate from its present level to the equilibrium level currently in view, while UIP is maintained throughout. Crisis-driven surges in currency risk intertwined with political risk (Lessard, 1989, explores their interdependence) can then be identified in emerging markets in a way that is disciplined by a multivariate model in which product and asset markets equilibrate realistically with different speeds after any shock.

II. Traditional Static Decompositions of International Interest Rate Spreads

Treating risk premiums as implied in a set of model relationships is very different from reading them directly from data, as is still commonly done. Yet it is necessary to

provide an organized explanation of existing practices before recommending new workable concepts and measures. Various risk premiums that arise in international financial relations previously have been quantified on the premise that the *risk-adjusted* real interest differential on highly liquid sovereign claims, such as Treasury bills, is zero always, and not just in equilibrium, as in the Dornbusch (1976) model. Hence the risk factors must add up to the difference in real interest rates estimated for any given term to maturity, and this means that defining any one of two risks, such as political risk, defines the other, such as currency risk, by exclusion. But which components of risk -- defined by successive differences in pairs of real (R, column 1) or nominal (N, column 2) interest rates in Table 1 -- are included in any particular definition differs in this literature. That too needs to be surveyed to understand what sources of risk dominate in the intertemporal setting² in open international financial markets among currencies that float against the leading denominations.

Claassen (1996, pp. 70-71) expresses the political risk premium as the differential between the interest rates on claims issued in both home and foreign currency denominations in the *same* country *minus* the forward premium. The latter is given by the corresponding international interest differential in the eurocurrency or offshore (*o*) market. If *h* stands for Mexican peso (first subscript), or for Mexico's onshore market (second subscript), and *f* similarly for the U.S. dollar, or for the U.S. financial market, Claassen's definition of political risk amounts to the sum of components (1), (2) and (4) in the second column of Table 1, or to $N(hh)_t - N(fh)_t - [N(ho)_t - N(fo)_t]$.

In principle political risk may attach to both domestic-currency and foreign-currency claims on a country, but to quite different degrees. The chance of a sovereign

defaulting, either overtly or covertly through uncompensated inflation surprises, on domestic-currency debt may remain remote in open financial markets even when default on its foreign-currency obligations appears imminent.³ Capturing this differential *cross-border* element of country risk carefully discussed by Lessard (1989, p. 208) involves taking the difference between the yield required on formally comparable claims, such as short-term securities issued by different central governments in the international currency native to only one of them. A typical working definition of the country risk spread then is “the spread over [U.S.] Treasuries for sovereign, dollar-denominated emerging market bonds of similar maturity” (Goldman Sachs, 1999, p. 5), which reduces to just $N(fh)_t - N(ff)_t$. This is component (5) in the second column of Table 1. Although political risk may not be the only significant component of country risk, possible differences in coverage of nonpolitical country risks are not the issue here and thus ignored.

Frankel and MacArthur (1988) have used yet another definition that amounts to adding all the components mentioned so far. They have proposed the difference between two local or onshore interest rates, each quoted in its home currency, and the forward premium (the logarithm of the ratio of forward to spot exchange rate) as an inverse measure of the degree of international financial integration of less developed with advanced countries, claiming that this component “encompasses all factors related to the political jurisdiction in which the asset is issued” (p. 1093). Their decomposition in effect obtains political or country risk as the sum of the paired differences numbered (1), (2), (4) and (5) in Table 1, or as $N(hh) - N(ho) - [N(ff) - N(fo)]$. This is the difference between onshore and offshore (o) nominal interest rates in each -- home (h) or foreign (f) -- currency, where only the quality of claims against onshore obligors is taken to be

subject to political risk. The definition has the, perhaps unfortunate, implication that the measure of political risk is bound to be zero once the offshore and onshore financial markets are integrated in each of the currencies as increasingly is the case.⁴ This then would leave only currency risk and purchasing-power-parity (PPP) risk to account for international differences in real interest rates. As shown in the last column of Table 1, a measure of the average exchange (or currency) risk premium is the difference between the forward premium and the expected rate of change in the spot exchange rate. The latter minus the expected inflation differential yields the expected rate of real depreciation as the last source of risk in the decomposition shown in Table 1.

Country and currency risk are unlikely to be orthogonal if the exchange-rate regime and its policy management itself convey significant macroeconomic disturbances and risks.⁵ Furthermore, it appears that currency risk contributes much more to country risk than the other way around: Absent currency risk, there is very little country-risk differentiation among neighboring countries.⁶ Indeed, when the two types of risk become separable through the elimination of currency risk with the dominant international currency in the region (U.S. dollar, DM, or yen), as in Euroland,⁷ very little differential country risk remains priced in interest rates, as Alexander and Anker (1997) have predicted. Hence we will assume that the risk that arises in financially integrated markets -- though not independent of the quality of national macroeconomic and prudential policy -- is indeed mainly what Frankel and MacArthur called exchange risk in the sense that the prospect of instability in exchange relations with the major trading partners is its major source. However, as shown in the next section, that risk premium, with its permanent and transitory components, must be identified with the aid of an intertemporal model.

Careful attention to the actual measurement of the exchange risk premium and its expected persistence, while rare, is eminently called for in view of Baxter's conclusion (1994, p. 35) that "Almost of the movement in the temporary component of real exchange rates is attributed ... to the unobserved 'risk premium' from the open interest parity relation." Indeed shocks to the international risk premium -- whether viewed as portfolio allocation shocks imparted by professional fund managers cued by new information perhaps magnified by cascades and herding, preference shocks of the representative global financial investor, or risk aversion shocks directed against claims on weak banking systems operating in peripheral currencies -- must be added to the list of basic shocks affecting financially small countries. The ramifications of risk premium shocks, through large devaluations associated with financial constriction, are startlingly similar to those of major adverse aggregate supply shocks, as the final section of this short article will show.

III. A New, Intertemporal-UIP Based Measure of Currency Risk

It is useful to recall those elements of Dornbusch (1976) and Meese and Rogoff (1988) that will be needed for the subsequent derivation of a crisis-driven jump in the risk premium on home-currency claims in emerging-market economies even though these authors specified uncovered interest parity without risk. A home-currency (h) or foreign-currency (f) financial investment of N' at time t , N'_t , that grows with interest to N'_{t+k} in k years in nominal terms may be deflated by the corresponding price or unit-labor-cost ratio, U_{t+k}/U_t , to yield the difference (D) in cumulative international real net rates of return (R) up to horizon of length $k - 1$:

$$R^D_{t+k,t} = \ln[(N'_{t+k}/N'_t)/(P_{t+k}/P_t)]_h + \ln[(N_{t+k}/N_t)/(U_{t+k}/U_t)]_f. \quad (1)$$

By the expectations hypothesis of the term structure of interest rates in each of the two countries, underlying this cumulative international interest differential are a series of forward short, e.g., annual, rates whose difference is expected to decline at the rate traditionally labeled δ per year.⁸ Hence the law of motion for the annual international real interest differential, R^D , starting from the shock or crisis that first created it at time t , is:

$$R^D_{t+k,t+k-1} = (1-\delta)^{k-1} R^D_{t+1,t}. \quad (2)$$

It therefore follows by summation of the forward short interest rates, which decline at the rate δ per year, that the cumulative (not annualized) difference in real rates of return for up to k years ahead of t is:

$$R^D_{t+k,t} = R^D_{t+1,t} [(1 - (1-\delta)^k) / \delta]. \quad (3)$$

Solving this equation for k and then substituting from (3) for $R^D_{t+1,t}$ yields alternative expressions for the entire cumulative international real interest rate differential in prospect from the peak of an acute crisis:

$$R^D_{t+,t} = R^D_{t+1,t} / \delta = R^D_{t+k,t} / [1 - (1-\delta)^k]. \quad (4)$$

This is the total real interest differential which real exchange movements must be expected to offset if UIP holds continuously, given the current state of information, ex ante. For that expectation to be rational, a gap must therefore open up between the currently envisaged long-term equilibrium level of the real exchange rate, \bar{s} , and the current spot exchange rate, S_t ,⁹ that is equal to $R^D_{t+k,t}$ so that the closing of this gap ($\bar{s} - S_t$) at the rate $\bar{\epsilon}$ can offset the entire cumulative international real interest differential in prospect.¹⁰ Hence substituting $(\bar{s} - S_t)$ for $R^D_{t+k,t}$ in equation (4) and solving for the current spot rate yields the Meese and Rogoff (1988) equation that is conditional on UIP:

$$S_t = \bar{s} - R^D_{t+k,t} / [1 - (1 - \bar{\epsilon})^k] + \dots \quad (5)$$

While the previous authors used this equation mostly to test whether the implication of the UIP condition is met, that the coefficient on $R^D_{t+k,t}$ be negative and, for the low k values used in testing, appreciably greater than 1 in absolute value, the intention here is quite different. The question now is what equation (5), if it held, could reveal about the risk premium created by a crisis and about how a variety of other shocks would be processed in international financial markets under the identifying assumptions of the intertemporal maintained asset market equilibrium based on UIP. For this we reinterpret R^D as risky, being subject both to a chronic, or only very slowly changing, risk premium, $\bar{\epsilon}$, and to a crisis-driven temporary risk premium, $\tilde{\epsilon} - \bar{\epsilon}$. With all risk premiums assumed to be against the developing home country, substituting the explicitly risk-adjusted international real interest differential, $R^{DX} = R^D - (\tilde{\epsilon} - \bar{\epsilon}) - \bar{\epsilon}$, for its previously riskless ($\tilde{\epsilon} = \bar{\epsilon}$) representation¹¹ R^D in equation (5) yields, with k set to 1 for convenience:

$$S_t = -[(R^D_{t+1,t} - (\tilde{n}_{t+1,t} - \ddot{o}) - \ddot{o}) / \dot{\epsilon}] + . \quad (6)$$

Compared with equation (5), this equation introduces two unknowns, one of which is zero in equilibrium when the total risk premium, \tilde{n} , must be equal to its permanent component, so that $\tilde{n} - \ddot{o} = 0$ and only \ddot{o} remains to be determined. If \ddot{o} has been estimated during the quiet before the storm, the temporary component of the risk premium, $\tilde{n}_{t+1,t} - \ddot{o}$, can be inferred from conditions at the height of crisis. From that point on, the risk-adjusted international real interest rate differential, in the sequence of forward short rates, falls by $\dot{\epsilon}$ percent per period, as implied by the single-parameter specification commonly used in this literature. In the presence context with temporary and permanent risk premiums, the shrinkage in the risk-adjusted differential, $R^{DX} = R^D - \tilde{n}$, toward zero can be decomposed into (i) a decline in the rate differential adjusted only for the permanent risk component \ddot{o} and (ii) the decline in the temporary risk component. The fall in the latter slows the expected decline in the international real interest differential to its permanent level, \ddot{o} , as shown below:

$$\ddot{A}R^{DX}_{t+2,t+1} = -\dot{\epsilon}R^{DX}_{t+1,t} = -\dot{\epsilon}(R^D_{t+1,t} - \ddot{o}) + \dot{\epsilon}(\tilde{n}_{t+1,t} - \ddot{o}) . \quad (7)$$

Equation (7) indicates that equilibrium in international interest rate relations is defined by the two conditions, $\tilde{n} = \ddot{o}$, and $R^D = \ddot{o}$. Equilibrium thus requires that there be no transitory element included in the risk premium whose total size must be equal to its

permanent level, \bar{o} , and hence equal to the permanent international real interest rate differential between a developing and a financially leading country.

IV. Estimating a Surge in The Currency Risk Premium: Mexico, December 1994

Before turning to the empirical work, it is useful to recall all the principal variables and parameters to which values have to be assigned before the currency risk premium can be deduced from intertemporal asset-market equilibrium conditions. The rate δ , with $0 < \delta < 1$ in discrete time, is not a free parameter. Rather it has been structurally identified (see Dornbusch, 1980, p. 206) to be consistent with the gradual adjustment of output prices.¹² It is both the rate at which the short-term international interest differential shrinks from period to period and the rate at which the gap between the current and the equilibrium level of the real exchange rate must shrink to compensate the sum of all remaining short-term forward international real interest rate differentials. Furthermore, for these successive movements to be rationally expected, they would in the end have to return the real exchange rate to PPP in response to purely nominal shocks and to whatever new equilibrium level of the terms of trade, \bar{s} , results from any permanent real shocks. Indeed Baxter (1994, p. 35) has emphasized the need to allow for changes in the permanent component of real exchange rates before analyzing the link between temporary components of real exchange rates and real interest differentials.

Now if the real interest rate spread R^D over any term of length k , the current level of the differential risk premium \tilde{n} , the rate of adjustment δ , and the equilibrium level of the real exchange rate inferred from current conditions, \bar{s} , could be known, equation (6) would tie down how far the current level of the real exchange rate, S_t , would be predicted

to move (overshoot) in response to shocks. However, neither $\bar{\pi}$ nor $\tilde{\pi}$ generally is known beforehand. Thus, it is more feasible to solve that equation for $\tilde{\pi}$, given the actual value of S_t and all the other actual and inferred variables and parameters, while still assuming that equation (6) holds without error. The solution procedure and the new insights it yields will be demonstrated for Mexico with the data in Tables 2 and 3 for the period 1993 to 1998, surrounding the crisis that started in December 1994. To obtain the permanent component of the risk premium, $\bar{\pi}$, it is useful to recall that the risk-adjusted international real interest-rate differential ($R_{M,t+1,t} - \tilde{\pi}_{t+1,t} - R_{US,t+1,t}$) equals zero only in general equilibrium, with $\tilde{\pi}$ then equal to its permanent annual level $\bar{\pi}$, and the temporary risk component, $\tilde{\pi} - \bar{\pi}$, zero. Hence a period of approximate equilibrium is needed for distinguishing temporary from permanent risk premiums during an ensuing crisis.

Because the quality of bank claims is most likely to be affected by changes in the international competitiveness of loan clients, it appears most relevant to define real exchange rates by means of unit labor cost developments in Mexico compared with the United States. Producer real interest rates can be defined in a similar way by reference to differences in rates of change in unit labor costs between the two countries. I assume that *expected* unit labor costs are a simple centered moving average of the logarithmic rates of change of unit labor costs over the year up to, and starting from, the quarter in which the expectations are formed within any regime. However, if the regime changes unexpectedly, as it did in December 1994, expectations are assumed to be entirely nonanticipating, or “backed up,” until the time at which the regime changes, and entirely forward-looking once it has changed. This treatment is appropriate because a major currency crisis often appears like a step in a random walk that is taken without advance

warning from financial prices, but once taken has implications for the future inflation regime that are plain enough.¹³

Hence the logarithmic real interest rate differential for the first two months of the fourth quarter of 1994 is assumed to be $0.0819 - 0.0415 = 0.0404$ from the data in Table 2. Assuming that this was a time of soon-to-be-disturbed equilibrium, but equilibrium nonetheless, Mexico's normal country and currency risk premium relative to the United States and the U.S. dollar would be revealed to be $\delta = 4.04\%$, or about 4 percentage points per annum. We assume that this "permanent" level of differential risk changes only slowly within a given exchange rate regime as the country's political, legal, regulatory, and financial systems evolve.

Apart from δ , estimates of ϵ and β are needed before the crisis-induced temporary change in the risk premium, $\tilde{\pi} - \delta$, can be inferred. Informed by the results in the last column of Table 3, we assume that ϵ is about 0.5. Although only 42% of the excess real depreciation (and hence of the cumulative international annual forward interest differentials) is offset in the first year, the fact that 75% is offset after two years indicates that $\epsilon=0.5$ is an acceptable compromise. It fits the pattern of exponential decline to several points over the initial years about as well as is possible with a single-parameter specification. In addition, major international crises, including the Southeast Asian Crisis that started in the summer of 1997, have, in fact, receded considerably within two years, although the developing-country debt crisis that started in 1982 took much longer to heal.

The next task is to infer β , which is also the change in the fundamental equilibrium level of the real exchange rate of Mexico with the United States from an index base of $\ln(1)=0$. The entries in column (3) of Table 3 show that a logarithmic

depreciation of 0.3640 remained in the fourth quarter of 1997 before a new crisis struck in 1998. With $\delta = 0.5$, three-quarters of the adjustment from the real (over)depreciation of 0.5676 in 1995:IV to the new equilibrium would have been made within two years. With one quarter of the adjustment still outstanding upon partially rebounding to 0.3640, this consistent conjecture points to 0.2961 as the endpoint toward which the adjustment was tending, although a new crisis erupted in 1998 before that adjustment was complete. Hence we estimate the change in the equilibrium level of the logarithm of the real exchange rate that was associated with events surrounding the 1994-1995 crisis to be = 0.2961.¹⁴ This implies that the “permanent” real depreciation called for by these events was 34 percent, with more than twice as much experienced in the initial overshooting.

The change in the risk-adjusted real interest differential, R^{DX} , can now be expressed as a function of the unknown new risk premium, \tilde{n} , that was precipitated by the Mexican crisis of December 1994. For it follows with our assumptions about the formation of inflation expectations around the time of regime change and with data from Table 2 that the risk-adjusted change in the real interest rate from just before the crisis to the fourth quarter of 1995 is:

$$R^{DX}_{t+1} - R^{DX}_t = (N^D_{t+1} - N^D_t) - 0.5[(u^D_{t+2} + u^D_{t+1})] + u^D_t - (\tilde{n} - \delta) = 0.2574 - 0.5[0.3109] + 0.0415 - \tilde{n} + 0.0404 = 0.1839 - \tilde{n} . \quad (8)$$

Differencing equation (6) and noting that the change and in $\tilde{n} - \delta$, starting from a pre-crisis level of 0, can also be written as and $\tilde{n} - \delta$, respectively, yields the rate of change in the real exchange rate from 1994:IV to 1995:IV:

$$S_{t+1} - S_t = -(1/\epsilon)(R_{t+1}^{DX} - R_t^{DX}) + \dots \quad (9)$$

Substituting from equation (8) and using Table 3 to obtain the rate of change in the real exchange rate from the fourth quarter of 1994 to that of 1995 permits solving consistently for the risk premium in the year of crisis with $\epsilon=0.5$:

$$\tilde{\pi}_{t+1,t} = \epsilon(0.5676 - 0.2961) + 0.1839 = 0.3197. \quad (10)$$

Hence the initial crisis-driven surge in the risk premium on Mexico, $\tilde{\pi}-R$, was $0.3197 - 0.0404 = 0.2793$ in logarithms or over 32 percentage points at an annual rate.

The disciplined conjecture based on equation (6) therefore informs us that, in spite of the steep rise in Mexico's nominal and real interest rates after the December 1994 crisis, its risk-adjusted real interest differential with the United States declined.

Substituting the value just found for $\tilde{\pi}$, equation (8) reveals that this differential changed by $0.1839 - 0.3197 = -0.1358$, falling by almost 13 percentage points from 1994:IV to 1995:IV. Put differently, the rise in the real interest differential of 0.1435 matched only about half of the temporary surge in the risk premium ($\tilde{\pi} - \bar{\pi}$) of 0.2793. Such insights are not, of course, available when risk is measured without an intertemporal model simply by (elements of) the current international real interest differential, as is the common practice.¹⁵

It is plausible to argue that some of the increase in the currency risk premium on the Mexican peso is endogenous in that the rise in interest rates and the large devaluation

that undermined bi-monetary (peso and dollar-based) balance sheets, particularly of financial institutions, themselves contributed greatly to economic instability and decline. Stiglitz (2000) has taken this position to the extreme of arguing that a rise in interest rates, by raising the risk premium on a currency by a like amount, may leave the risk-adjusted international interest differential largely unaffected. In that case increases in interest rates would not be capable of arresting the decline in the exchange rate or of stemming a precipitous outflow of capital. Instead they would contribute to the disruption of financial intermediation and of the economy. Hausmann (2000), by contrast, treats changes in the country-risk premium, which he identifies by dollar-denominated eurobond spreads (the Latin American eurobond yield relative to the equivalent U.S. Treasury yield), as contagion-induced or subject to exogenous changes in perception. This treatment allows him to offer interest-rate and exchange-rate elasticities with respect to that risk factor. However, the fact that these estimates are both very high itself tends to contradict the exogeneity assumption.¹⁶

V. How a Surging Risk Premium Affected Mexico's Financial and Economic System

Changes in risk premia may sometimes arise seemingly exogenously, as when international financial investors wish to redeploy their assets simply because other markets suddenly appear to them more attractive. Their behavior could then be self-fulfilling because it would contribute to the poor performance and downgrading of the Mexican market that was expected in the first place. While exogenous portfolio shocks of this kind may play a role, sustained and major changes in risk premia are likely to be

subject to endogenous feedback: They both reflect, and reflect on, economic and financial conditions in a country in relation to the world economy.

For this reason it can be misleading to ask how a change in the risk premium affects asset values, financial stability, and the economy. Even though the risk premium can change much faster than the record of economic activity, the assumption of *post hoc ergo propter hoc* is known to be fallacious when forward-looking expectational processes are involved. Nevertheless, treating changes in risk premiums in liquid financial markets as *prima causa* is useful to gauge associated changes in other prices and valuations.

Asset Valuations

The Mexican stock market started falling one quarter before the development of a full-blown foreign exchange crisis, dropping 44% in nominal terms, and about 50% in real terms from September 1994 to February 1995, using unit labor costs as a deflator appropriate for business as before. Thereafter, however, there was some recovery so that, excluding December 1994, the average monthly level of the *bolsa de valores* index was almost the same in 1994:IV (2572, excl. December) and 1995:IV (2590). However, because of a 19.6% rise in unit labor costs, the real value of Mexican stocks had fallen 16%. At between 17 and 18 times most recent earnings (IFC, 1995, p. 175) at the start of the decline, an expected growth rate of real earnings of about 6 percent per annum combined with a real discount rate of 12 percent¹⁷ would produce a corresponding price-earnings multiple (exactly of 17.67). A temporary rise in the risk premium by 0.2793 or 32.22% deduced before that melts away by half in each subsequent year ($\delta=0.5$) would be equivalent to raising the discount rate on the permanently growing stream of earnings

from 12 percent to 16.16 percent, thereby causing a loss of asset value of 41%. Clearly more than a pure discount rate effect was reflected in the immediate stock market decline from peak to trough as the increase in the risk premium also caused collateral damage to earnings prospects themselves. However, the significant recovery in real stock valuations that occurred after the first few months of crisis leaves the decline of 41%, which is deduced from the valuation model on account of the change in the risk premium alone, well inside the range of -16% to -50% observed in the data.

Decline in GDP

If we take a supply-side view of economic activity and ignore the fact that fixed costs are sunk, we can ask how much capacity might have to be idled, or discarded and not replaced, to raise the gross rate of return on capital by 4.16 percentage points permanently, as inferred before. Such a reversal of capital deepening would carry that rate from 18% to 22.16%, assuming the capital stock depreciates by 6% annually. Hence, assuming that the logarithmic rate of change in technological progress, da_t , and in the labor supply, dl_t , are both zero, we can solve the equation below for the rate of change in the capital stock, dk_t , that would produce a rate of change in the gross marginal product of capital equal to $\ln(22.16/18)$ or 0.208, when the share of capital, α , is 1/3:

$$da_t - (1-\alpha)(dk_t - dl_t) = \text{dmp}_t = 0.208, \quad \text{or } dk_t = -0.312. \quad (11)$$

Multiplying this inferred change in capital input by the share of capital yields an expected year-over-year decline in GDP of 10.4% which compares with an actual absolute decline

of 6.2% from 1994 to 1995 and with a decline of 12.2% relative to trend growth, assuming a cycle-average rate of growth of about 6 percent for the formal sector of the Mexican economy.

Again these disciplined, if heroic, conjectures show that the crisis-induced increase in the risk premium inferred from Mexican data, while temporary, could have had a pervasive effect on its economy similar to what actually was observed. Since this risk premium consists mostly of currency risk, currency consolidation is becoming increasingly imperative to avoid macroeconomic exposure to a variety of financial-sector shocks. These shocks, much more than conventional supply shocks, afflict financially small countries with low-credibility currencies relative to their high-credibility neighbor(s) in their region.

VI. Summary and Conclusions

Compelled by the high and volatile currency-risk premiums incurred on doing business in, or hedging, low-credibility currency denominations in open financial markets,¹⁸ advocacy of rapid dollarization and of multilateral forms of monetary union has been spreading. This advocacy is spurred by the desire to shed exposure to exchange-rate and financial crises in which a rise in the currency risk premium, consistently measured here in a multivariate intertemporal framework of maintained asset market equilibrium, imparts the equivalent of a strong adverse supply shock to the economy.

Such a shock was identified for the Mexican economy with the aid of a model in which uncovered risk-adjusted interest parity holds over the entire adjustment horizon until real-interest parity, adjusted only for permanent differences in country risk, is

restored. To highlight the pervasive importance of the temporary shock to currency risk quantified with data for 1994-1998, financial and economic consequences were deduced that roughly matched the large declines in Mexico's stock-market capitalization and GDP that actually occurred. Hence the new way of inferring currency risk premiums as latent variables may yield important insights into their size and destructive power during major crises. Such insights are not available from interpreting international differences in real interest rates as risk premiums directly, as if risk-adjusted real interest rate differences could not persist in open capital markets, not even with sticky factor and product prices.

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Table 1. The Attribution of an International Real Interest Differential to Different Risks

$R(hh)_t - R(ff)_t$	(1) $N(hh)_t - N(hf)_t$		Component of Political Risk
$= R(hh)_t - R(hf)_t$	(2) $+ N(hf)_t - N(ho)_t$		Component of Political Risk
$+ R(hf)_t - R(ho)_t$	(3) $+ N(ho)_t - N(fo)_t$	(3 cont.) $- [S_{t+1}^e - S_t]$	Currency Risk: $F_{t+1,t} - S_{t+1}^e$
$+ R(ho)_t - R(fo)_t$	(4) $+ N(fo)_t - N(fh)_t$		Component of Political Risk
$+ R(fo)_t - R(fh)_t$	(5) $+ N(fh)_t - N(ff)_t$		Component of Political Risk
$+ R(fh)_t - R(ff)_t$ $=$	(6) $- [I^e(hh)_t - I^e(ff)_t]$	(6 cont.) $+ [S_{t+1}^e - S_t]$	PPP Risk: $I^e(hh)_t - I^e(ff)_t - [S_{t+1}^e - S_t]$

Glossary

- $F_{t+1,t}$ Forward exchange rate for period t+1 quoted at time t. With perfect arbitrage, the forward premium, $F_{t+1,t} - S_t$, must equal the offshore (o) interest differential in (3).
- I_t^e Inflation rate expected, at time t, to prevail in the period just ahead
- N_t Nominal interest rate, quoted at time t, for the investment period just ahead
- R_t Real interest rate, expected at time t, for the period just ahead
- S_{t+1}^e Spot exchange rate expected, at time t, to prevail after one period, at time t+1
- S_t Spot exchange rate at time t, defined as the home (h) currency price of a unit of foreign (f) currency

Lower-case letter combinations, in parentheses, identifying the different rates

The *first letter* indicates the currency denomination of the financial contract: h or f.
The *second letter* indicates the country, jurisdiction, and/or market in which the contract is booked: f, h, or o.

Examples: (hh) identifies a home-currency contract issued in the home market under home country jurisdiction; (fo) identifies a contract issued in the foreign currency denomination in the offshore market outside, or exempt from, national jurisdiction.

Table 2. Financial Data for Mexico and the United States, 1993-1998, 4th-Quarter Avg.

	Cetes - 91 Day, n _M %	T-Bill U.S., n _{US} %	ln[(N' _M)/ (N' _{US})] (3)	Unit Lab Cost, u _M %	Unit Lab Cost, u _{US} %	ln[(U _M)/ (U _{US})] (6)	Peso/ Dollar exch rate
1993:IV	12.66	3.08	0.0918	Fr. Prev.	Fr. Prev.	Fr. Prev.	3.1257
1994:IV	14.26*	5.28	0.0819	6.27	1.95	0.0415	3.5964
1995:IV	47.80	5.27	0.3393	17.74	1.82	0.1453	7.3364
1996:IV	27.71	4.97	0.1961	19.79	1.51	0.1656	7.8270
1997:IV	20.60	5.09	0.1377	16.70	2.04	0.1342	8.0770
1998:IV	35.39	4.28	0.2611	16.37	1.46	0.1371	10.0171

Sources: Banco de México, *The Mexican Economy, 1994 to 1999* (annual reports).
USGPO, *Economic Indicators* (monthly). The three-month U.S. Treasury bill rate shown
is for new issues. * Excluding December 1994.

Table 3. Logarithmic Rates of Change from 4th Quarter 1994

1994:IV -	Nominal Exchange Rate (1)	Relative Unit Labor Cost Incr. (2)	Real Exchange Rate (3)	Inflation Offset: (2) in % of [(1) minus 0.2961]
1995:IV	0.7129	0.1453	0.5676	35
1996:IV	0.7776	0.3109	0.4667	65
1997:IV	0.8091	0.4451	0.3640	87
1998:IV	1.0244	0.5822	0.4422	

Notes: Depreciation is signed positive. Entries in column (2) are cumulated from those in col. (6) in the previous table, starting with the rate of change from 1994:IV-1995:IV. In the last column, the inflation offset percentage (through differentially higher unit labor cost increases in Mexico than the United States) to the crisis-driven excess depreciation is calculated on the assumption that the new equilibrium real exchange rate is 34% [$\ln(1.3446) = 0.2961$] above its 1994:IV equilibrium level (of 0 in log-index metric), with three-quarters of the adjustment to that level since 1995:IV made by 1997:IV before a new crisis began (in August 1998). The cumulative offset, $0 \leq \hat{u} \leq 1$, after k periods is $u_{t+k,t}^D = \hat{u}(e_{t+k,t} -)$.

Endnotes

¹ For more favorable evaluations of uncovered interest parity than provided by Meese and Rogoff (1988) and Engel (1996) see Baxter (1994), McCallum (1994), and Lothian and Simaan (1998) although the empirical applicability of that hypothesis remains in doubt. For a related defense of the expectations theory as a model of long-term interest rates see Sutton (2000).

² At a finer level than here considered, international interest parity relations over any given term to maturity involve at least two interest-rate contracts and a forward-exchange contract, each with two contracting parties. The exact circumstances, terms, recourse, markets, and locations of each of these six parties, who, in turn, may be exposed to other parties and counterparties, are crucial to understanding how currency and country risk premiums can arise and be measured in individual instances.

³ Sims' (1999) attempt to identify foreign-currency debt with the default risk free debt of the Modigliani-Miller theorem, and domestic-currency debt with risky equity seems to have their roles reversed in arguing that dollarization would make the government's debt *more* risky than its dollar-denominated debt was prior to dollarization.

⁴ Grabbe (1996, p. 110) reports that, as of 1985, there were functioning interbank forward markets for about 21 currencies and eurocurrency rates for most of them. The former figure had risen to 33 by the spring of 2000, with Mexico included.

⁵ Country risk that is quantified by an observed interest differential needs to be distinguished from country risk ratings derived by taking a weighted average of a variety of political, financial, and economic factors. See, for instance, the composite ICRG country risk rating and the Institutional Investor country credit rating described in World Bank (2000, pp. 282-283).

⁶ In surveying what we have learned from recent financial crises, White (2000, p. 27) notes that domestic financial markets have become much more liberalized in the last few years, and international linkages have grown remarkably and that "associated with developments of this sort is a heightened tendency to financial instability and even sporadic crisis." He does not point out that the profusion of "independent" currencies may be partly to blame for this "heightened tendency" and that currency consolidation could be part of the solution.

⁷ A spot-check may suffice to show that interest rates on benchmark bonds issued by the respective governments have clustered tightly. They have deviated by no more than 40 basis points in the 1-1/2 to 2-1/2 year maturity range and by less than 30 basis points in the 9 to 10 year range among any of the members of Euroland, judging by conditions reported for January 21, 2000 (*Financial Times*, January 22-23, 2000, p. 16). The latter finding appears to be representative as Corsetti and Pesenti (1999, p. 325) report that during the entire first half of 1999, "relative to ten-year German bunds, the largest spreads have not exceeded 33 basis points." This is a far cry from risk premia, at times exceeding 1,300 basis points, estimated by Banco de Mexico (1997, p. 303; 1999, p. 276) from Mexican discount Brady bonds. Although identified as attributable to "uncovered, or pure, *country* risk" according to the conventional methodology, these premia have, in fact, fluctuated in sync with currency crises, reaching peaks in March 1995 and in August 1998. Clearly currency risk is the main driver of country risk, and without the former, little remains of the latter among adjoining countries.

⁸ Dornbusch (1980, pp. 203-205) shows that ϵ is not a "free" parameter but that it has a structural identification that links it model-consistently to the degree of price stickiness in the output sector. Given the strength of the reaction of the price level to the model's specification of excess aggregate demand and given the elasticity coefficients required to estimate the degree of excess demand, the value of ϵ is implied.

⁹ The exchange rate is defined as the home currency price of a unit of foreign currency.

¹⁰ Algebraically, the current rate of change (i) in a particular annual starting value of x and (ii) in the integral over that and all subsequent values necessarily coincide if ϵ is a constant.

¹¹ Meese and Rogoff (1988) reasonably assumed that net risk premiums are negligible among major international currencies so that $R^{DX} = R^D$ but this assumption is not warranted when comparing real interest rates in a developing country in its own currency with those prevailing in a country with a leading international currency, like the United States. Cumby (1988) and Froot and Frankel (1989) could not reject the hypothesis that none of the forward discount bias is due to a time-varying risk premium among major currencies. Again, however, the joint occurrence of surging real interest rates and depreciating currencies

in developing countries is compatible with volatile currency risk premiums, whose movements are less than compensated by interest rate movements, playing an active part.

¹² The real interest rates refer to rates required on financial claims and not to actual rates of return on productively invested capital. The latter rates may differ from the former for extended periods because the adjustment of Tobin's "q" to an equilibrium value of 1 (in the absence of tax credits) is notoriously slow.

¹³ Using a simple centered moving average throughout as if unexpected regime breaks did not matter to the expectations' formation process would not make very much practical difference in the present instance.

¹⁴ That level may very well again have been disturbed, this time in the direction of a fall in signifying appreciation, by the persistent unanticipated rise in oil prices in 1999 that has benefited Mexico as an oil-exporting country. However, we will limit this discussion to the earlier period, 1994-1998, to retain a clear focus.

¹⁵ Hausmann (2000), for instance, equates positive innovations in country risk with an observed widening of the spread on the Latin American eurobond index relative to the equivalent U.S. Treasury security. He then estimates the elasticity of Mexican nominal interest rates to changes in this incorrect measure of innovations in country risk and finds that elasticity to be higher than 6 during Mexico's most recent period of floating that started in the crisis of December 1994. Hausmann attributes the difference from proportionality in large part to continuing fears of depreciation.

¹⁶ Assume that $r = f(\rho_0 + \rho(r))$. Then $dr/d\rho_0 = f'/(1-f'\rho_r)$. Hence if a rise in interest rates raises ρ by three-quarters as much over the same term, so that $\rho_r = 0.75$, the rise in interest rates required to hold the risk-adjusted interest rate constant (implying $f' = 1$) would be four times as large as the original (exogenous) rise in the risk premium, $d\rho_0$. Stiglitz and Weiss (1981) have explained why such an increase might not be credible and why credit rationing might ensue.

¹⁷ The discount rate is composed of the real rate of return on long-term U.S. Treasuries (3 to 4%), an addition for corporate risk (1 to 2% for Baa rated bonds), and an equity premium (3 to 6%) with a weight of two-thirds at a debt-equity ratio of one-half, plus the permanent component of Mexico's country risk premium (4%), for a total of 10% to 14%. The chosen value of 12% is at the middle of this range. Even in the United States, the appropriate discount rate is both uncertain and variable because values outside this already appreciable range at times have been observed. For instance, the Livingston Survey forecast of the average annual inflation rate over the ensuing 10 years was 2.5% in December 1998 when U.S. Treasuries with a constant maturity of 10 years yielded 4.65 percent, for an ex ante real interest rate of only 2.1% by this measure. One year later, in December 1999, the dividend-price ratio in the Standard and Poor's series of common stock yields had fallen to a low of 1.18%, a percentage very difficult to reconcile with an equity premium of more than 3%. The assumption that the increase in the risk premium inferred from international comparison of real yields on short-term Treasury securities applies equally to the discount rate applied to corporate earnings may be excessive. For while the equity premium could contain an element of currency risk particularly when there is a risk of major crisis (Domowitz, Glen, and Madhaven, 1998), real devaluations could be helpful for adjustment to economic shocks when economic disruption is less general. This could cause "local returns" and "currency returns" to correlate negatively for foreign investors (Zhang and Johnson, 1998) even though the comfort provided by local-currency returns holding up or even increasing during an exchange rate and intermediation crisis may be small.

¹⁸ To the extent there is a permanent risk premium, \ddot{o} , against a currency, the forward rate tends permanently to overpredict the expected (depreciation of) the future rate, creating a corresponding financial incentive not to hedge in view of the high expected costs that include \ddot{o} . G89916jj.doc