CONTAGION

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February, 2000
Revised: March, 2000

* This is a revised version of the 1999 World Economy Lecture, delivered at the University of Nottingham, on October 28th, 1999. I have benefited from discussions with Ed Leamer. I thank David Greenaway for his hospitality and I am grateful to Igal Magendzo for his assistance.

I. Introduction

"Contagion" is a relatively new concept in economics. A search of the ***EconLit*** data set for 1969-February 2000, yielded 147 entries that had the word "contagion" in either the title or in the abstract. Of these, only 17 corresponded to works published before 1990. This contrasts sharply with, say, "devaluation," a word that is also associated with financial turmoil in global markets. A search of the same data set, for the same period, yielded 1,031 works with the word "devaluation" in either the title or in the abstract; of these 390 were published before 1990.[1]

Economists' interest in "contagion" surged during the second half of the 1990s, when financial crises spread across emerging countries, affecting nations with apparently healthy fundamentals and whose policies, only a few months earlier, had been praised by market analysts and the multilateral institutions.[2] The following statement by Mexico's Secretary of the Treasury José Angel Gurría, at the time of the Russian crisis, vividly captures policy makers' concerns and frustrations with financial contagion:

> "Ninety percent of Mexicans have never heard of the Duma, and yet the exchange rate and interest rates that they live with every day were being driven by people with names like Kiriyenko and Chernomydrin and Primakov." (Gurría, 1999)

Analysts, academics and policy makers have recently asked three fundamental questions related to "contagion": (1) What are the channels through which financial upheaval is transmitted across countries. (2) Why do some crises spread so quickly and violently, while others are constrained to a particular country. And, (3), is there anything can be done to reduce a country's vulnerability to externally-originated shocks. Some authors – including some senior World Bank officials -- have argued that the "excessive" degree of capital mobility of the 1990s contributed to an increase in emerging country's vulnerability to contagious attacks (Stiglitz, 1999). According to others, the degree of

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[1] On the other hand, the analysis of contagious diseases has a long history. In the ***History of the Peloponnesian Wars***, for example, Thucydides recounts the speed with which the plague of 431 B.C. spread throughout Athens. And in the ***Decameron,*** Giovanni Bocaccio dealt with the devastation created by the spread of the Black Death plague in fourteenth century Florence. During the second half of the 19th century – and after British doctor John Snow made impressive progress in the study of the transmission of cholera in London --, epidemology became a stable branch of medicine.

vulnerability to contagion is larger in countries with exchange rate systems that lack credibility (Calvo, 2000).

In this paper I analyze several issues related to "contagion," including its definition, recent experiences, alternative channels at work, and possible prevention mechanisms. My discussion deals with the macroeconomics implications of contagion, and concentrates on the relationship between the degree of openness of the capital account and the transmission of foreign shocks. More specifically, I ask whether restrictions to capital mobility – and, in particular, controls on capital inflows – reduce a country's vulnerability to contagion. I also deal, albeit briefly, with the connection between the exchange rate regime and the propagation of international shocks. The paper is organized as follows: Section I is the introduction. In section II I present some important stylized facts on recent episodes of global financial turmoil. This discussion puts things into perspective, and provides background information for the analysis that follows. In Section III I deal with a number of analytical issues, including the distinction between contagion and more traditional forms of international transmission of financial shocks. I argue that, in the tradition of epidemiological studies, contagion reflects a situation where the effect of an external shock is *larger than what was expected* by experts and analysts. In Section IV I discuss briefly the relatively less known phenomenon of "volatility contagion." In Section V I analyze whether, as it has been recently argued by a number of authors, capital controls provide a useful mechanism for reducing emerging countries vulnerability to external shocks. The analysis in this section concentrates on the much-admired system of controls implemented by Chile during most of the 1990s. Finally, Section VI contains some concluding remarks, including a brief discussion on the relationship between exchange rate regimes and contagion.[3]

II. Some Stylized Facts from the 1990s

The international transmission of financial shocks is not a new phenomenon. What is new, or at least surprising, is that shocks originating in a particular country affect, in a very severe and unexpected way, nations that are very distant and that appear

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[2] See, for instance, the discussion in Masson (1998).

[3] My original intention was to provide a fuller coverage of this issue. As I worked on it, however, I realized that a complete analysis required many pages of text, plus a number of tables and diagrams. That long treatment would have made this paper exceedingly long.

to be largely unrelated to the shock originator. Examples of this type of situation include, among other, the transmission of turmoil from Hong Kong to Mexico and Chile in 1997; and the dramatic spillover of the Russian crisis of August 1998 into Mexico and other Latin American countries. In this section I provide some preliminary evidence of "contagion" episodes during the second half of the 1990s. In order to focus the discussion I concentrate on the case of Argentina and Mexico. It should be noted, however, that the situation described for these countries applies to most Latin American nations, as well as to other emerging countries.

In Figures 1 and 2 I present daily data for Mexico's domestic interest rates, peso/dollar spot exchange rate, Brady bond price indexes (JP Morgan Mexico's EMBI) and stock market index (expressed in U.S. dollars).[4] In Figures 3 and 4, on the other hand, I present daily data on Argentina's domestic interest rates – both in pesos and in dollars --, as well as on prices of Argentina's Brady bonds and the Argentine *Merval* stock market index. Since Argentina has had (since 1991) a one-to-one fixed exchange rate to the U.S. dollar, I have not included the exchange rate in these figures.

In each figure I have included four vertical lines, corresponding to the date when major currency crises emerged in other countries – the so-called "shock originators." The first vertical line corresponds to the Thai devaluation of early July 1997; the second depicts the attack on the Hong Kong currency board and the collapse of the Korean won in late October 1997; the third vertical line is drawn at the time of the Russian crisis (mid-August 1998); and the fourth vertical line corresponds to the Brazilian devaluation of January 13th 1999. These figures capture vividly the type of situation described by Mexican Secretary of the Treasury Gurría in the quote in section I of this paper.

It is clear from these figures is that in the days immediately following the Thai crisis – an episode that, as we now know, ignited the gigantic East Asian currency crisis --, there was no effect on Argentine or Mexican domestic interest rates, and no discernible negative effects on Brady bonds prices or stock market indexes in these two countries. In fact, Figures 2 and 4 indicate that in the days following the Thai crisis in both Latin American countries the stock market the Brady bond price indexes continued to climb. Although this is, admittedly, a rather simplistic analysis, it clearly suggests that during

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[4] The original data were obtained from the Datastream data set.

the very early phases of the East Asian crisis, that region's financial turmoil was not transmitted to the Latin American countries. In fact, this continued to be true after the crisis had already moved to Malaysia and the Philippines. Things changed drastically, however, in October 1997 when speculators attacked Hong Kong's currency board and the Korean won was devalued. As Figures 1 through 4 clearly show, during the days following that episode (which, as noted, is captured by the second vertical line) domestic interest rates in Argentina and Mexico experienced sudden jumps, the price of international bonds tumbled and stock markets declined drastically. It is interesting to notice that both in Argentina and Mexico, after an initial jump, domestic interest tended to stabilize. In the case of Argentina they stabilized at a slightly higher level than prior to the Hong Kong attack. In Mexico, interest rates declined a few weeks after the Hong Kong-originated shock, but the exchange rate continued to depreciate. Throughout December 1997 and July 1998 prices of Mexican bonds increased, as did the stock market index. This is indeed what one would expect in a floating regime country, where the exchange rate acts as the main (although not only) shock-absorber.

The next chapter in this saga corresponds to the Russian currency crisis and default of August, 1998. As it turned out, what started as a localized problem in a financially small country – but one with a vast nuclear capacity --, became a major international liquidity crisis. Its ultimate manifestation was the collapse of the mega hedge fund, *Long Term Capital Management* (LTCM), and its consequent bailout by a consortium of investment banks coordinated by the Federal Reserve Bank of New York. Figure 1 illustrates the way in which this crisis affected Mexico's financial variables. As may be seen, immediately following the Russian default Mexico's exchange rate experienced a steep depreciation, *and* domestic (peso denominated) interest rates increased significantly. This contrasts with the effect of the Hong Kong shock, described earlier. On that occasion, as reflected in the figures, the peso also depreciated, but domestic interest rates remained relatively stable. Not surprisingly, as Figure 2 illustrates, following the Russian debacle Mexico's stock market also collapsed, as did prices of its Brady bonds. As Figures 3 and 4 show, this episode also created major turmoil in Argentina: immediately following the Russian default Argentine interested rates skyrocketed and the *Merval* stock market index plummeted. Although after a few weeks interest rates came down, they never reached the pre-crisis level, and the spread between peso- and dollar-denominated interest rate stabilized at a much higher level than it had previously reached.

The final financial shock captured in figures 1 though 4, corresponds to the Brazilian devaluation of January 13, 1999. Not surprisingly, and as illustrated in Figures 3 and 4, this episode had a major effect on Argentina's financial markets. This was, in many ways, expected, since Brazil is Argentina's main trade partner, and a major local financial force. What is surprising, however, is that the Brazilian shock had a relatively small effect on Mexico's financial market, indeed much smaller than the Russian crisis.

The stylized facts presented in this section suggest, then, that during the second half of the 1990s financial shocks were rapidly, and in some times intensively, propagated across emerging countries. Although the episodes discussed here are by no means exhaustive, they do suggest the presence of a number of patterns. In some cases the spillover of turmoil was, if not expected, at least not surprising. This was the case of the effects of the Brazilian crisis on Argentina and, to a lesser extent, the spillover of the Hong Kong crisis to Argentina (these are two of the very few countries that have a currency board). In other cases, the intensity with which the shocks were transmitted across countries was unexpectedly severe – as in the Russian case --, and yet in other cases what was surprising was the mildness of the effect, as in the Brazil-Mexico episode

III. Analytical and Empirical Issues

Contagion has been defined in the economics literature in many different ways, including as *any* transmission of shocks across countries. Eichengreen and Rose (1999) and Kaminsky and Reinhart (1999), for example, have defined contagion as a situation where the knowledge that there is a crisis elsewhere, increases the probability of a domestic crisis. I believe, however, that it is more useful to restrict the term *economic contagion* to those situations where the extent and magnitude to which a shock is transmitted internationally *exceeds what was expected ex ante*. This definition is, in fact, consistent with the modern epidemiology literature. For example, in his epidemiology textbook, Gertsman (1998) argues that contagion is present when "any disease or event occurs in clear excess of *normal expectancy* (p. 1 emphasis added)." See, also, MacMahon and Trichopoulos (1996).

In order to formalize this definition we can distinguish between three mechanisms through which economic shocks are propagated across countries.[5] The first one corresponds to global disturbances that affect all (or most) countries in the world. The oil shocks of 1973 and 1979 are good examples of these aggregate disturbances, which Masson (1998) has called international *"monsoons."* The second mechanism corresponds to shocks coming from a related country. Some authors have referred to this phenomenon as *spillovers* (Masson, 1998) or as *fundamentals-based contagion* (Kaminsky and Reinhart, 1999). This would be the case, for example, when a crisis in a trade partner reduces greatly the demand for our exports. A number of authors – most notably Eichengreen and Rose, 1999 – have emphasized this trade-related transmission mechanism. As explained below, however, this channel doe not appear to be particularly important in the case of emerging economies.[6] The third mechanism includes all instances not covered by the two previous cases, and corresponds to our definition of *contagion*. That is, contagion is defined as a *residual,* and thus as a situation where the extent and magnitude of the international transmission of shocks exceeds what was expected by market participants.

III.1 Contagion and "Residuals"

Assume that economic agents are interested in extracting a signal from noisy (financial) data in country j. Assume further that they do this by using a linear model, and conditioning the prediction on the information set that they believe to be relevant. In equation (1) x_{jt} is the variable of interest, y_{jt} is a vector of domestic variables that are specific to country j, g_t is a vector of global or aggregate variables, and z_{kt} is a vector of variables from a group of related countries k.[7] The latter vector includes only variables from those countries that, according to the analyst's beliefs, affect the behavior of x_{tj}. α, β, and γ are parameters and ε_{jt} is a random term with standard properties.[8] The g_ts and z_{kt}s can be variables that are related to trade, finance or other aspects of the economic and/or political aspects of the country in question.

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[5] Masson (1998) and Forbes and Rigobon (1999) have suggested a similar classification.

[6] See also Glick and Rose (1998).

[7] This variable could, of course, refer to a "crisis index," such as the one defined by Eichengreen, Rose and Wyplosz (1996).

[8] Notice that this equation is very similar -- almost identical, in fact – to Forbes and Rigobon's (1999) equation (1). However, as will become clear, the spirit of my analysis is quite different from theirs.

(1) $$x_{jt} = \alpha + \lambda\ y_{jt} + \beta\ g_t + \gamma\ z_{kt} + \varepsilon_t.$$

The first term in the right hand-side (α) is the constant. The second term captures the role of domestic factors in the determination of x_{jt}. The next term (βg_t) captures the role of *aggregate* external shocks. Finally, $\gamma\, z_{kt}$ is the *spillover* or related-country effect. In this set-up, analysts (and the public in general) use this equation to "forecast" $x_{jt.}$ Contagion will occur if there are (large) changes in x_{jt}, that are not accounted by changes in y_{jt}, g_t or z_{kt}. In this context, then, large residuals in an equation such as (1) would provide (some) evidence of the existence of "contagion." Notice that equation (1) may be subject to endogeneity, and that the appropriate instruments may not be available for properly estimating it. This would make the interpretation of the estimated coefficients particularly difficult.

One way of dealing with the potential endogeneity problem is by estimating a VAR system, where all variables are treated as potentially endogenous. In Figure 5 I present residuals from the estimation of a VAR for Argentina's short term nominal interest rates using weekly data for 1991-99. As may be seen, these residuals are indeed very large during October-December 1997, August-September 1998 and December 1998-January 1999. These periods correspond, exactly, to the East Asian, Russian and Brazilian currency crises.[9]

There are three broad explanations for the presence of large residuals in an equation such as (1). First, the transmission mechanism may be state-dependent and, thus, the equation for x_j may be subject to "break points." That is, it is possible that at certain point in time the key coefficients in equation (1) α, β and/or γ experience a structural change. If the existence of such breaks is not taken into account, the estimation of (1) will indeed yield large residuals. Most analyses on the presence of contagion in the finance literature have centered on this mechanism.[10] Second, there may be non-

[9] The data refer to 30 days deposit rates in pesos. The right-hand-side variables included in this estimation are dollar-denominated Argentine interest rates; Brazilian, Mexican, Chilean and U.S short term interest rates; and the (actual) rate of change in the value of the exchange rate in Brazil, Chile and Mexico. These data were obtained from the Datastream data set.

[10] Typically, analysts, divide the sample in two – before and after a "crisis" – and test whether there are significant changes in the parameters.

linearities in the "true" equation for x_{jt}. In this case, by using a linear representation, as in equation (1), agents and analysts would miss the possible magnification of large shocks. And, third, economic agents may be using a misspecified equation to explain the financial variable of interest. In particular, the analyst may have conditioned the signal extraction process to the wrong information set. In this case equation (1) would be subject to an omitted variables problem, as some variables that belong to the "true" equation for x_{jt} are not being included in the forecasting equation.[11]

III.2 Mechanisms and Channels

Several theoretical explanations have been given for the existence of contagion. A popular class of models has emphasized the existence of multiple equilibria. In this case changes in expectations, or in investors' sentiments, will result in the economy suddenly shifting from a good to a bad equilibria (see Masson 1998, Rodrik and Velasco 1999, and the literature cited there). In terms of our previous discussion, this would be reflected in state-contingent coefficients in equation (1), and in sudden break-points in the relationship between x_{jt} and its determinants. A number of empirical studies on contagion have analyzed whether the correlation coefficient between stock market returns in different countries indeed exhibits a structural change at the (approximate) time of a crisis.[12] Recently, however, Forbes and Rigobon (1999) have argued that this approach is flawed. The problem, according to them, is that if the second moments of the relevant variables -- stock market returns in the country where the crisis has originated, for example—are higher during turmoil periods, the estimates of the correlation coefficient will be biased. They argue that once adjusted correlation coefficients are estimated, most cases of alleged "contagion" become simple cases of "spillovers."

A second class of models has emphasized the role of incomplete and/or asymmetric information. Calvo (2000) and Calvo and Mendoza (2000), for example, have developed formal models where due to the existence of costly information, most investors follow a handful of supposedly informed market participants. As a result of this, the market will be subject to rumors and fads, and will exhibit herd behavior. This,

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[11] If equation (1) is interpreted as a reduced form, the omitted variables would belong to the "true" equation. Alternatively, we can think that the "true" relationship implies a complex set of equations, and that the analyst has ignored some of them.

[12] See, for example, Bertero and Meyer (1990).

in turn, will generate large and unexpected swings in financial variables even in countries with healthy fundamentals. This type of model is consistent with both the existence of nonlinearities, and with the idea of a misspecified equation (1). An important implication of this view is that credible macroeconomics institutions -- that is, institutions that facilitate the process of extracting signal from noise--, will tend to reduce emerging countries' vulnerability to external shocks. Calvo (2000) has recently argued that the exchange rate system is the most important of these institutions, and that countries with either a super-fix or a freely floating exchange rate system are less prone to contagion. I return to this point in the concluding section of this paper.

In incomplete information models, a crisis may play the role of a *"wake up call"* (Goldstein, Kaminsky and Reinhart, 1999). In this case, a crisis in country k allows investors to reassess their emerging countries' models. In particular, it is possible that because of developments in k, investors realize that their forecasting model – given by, say, an equation of the type of (1) -- was misspecified, and that it has omitted one or more key variables. When the new variables are included, the forecast may be such that investors (both domestic and foreign) decide to reduce their holdings of securities issued by residents of country j. In terms of the original model – that is, the model used before the *"wake up call"*-- the movement in variable x_j is larger than anticipated, and thus constitutes a contagion episode.

A third class of models has emphasized the role of liquidity squeezes (Valdes, 1998). In this case, when international investors face difficulties in a particular emerging country, they may be forced – or, to be less dramatic, they may decide – to sell-off other securities in the same asset class. This could result in drastic declines in asset prices in countries that were originally unaffected by the crisis, and that had strong fundamentals. This would be the case, for instance, if banks consider loans to certain regions of the world as belonging to the same asset class. Kaminsky and Reinhart (1999) have recently used a twenty-country data set to investigate the role of a common-bank-lender channel as a main determinant of the international propagation of shocks. They find that, in the case of the emerging countries, this financial transmission mechanism plays a significantly more important role than the international trade channel emphasized by Eichengreen and Rose (1999) for the case of the advanced nations.[13]

IV. Volatility Contagion

Most of the economics literature on contagion -- including those works discussed in the preceding section -- has analyzed the way in which changes in the first moments of key variables are propagated across countries. Equally important, however, is the transmission of changes in volatility – or second moments -- across nations. In order to illustrate the point, in Figure 6 I present data on the first differences of short term domestic interest rates in Hong Kong, Argentina, Chile and Mexico for the period surrounding the East Asian currency crises. The data in this figure clearly show that in late 1997 – when the East Asian crisis was at its peak -- interest rate volatility in Hong Kong experienced a drastic increase. More importantly, however, this figure suggests that this increase in volatility was transmitted – to different degrees -- to Argentina, Chile and Mexico. To the extent that financial volatility is a key determinant of investment and other economic decisions, it is important to understand if these changes in volatility regimes are independent across countries, or if they are the result of the international propagation of financial turmoil.

Although there have been a number of studies on "volatility contagion" in stock markets, there have been very few analyses on how macroeconomic volatility, and in particular interest rate volatility, is transmitted across countries. Edwards (1998) and Edwards and Susmel (2000) have recently tackled this issue using interest rate data for a number of Latin American and East Asian countries.[14]

Edwards (1998) estimated a series of augmented GARCH models of domestic interest rates to analyze whether the Mexican currency crisis of 1994 had resulted in "volatility

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[13] Notice, however, that both Kaminsky and Reinhart (1999) and Eichengreen and Rose (1999) are really dealing with "spillovers" and not with contagion as defined by Masson (1998), Forbes and Rigobon (1999) and this paper.

[14] Other papers that deal with cross country volatility include the studies on "meteor showers" by Engle and Ng (1993), Ito, Engle and Lin (1990, 1992), and Hamano, Ng and Masulis (1990), and the studies on equity markets time-varying correlations by Longin and Solnik (1995), and the Ramchand and Susmel (1998). See also Bennett and Kelleher 1988, King and Wadhwani 1990. In contrast to Edwards and Susmel (2000), most work on switching interest rate volatility have tended to focus on only one country. Hamilton (1989), for example, shows that the time series behavior of U.S. interest rates changed significantly during the 1979-1982 Federal Reserve's monetarist experiment. Ball and Taurus (1995), Gray (1996), and, more recently, Kalimipalli and Susmel (1999) have used switching models to analyze the volatility of U.S. interest rates.

contagion" into Argentina and Chile. In this model, interest rates in each country are subject to conditional heteroskedasticity, and the conditional variance can be affected by exogenous shocks stemming from the rest of the world. Using weekly data for 1994-1998 Edwards (1998) found that while increases in financial and currency volatility in Mexico had been transmitted into higher volatility in Argentina, they had not affected the conditional variance of Chile's nominal interest rates.

Edwards and Susmel (2000) used both univariate, as well as multivariate techniques to investigate whether financial crises have been characterized by "volatility contagion." Their data set includes Argentina, Brazil, Chile, Hong Kong and Mexico. They first used a variant of Hamilton and Susmel's (1994) switching autoregressive conditional heteroskedasticity (SWARCH) methodology, to identify breakpoints in an ARCH model of the conditional variance.[15] A particularly attractive feature of this approach is that it allows the authors to date periods of high volatility endogenously. They find that, in all countries it is not possible to reject the hypothesis that there have been three distinct volatility states: high, medium and low volatility. In most countries the "high volatility states" are rather short-lived. They also find that periods of "high volatility" tend to roughly coincide across some countries. Table 1 contains a summary of the Edwards and Susmel (2000) findings on the extent and duration of high volatility in the periods surrounding the Mexican, East Asian, Russian and Brazilian currency crises of the 1990s. Each entry in Table 1 provides, for each country, a starting date for the high volatility state, as well as the number of weeks the economy was in the high volatility state. The authors argue that it is suggestive that our countries experienced a significant increase in volatility in the period *following* a major crisis. They also note that the crisis countries themselves are indeed the first to experience a shift to the high volatility state. The authors argue that the fact that the dates of high volatility states *roughly coincide*, is indeed suggestive, but does not constitute statistical evidence in favor of either the "volatility co-movement" or the "volatility contagion" hypotheses.

In order to investigate this issue further, Edwards and Susmel (2000) extended their SWARCH analysis to the multivariate case. They concentrated on one particular case: when the data suggest that both the "crisis originator country" and another country are jointly (in a

[15] Their data set on weekly domestic interest rates covers 1991-1999.

statistical sense) in a high volatility state. Their results suggest that while there are several instances when Mexico and Argentina are jointly in a high volatility state, this happens only once for the case of Mexico and Brazil (in March 1995). Their findings also indicate that Chile and Mexico did not jointly experience high volatility states during the so-called "tequila episode" of 1994-1995. Surprisingly perhaps, Edwards and Susmel (2000) found that Argentina and Hong Kong jointly experienced a high volatility state during a number of periods going back to 1991. They also show that in the latter part of 1997 Hong Kong and Argentina were jointly in the high volatility state. They also show that after the attack on the Hong Kong currency board in October1997, Brazil and Hong Kong experienced short periods of joint high volatility.

Perhaps Edwards and Susmel's most interesting finding refers to the relationship between volatility switches in Hong Kong and Chile. Their multivariate SWARCH results indicate that between 1994 and late 1997 there is no evidence whatsoever of the two countries jointly experiencing high volatility states. And then, in October 1997, the probability of both countries being in a high volatility state jumps to one, and stays there. They argue that this is quite unusual, and that is as close as one can think of "volatility contagion". A particularly attractive aspect of the Edwards and Susmel (2000) analysis is that it directly addresses the (important) point made by Forbes and Rigobon (1999), regarding that the simple (unadjusted) correlation coefficient between two markets may change significantly due to an unexpected increased in volatility in an originator country.

V. Capital Controls and the Prevention of Contagion

A number of authors have recently argued that the extent of economic contagion has been greatly magnified by capital mobility. According to this view, controls on capital inflows constitute an effective way of reducing, and even eliminating, countries' vulnerability to external shocks. Joseph Stiglitz (1999), until recently the World Bank's Chief Economist, has said: "Volatile markets are an inescapable reality. Developing countries need to manage them. They will have to consider policies that help stabilize the economy…These could include … *Chilean-style policies that put some limits on capital flows* (emphasis added)." See also Ito and Portes (1998) and Eichengreen (1999).

From a policy perspective a key question refers to these policies effectiveness. More specifically, have countries that have implemented controls on capital inflows been able to protect themselves from externally-generated financial turmoil?[16] In this section I address this issue by analyzing in some detail Chile's experience with controls on capital inflows during the 1990s.

V.1 Controls to Capital Inflows in Chile: An Overview

Chile introduced restrictions on capital inflows in June 1991.[17] Originally, all portfolio inflows were subject to a 20% reserve deposit that earned no interest. For maturities of less than a year the deposit applied for the duration of the inflow, while for longer maturities, the reserve requirement was for one year. In July 1992 the rate of the reserve requirement was raised to 30%, and its holding period was set at one year independently of the length of stay of the flow. Also, at that time its coverage was extended to trade credit and to loans related to foreign direct investment. New changes were introduced in 1995, when the reserve requirement coverage was extended to Chilean stocks traded in the New York Stock Exchange (ADRs), to "financial" foreign direct investment (FDI), and bond issues. In June of 1998, and as a result of the sudden slow down of the inflows, the rate of the reserve requirement was lowered to 10%, and in September of that year the deposit rate was reduced to zero. Throughout this period Chile also regulated foreign direct investment: Until 1992, FDI was subject to a three years minimum stay in the country; at that time the minimum stay was reduced to one year. There are no restrictions on the repatriation of profits from FDI.

When the controls were imposed the authorities hoped to reduce Chile's external vulnerability through two channels. First, it was expected that the controls would reduce the volume of inflows, at the same time as they would increase their maturity. Second, it was expected that the controls would help avoid (or at least reduce) the extent of real exchange rate appreciation that usually accompanies capital inflows. This last objective was particularly important, since most analysts associated Chile's external crisis of 1981-82 with an acute overvalued real exchange rate that, eventually, triggered a massive speculative attack.[18]

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[16] In addition to Chile, Brazil and Colombia implemented some type of controls on inflows during the 1990s.

[17] Chile also implemented controls on inflows during the 1980s. That episode was clearly unsuccessful. For details see Edwards and Edwards (1991) and Edwards (1999a, b). Parts of this sub-section draw on Edwards (1999b).

[18] See Edwards and Edwards (1991) for a discussion of that period.

Chile's system of unremunerated reserve requirements is equivalent to a tax on capital inflows. The rate of the tax depends both on the period of time during which the funds stay in the country, as well as on the opportunity cost of these funds. As shown by Valdés-Prieto and Soto (1996) and De Gregorio, Edwards and Valdes (2000), the tax equivalent for funds that stay in Chile for k months, is given by the following expression:

$$\tau(k) = [\, r^* \lambda / (1 - \lambda)\,] (\rho / k), \qquad (2)$$

where r* is an international interest rate that captures the opportunity cost of the reserve requirement, λ is the proportion of the funds that has to be deposited at the Central Bank, and ρ is the period of time (measured in months) that the deposit has to be kept in the Central Bank.

Figure 7 contains estimates of this tax equivalent for three values of k: six months, nine months, one year and three years. Three aspects of this figure are particularly interesting: first, the rate of the tax is inversely related to the length of stay of the funds in the country. This, of course, was exactly the intent of the policy, as the authorities wanted to discourage short-term inflows. Second, the rate of the tax is quite high even for a three year period. During 1997, for example, the average tax for 3 year-funds was 80 basis points. And third, the tax equivalent has varied through time, both because the rate of the required deposit was altered and because the opportunity cost has changed.

Between 1988 and 1998 shorter-term flows into Chile –- that is, flows with less than a one year maturity-- declined steeply relative to longer term capital. The percentage of the county's liabilities in hands of foreigners maturing within a year, also declined in the period following the imposition of controls (Edwards 1999b). By late 1996 Chile had a lower percentage of short term debt to G-10 banks than any of the East Asian countries, with the exception of Malaysia. By end 1996, however, Chile short term residual debt was not significantly lower than that of Argentina, a country with no capital restrictions, and it was higher than that of Mexico another Latin American country without controls (Edwards 1999b).

A number of authors have used regression analysis to investigate the determinants of capital flows in Chile. Soto (1997) and De Gregorio et al (2000), for example, have estimated a system of VARs using monthly data to analyze the way in which capital controls have affected the volume and composition of capital inflows. Their results suggest that the tax on capital movements discouraged short term inflows. These analyses indicate, however, that the reduction in shorter term flows was fully compensated by increases in longer term capital inflows and that, consequently, aggregate capital moving into Chile was not altered by this policy. Moreover, Valdés-Prieto and Soto (1998) have argued that the controls only became effective in discouraging short-term flows after 1995, when its actual rate increased significantly.[19]

A traditional shortcoming of capital controls (either on outflows or inflows) is that it is relatively easy for investors to avoid them. Valdés-Prieto and Soto (1998), for example, have argued that in spite of the authorities' efforts to close loopholes, Chile's controls have been subject to considerable evasion. Cowan and De Gregorio (1997) acknowledged this fact, and constructed a subjective index of the "power" of the controls. This index takes a value of one if there is no (or very little) evasion, and takes a value of zero if there is complete evasion. According to them this index reached its lowest value during the second quarter of 1995; by late 1997 and early 1998 this index had reached a value of 0.8.

V.2 Controls on Capital Inflows, External Vulnerability and Contagion

A particularly important question is whether Chile reduced its financial vulnerability and was spared from financial "contagion" during the period when the controls on capital inflows were in effect (1991-98). More specifically, did these controls isolate Chile's key macroeconomics variables – and especially interest rates – from externally generated financial turmoil? In Figure 8 I present weekly data on the evolution of Chile's 30 and 90-day deposit interest rates for 1996-1999.[20] As may be seen, both interest rates experience a dramatic jump in late 1997, at the time when the East Asian crisis became generalized.

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[19] These results are consistent with Montiel and Reinhart (1999).

[20] While the data for 30-day rates refer to nominal rates, those for 90 day deposits are in Chile's "real" (inflation-corrected) unit of account.

In order to investigate this issue formally I estimated a series of VAR systems to analyze the way in which Chile's interest rates responded to shocks to the emerging markets' degree of "regional" risk, as measured by the cyclical component of JP Morgan's EMBI index for non Latin American countries. As a way to gain further insights into the way in which external shocks are transmitted internationally, I also estimated impulse response functions for domestic interest rates in Argentina and Mexico, and compared them to the results obtained for Chile. What makes this exercise particularly interesting is that neither Argentina nor Mexico had controls on capital mobility during the second half of the 1990s. I estimated the VAR systems using weekly data for a number a number of subperiods spanning 1994-1999.[21] I then used a series of bivariate and multivariate methods to analyze whether the relationship between Chile's interest rates and exogenous shocks experienced significant changes through time.

An advantage of the VAR approach is that it allows us to deal with the (potential) endogeneity problem that has affected many regression-based contagion studies.[22] Indeed, a VAR system explicitly allows for feedback going from the country's interest rates to the regional (or global) measures of country risk. Moreover, the use of weekly data permits us to interpret the interest rates' impulse response function to a "regional risk" shock in a structural way. This interpretation requires that changes in domestic interest rates are not reflected in changes in the non Latin American EMBI index during the same week. In the case of Chile, this is a particularly reasonable assumption, since during most of the period under consideration Chilean securities were not included in any of the emerging market EMBI indexes. The following endogenous variables were included in the estimation:

1. The cyclical component of the Non Latin American emerging markets JP Morgan EMBI index.[23] An increase in this index reflects a higher market price of (non Latin American) emerging markets securities and, thus, a reduction in the perceived riskiness of these countries. This variable was denoted as NONLATIN_CYC. Given the composition of the EMBI index, this indicator

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[21] The period was chosen in order to exclude the turmoil generated two major crises

[22] Forbes and Rigobon (1999).

[23] The cyclical component was calculated subtracting the Hodrick-Prescott filter to the index itself.

mostly captures the evolution of the market perception of "country risk" in Asia and Eastern Europe.[24]

2. The cyclical component of the Latin American emerging markets JP Morgan EMBI index. This variable was denoted as LATIN_CYC.
3. The weekly rate of change in the Mexican peso/US dollar exchange rate.
4. The weekly rate of change in the Chilean peso/US dollar exchange rate.
5. The spread between 90-day peso and U.S .dollar-denominated deposits in Argentina. This spread is considered as a measure of the expectations of devaluation in Argentina.
6. Argentine 90-day, peso-denominated deposit rates. This variable was denoted as ARG90DP.
7. Mexican 90-day, certificate of deposit nominal rates expressed in pesos (MEXCP90).
8. Chilean 90-day deposit rates in domestic currency.[25] This variable was denoted as CHLCD90

In addition, interest rates on U.S. 30 year bonds were included as an exogenous variable. All the data were obtained from the *Datastream* data set. In the estimation a two-lag structure, which is what is suggested by the Schwarz criteria, was used.. In determining the ordering of the variables for the VAR estimation, I considered the (cyclical component of the) EMBI Index for non Latin American emerging markets, and for the EMBI for Latin American countries to be, in that order, the two most exogenous variables.

In Figure 9 I report the impulse response functions of interest rates to a one standard deviation shock of the non Latin American EMBI index.[26] The results are quite interesting, and indicate that Chile's domestic interest rates were affected significantly by financial shocks from abroad. These figures show that an one standard deviation positive

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[24] Details on the index can be found in JP Morgan's Web site.

[25] As pointed out above, these deposit rates are expressed in "real" pesos. That is they are in terms of Chile's inflation-adjusted unit of account, the so-called UF. During the period under study Chile did not have a deep market for nominal 90-day deposits.

[26] These impulse response functions have been calculated from VARs estimated for the 1996-November 1999 period.

(negative) shock to the non-Latin American EMBI index generates a statistically significant decline (increase) in Chile's domestic interest rates. This effect peaks at of 30 basis points after three weeks, and dies off after seven weeks. According to these results, domestic interest rates in Argentina and Mexico were also significantly affected by shocks to the non-Latin American EMBI index. Notice that according to these results, these non-Latin American shocks had a greater effect on Chilean that on Argentine interest rates. At the same time, these figures show that Mexican interest rates have been the ones affected the most by these shocks. Overall, these results provide some preliminary evidence suggesting that shocks emanating from other emerging regions are transmitted to the Latin nations in a way that is independent of the existence of controls on capital inflows. It is important to notice that the above results hold for alternative definitions of Chile's domestic inbterest rates. In fact, when (very) short interest rates are used, such as the Central bank's seven days repo rate, the impact of the external shock appears to be even more pronounced.

An important question, and one that the results reported above do not address, is whether the relationship between Chile's interest rates and the market perception of non-Latin American country risk has experienced changes through time. This question, of course, is related to the issue of "contagion" addressed in the preceding sections of this paper. In order to address this issue I compared the error variance decomposition for Chile's interest rates for two sub-periods. The first one goes from the first week of 1994 through the last week of 1996, while the second sub-period covers the first week of 1997 through the last week of October of 1999. That is, the first sub-period includes only the Mexican crisis, while the second sub-period covers the East Asian, Russian and Brazilian crises.

In Table 2 I present data on the variance decomposition at a 24-month forecasting error for Chile's interest rates, for the two periods under consideration. In order to concentrate on the variables of interest I have only reported the variance decomposition for shocks in the non-Latin American EMBI index, the Latin American EMBI Index and the Chilean interest rate itself. For this reason the percentages in each row do not add up to 100. These results are quite striking, and clearly show that in 1997 there was a significant break in the relationship between Chile's interest rates and emerging markets' country risk indexes. The first row shows that during the 1994-1996 period neither of the two emerging markets EMBI indexes were not particularly important in explaining the variance of Chile's interest rate. Indeed, shocks to these indexes explained less than one percent of the interest rate variance. Moreover, the null hypotheses that all their lagged coefficients are equal to zero cannot be rejected at conventional significance levels.[27] The results for the latter (1997-99) period are very different, as is reflected by the second row in Table 2. During this period shocks to the non-Latin American EMBI index played a significant role in explaining the interest rate variance: more than 22% of the variance in interest rates is explained by the non Latin American EMBI index. Indeed, as the p-values show, for this period the hypothesis that all lagged coefficients of each of the EMBI shocks are jointly zero is strongly rejected.

In order to illustrate the structural break in the relationship between Chile's interest rates and its external determinants, I used the estimated VAR system for 1994-96 to "forecast" weekly interest rates during 1997-99. The residuals from this forecast exercise are presented in Figure 10. As may be seen, the residuals are rather small until late 1997. From that point on there are very large residuals corresponding to the East Asian attack, as well as to the Russian and Brazilian crises.

The results reported above show that Chile was vulnerable to the propagation of shocks coming from other emerging markets. Moreover, these results indicate that in 1997, six yeas after having controls on capital inflows in place, the relationship between domestic interest rates and emerging markets risk experienced a significant structural break, that resulted in the amplification of externally-originated shocks All of this suggests that at that time the country suffered from contagion.

A potential limitation of the analysis presented above is that, as it is the case with VAR estimates, it may be affected by the order in which variables are introduced into the estimation. In order to address this issue I analyzed the relationship between Chile's interest rates and the non-Latin American risk index using a sturdy bi-variate procedure. More specifically, I used a Granger-causality test to investigate whether during 1994-

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[27] During this period shocks to Argentina's expected devaluation – measured as the spread between peso and dollar denominated deposits – was more important than either of these indexes, explaining 11 percent of CHLCD90.

1999 there were changes in the relationship between Chile's domestic interest rates and the non Latin American EMBI index. The following system was estimated:

(3) $CHLDC90_t = \alpha + \Sigma\, \beta_j\, CHLDC90_{t-j} + \Sigma\, \gamma_j\, NONLATIN\_CYC_{t-j} + \mu_t$

(4) $NONLATIN\_CYC_t = \alpha + \Sigma\, \beta_j\, NONLATIN\_CYC_{t-j} + \Sigma\, \gamma_j\, CHLDC90_{t-j} + \varepsilon_t$

Different lag structures were used, and the joint hypothesis: $\gamma_1 = \gamma_2 = \ldots = \gamma_k = 0$, was tested for each equation. If this hypothesis is not rejected, there is evidence that there is no causal effect between the variables of interest during the period in question.

In Table 3 I present the results from these F-tests for the case of two lags. According to these results, during the earlier period it is not possible to reject the null hypotheses that there is no causal effect in either direction. However, the F-statistics indicate that during the latter period it is possible to reject the hypothesis of no causality running from the non Latin American EMBI index to Chile's interest rates. At the same time, it continues to be the case that the hypothesis of no causality going from Chile to the EMBI cannot be rejected. These results provide additional support to the findings reported above, indicating that in spite of the existence of controls on capital inflows, Chile was not spared from the turmoil stemming from the Asian and subsequent crises. In fact, the results presented here suggest that, contrary to the expectations of the architects of the capital controls policy, Chile was indeed subject to contagion during the latter part of the 1990s. What these results are unable to tell us, however, is whether Chile would have done better in the absence of controls. I am afraid that constructing such counterfactual scenario is extremely difficult and may, in fact, not be possible to implement in a satisfactory way. However, as I have argued in Edwards (1999b) I do believe that, in many instances, the existence of controls of the Chilean-type have created a false sense of security among policy makers, making the country more – rather than less – prone to suffering the consequences of externally-generated crises.

VI. Concluding Remarks

During the second half of the 1990s the world economy experienced a series of deep financial crises. The emerging countries were particularly affected by this financial turmoil, as country after country saw the value of their currencies collapse, and were forced to implement deep adjustment programs. The spreading of instability around the globe has been loosely called financial "contagion." In this paper I have analyzed several aspects of the international transmission of economic disturbances, and I have argued that it is useful to distinguish contagion from other forms of shocks' propagation. Taking a lead from the epidemiology literature, I argue that "contagion" occurs when the extent and magnitude of the international transmission of shocks exceeds what was expected ex-ante.

In a world with high capital mobility, even small adjustments in international portfolio allocations to the emerging economies result in very large swings in capital fl*ows*. Sudden reductions in these flows, in turn, can have serious effects on domestic interest rates and exchange rates, bruising credibility and unleashing a vicious circle. Crises, thus, tend to be deeper than in the past, imposing serious costs to the population of the counties involved. Some analysts have argued that the imposition of capital controls – including controls on capital inflows – provides an effective way for reducing the probability of crises such as the one described above. The experience with capital controls, however, has been rather disappointing. In fact, as the evidence presented in section V of this paper shows the effectiveness of Chile's controls on inflows has often been overstated. Indeed, Chile was severely affected by the East Asian, Russian and Brazilian crises. Moreover, as De Gregorio, Edwards and Valdes (2000) have shown, these controls had no effects on the behavior of the country's real exchange rate and did not help slow down the real appreciation process that had begun in 1990.

Recently, and partilally as a result of the perceived limited effectiveness of controls on inflows, an increasing number of analysts has argued that there is a need to introduce major changes to exchange rate practices in emerging economies, moving towards credible regimes, that will reduce rumors-based reversals in capital flows – or what Dornbusch et al (1995) and Calvo (1999) have called "sudden stops." In the last few years, fixed-but-adjustable regimes rapidly lost adepts, while two extreme positions—super-fixed (through a currency board or dollarization), and floating rates gained in popularity. Interestingly enough, the support for these regimes is largely based on the shortcomings of the intermediate systems – pegged-but-adjustable, managed float and (narrow) bands --, and not on their own historical merits. Indeed, in emerging markets there have been very few historical experiences with either super-fixity or with floating. Among the super-fixers, Argentina, Hong Kong and Estonia have had currency boards and Panama has been dollarized. This is not a large sample. Among floaters, the situation is not better. Only Mexico has had a somewhat longish experience with a somewhat flexible rate (1995 to date), and most of it has taken place during periods of high international turmoil. Current skepticism regarding pegged-but-adjustable regimes is partially based on the effect that large devaluations tend to have on firms' balance sheets and, thus, on the banking sector. As the experience of Indonesia dramatically showed, this effect is particularly severe in countries where the corporate sector has a large debt denominated in foreign currency. Calvo (2000) has offered one of the very few theoretical justifications for ruling out middle-of-the road exchange rate regimes. He has argued that in a world with capital mobility, and poorly informed market participants, emerging countries are subject to rumors, runs an (unjustified) panics. This is because these uninformed participants may – and usually will – misinterpret events in the global market. This situation may be remedied, or at least minimized, by adopting a very transparent and credible policy stance. Only two type of regimes satisfy this requirement: super-fixes, and in particular dollarization, and a (very) clean float.

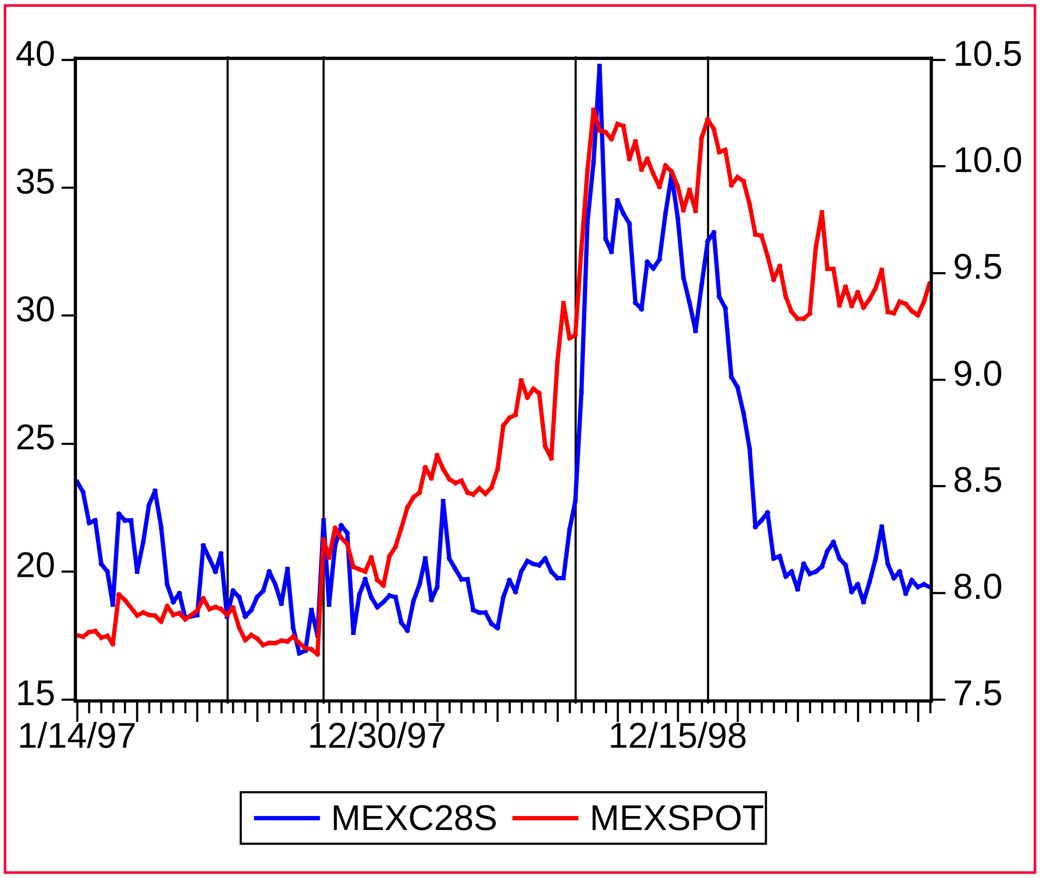

Figure 1: Short Term Interest Rates (MEXC28S) and Spot Exchange Rate in Mexico, 1997-99

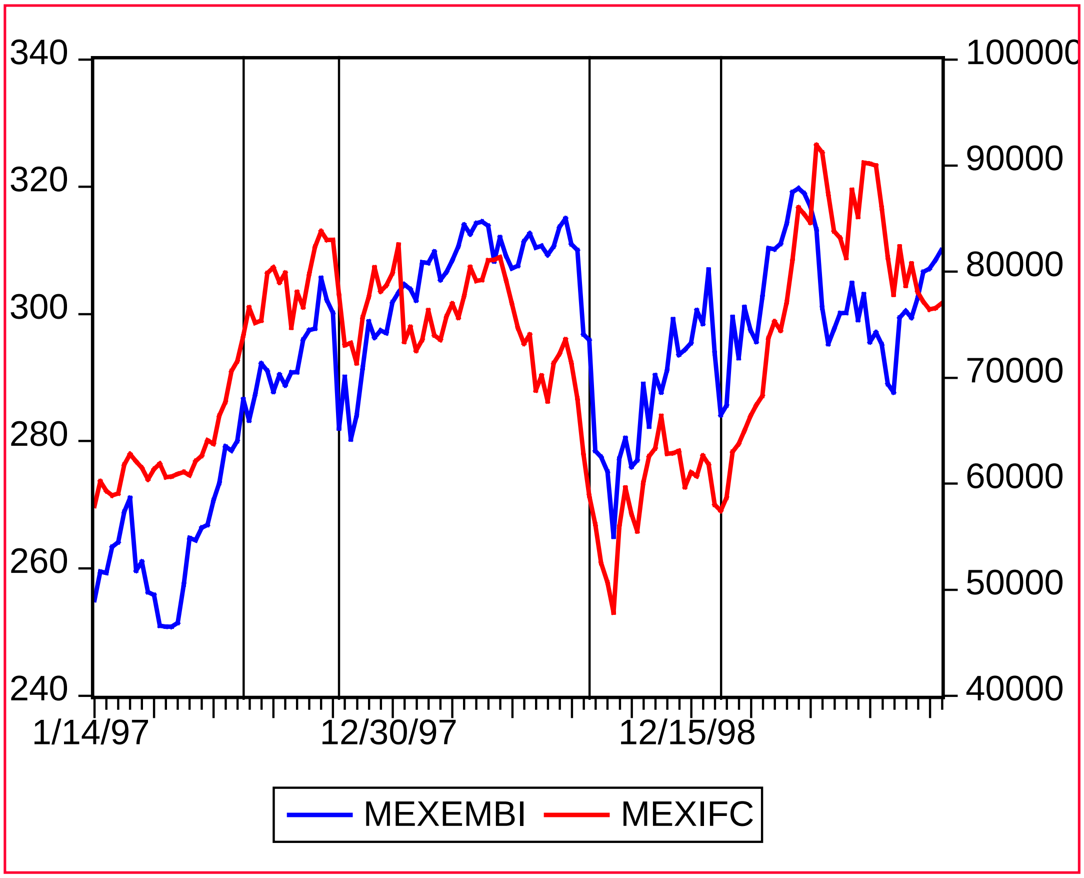

Figure 2: Bond Price Index (MEXEMBI) and Stock Market Index (MEXIFC) in Mexico, 1997-99

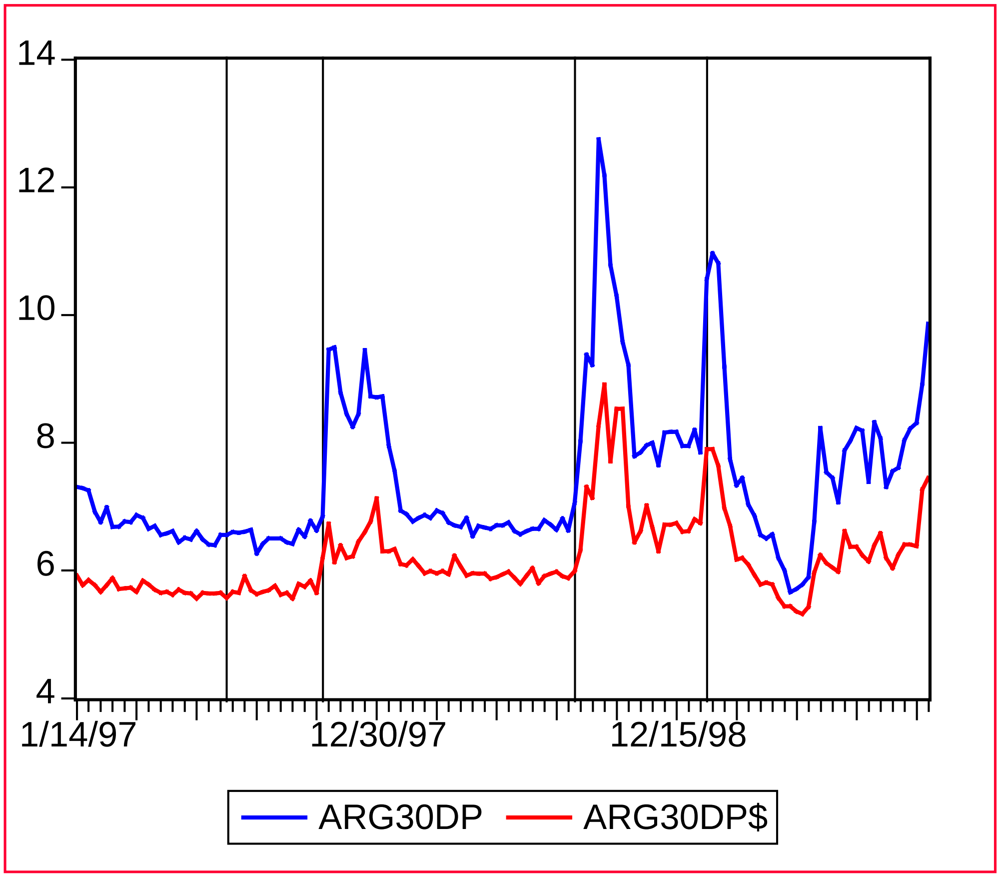

Figure 3: Short Term Interest Rates in Pesos (ARG30DP) and Dollars in Argentina, 1997-99

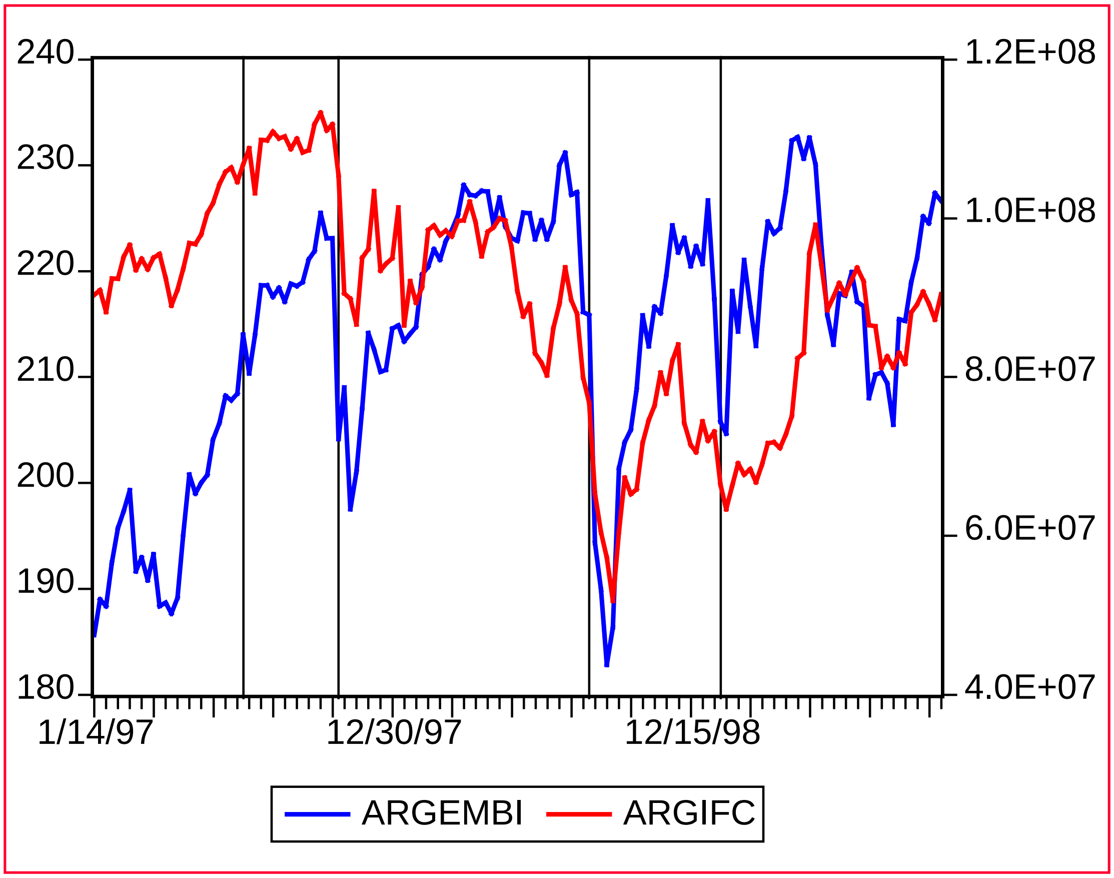

Figure 4: Bond Price Index (ARGEMBI) and Stock Market Index (ARGIFC) in Argentina, 1997-1999

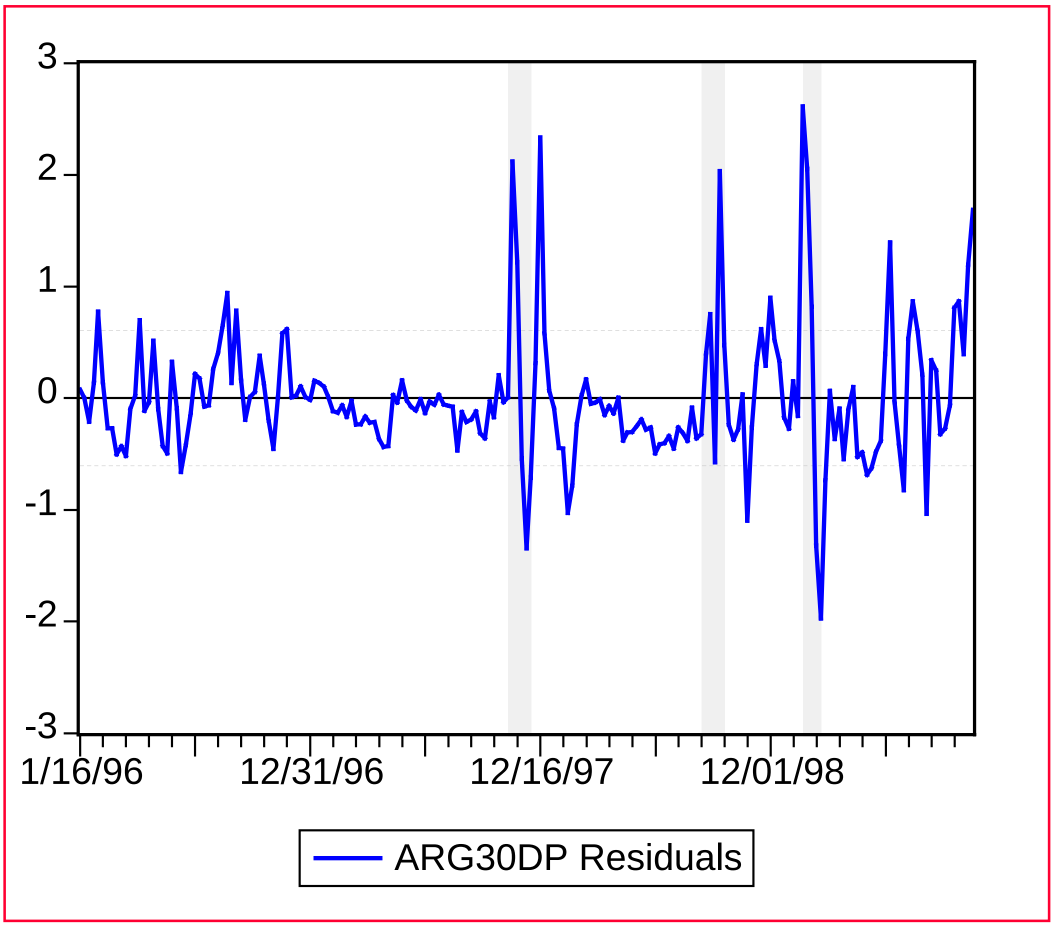

Figure 5: Residuals from VAR Estimation of Argentine Short Term Peso Denominated Interest Rates, 1996-1999

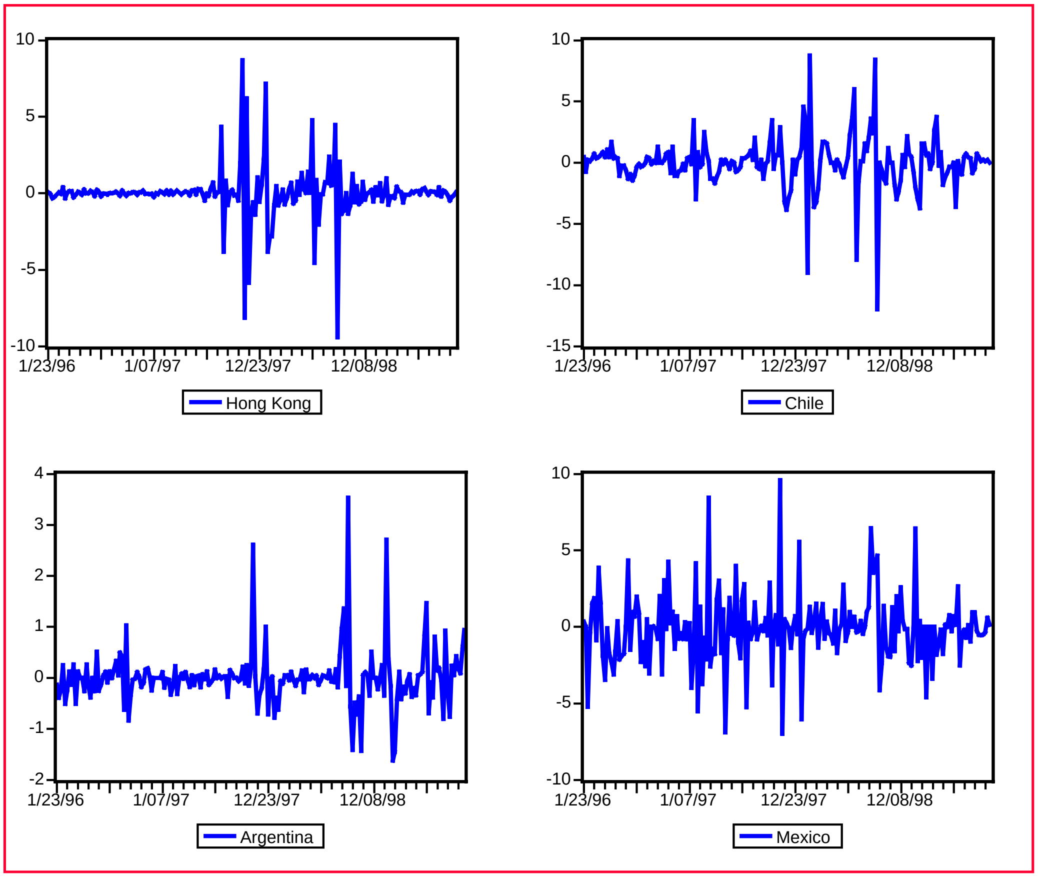

Figure 6: First Differences of Domestic Short term Interest Rates
In Hong Kong, Argentina, Chile and Mexico:
Weekly Data, 1996-99

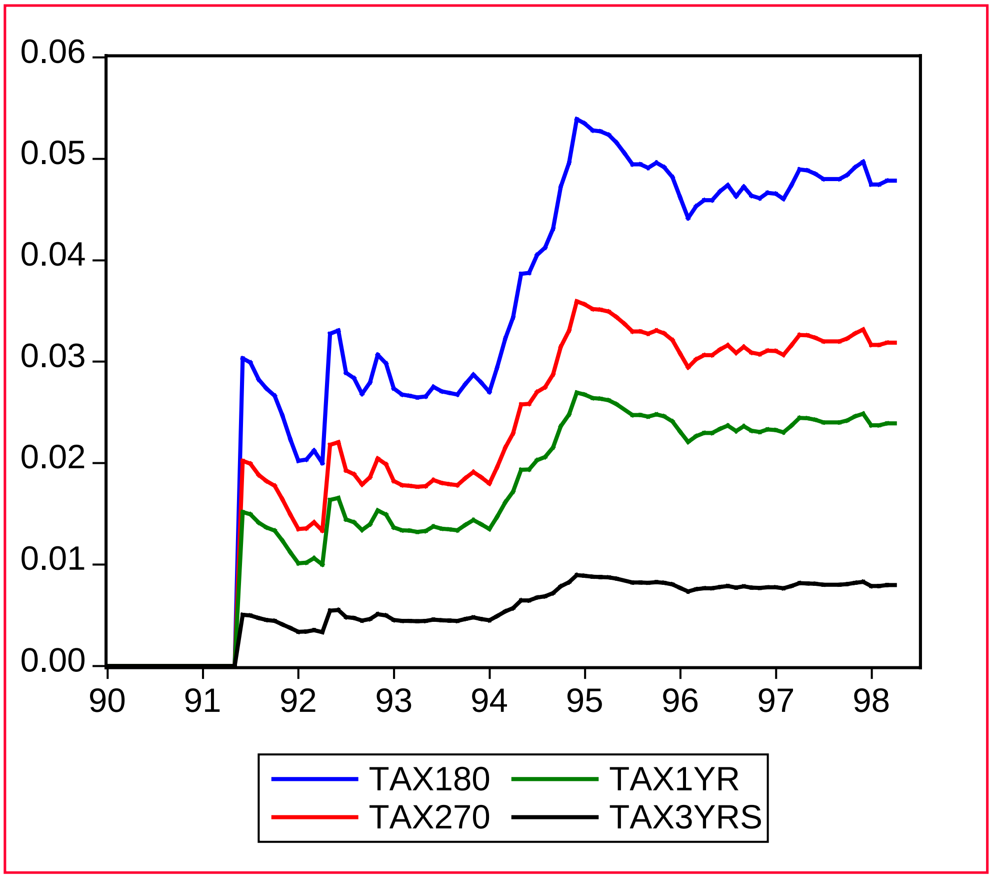

Figure 7: Tax Equivalence of Chile's Controls on Capital Inflows

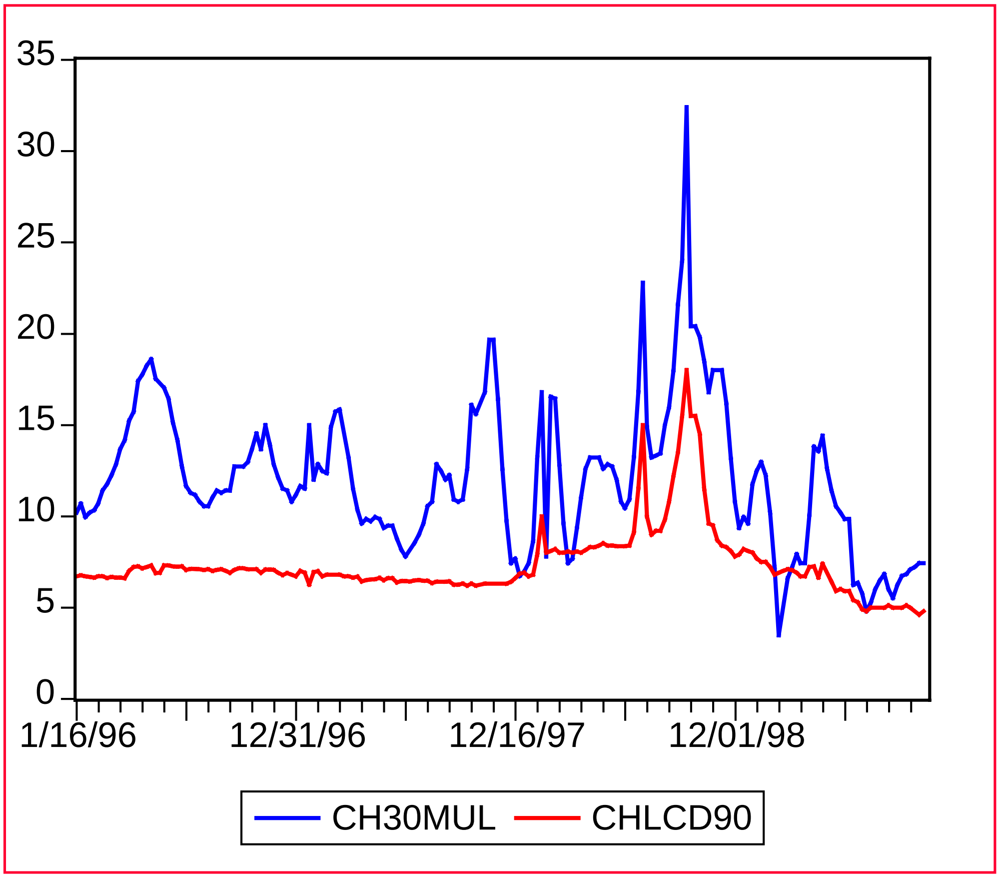

Figure 8: Interest Rates in Chile: 30-day (CH30MUL) and 90-day (CHLCD90) Deposits

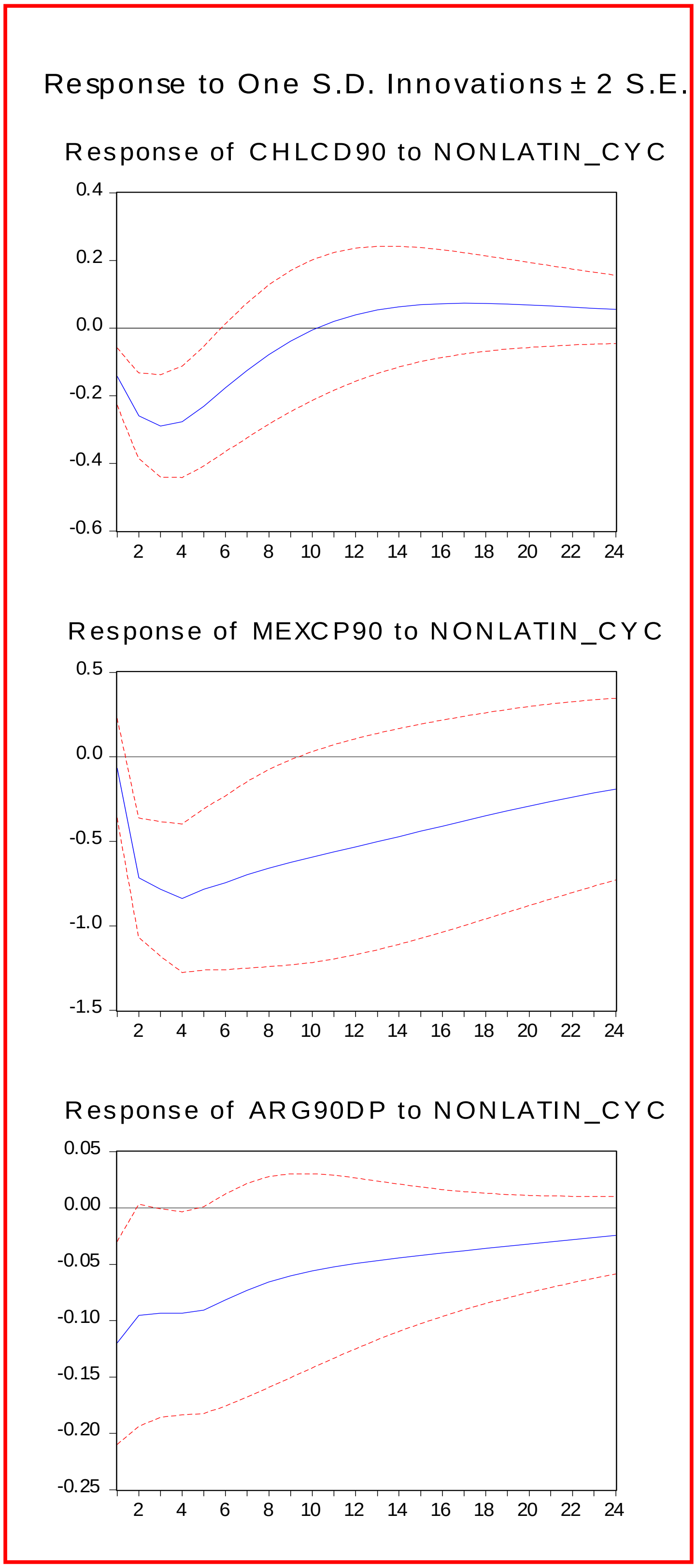

Figure 9: Impulse Response Functions of Domestic Interest rates in Chile, Mexico and Argentina to a One Standard Deviation Shock of the Non Latin American EMBI Index

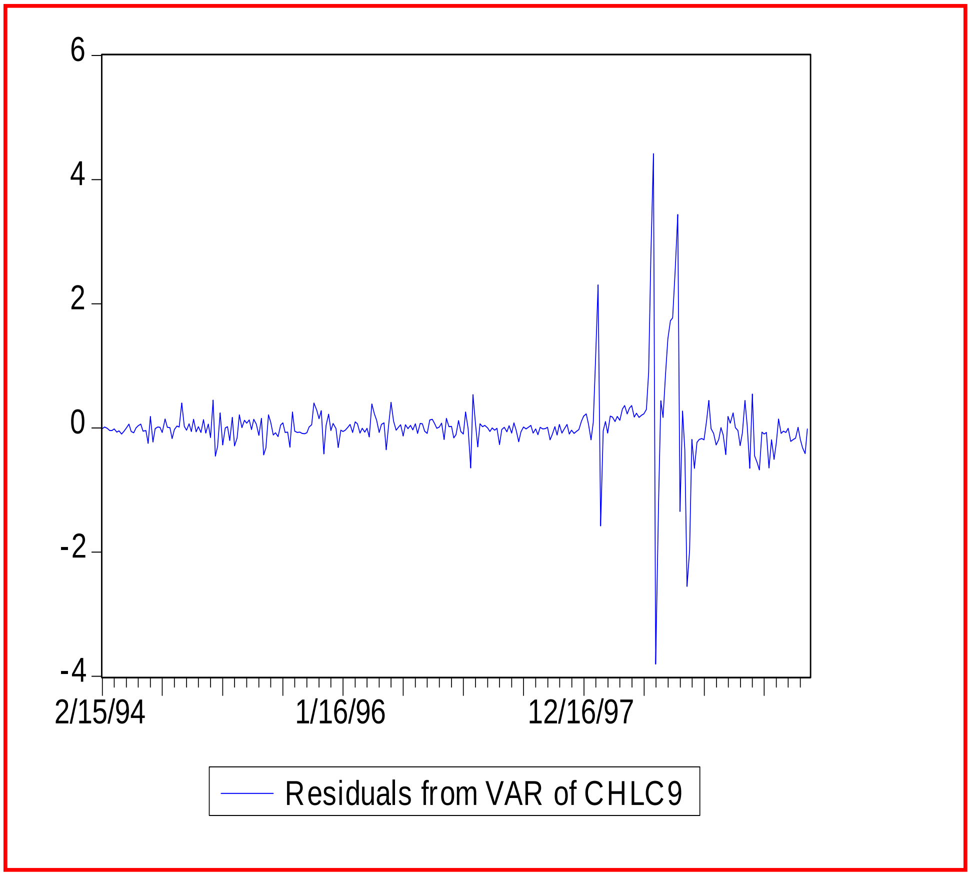

Figure 10: Residuals from VAR Forecast of Chile's Domestic Interest Rates

TABLE 1: HIGH VOLATILITY EPISODES AROUND MAJOR CURRENCY CRISES:

December 1994-April 1999

	MEX CRISIS 12/30/94	ASIAN CRISIS 10/24/97	RUS CRISIS 9/04/98	BRAZ CRISIS 1/15/94
ARGENTINA	3/10/95 (5)	10/31/97 (6)	8/28/98 (5)	1/15/99 (5)
BRAZIL	3/10/95 (1)	10/31/97 (1)	9/11/98 (1)	1/15/99 (1)
CHILE	xxx	3/06/98 (2)	9/04/98 (4)	2/05/99 (3)
MEXICO	12/30/94 (25)	10/24/97 (7)	9/04/98 (5)	xxx
HONG KONG	1/13/95 (2)	10/24/97 (52)		xxx

Source: Edwards and Susmel (2000)
Notes:
Each entry provides a starting date for the high volatility state (3rd state) and the number of weeks the economy was in the high volatility state during each crisis. xxx means the economy was not in the 3rd state during the given crisis.

TABLE 2: Variance Decomposition of Chile's Domestic Interest Rates
at a 24-month Horizon*

	Shock to:		
	Non Latin American EMBI	**Latin American EMBI**	**Chile's Domestic Interest Rates**
Period I: (1994-1996)	0.40 (0.32)	0.54 (0.47)	76.5 (0.00)
Period II: (1997-1999)	22.2 (0.01)	0.93 (0.03)	49.8 (0.00)

*The numbers in parentheses correspond to the p-values for the null hypothesis that all the lagged coefficients for the corresponding variable are equal to zero.

Table 3: Granger Causality Tests for Chilean Interest Rates And Non-Latin American EMBI Index: F-Statistics and p-values

A. Period A: 1994-1996

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
NONLATIN_CYC does not Granger Cause CHLCD90	152	0.74128	0.47828
CHLCD90 does not Granger Cause NONLATIN_CYC		0.24838	0.78039

B. Period B: 1997-1999

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
NONLATIN_CYC does not Granger Cause CHLCD90	138	3.62518	0.02931
CHLCD90 does not Granger Cause NONLATIN_CYC		1.08305	0.34153

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