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Are Changes in Spreads of External-Market Debt also Induced by Contagion?

As governments and private companies from emerging markets have increasingly issued foreign-currency denominated debt through the 1990s, the economies concerned have become more vulnerable to abrupt changes in sovereign risk. At the same time, with closer economic integration countries have become more likely to be affected by economic problems that arise in neighboring countries. The following article uses the example of four Latin American countries to evaluate empirically the extent to which "contagion" explains changes in sovereign risk.

Just as foreign capital can encourage economic growth, it can also hurt ill-prepared countries. The Mexican crisis in 1994, the Thai crisis in 1997 and more recently, the Russian and Brazilian crises in 1998 and 1999, have opened a new paradigm in research, since they show that globalization does not come without a cost. Not only domestic fundamentals, but also external factors and economic interdependency can determine the development path of a country. Just as countries can benefit from closer economic integration, they can also be affected by economic problems that arise in neighboring countries. This "contagion" effect has become much more severe in the 1990s and therefore policymakers as well as investors should underscore its importance in order to assess sovereign risk. As governments and private companies from the emerging markets have increasingly issued foreign-currency denominated debt through the 1990s, abrupt changes in sovereign risk could undermine a country's ability to service its debt and consequently increase the cost of capital for the emerging markets to finance their economic growth. This is the scenario experienced by Mexico and other Latin American countries in 1994 and 1995.

The purpose of this article is twofold: first, it examines the changes in sovereign risk premia of Argentina, Brazil, Mexico and Peru by using as a proxy the volatility of spreads of external-market debt instruments through the period 1994:1 – 1999:1; and second, it introduces an alternative measure of stock market integration which is used to evaluate the extent to which "contagion" explains changes in the sovereign risk of the selected countries.

The article is organized as follows: it first reviews the different strands in the literature of sovereign risk from the 1970s, 1980s and 1990s; next a basic model of sovereign risk is presented in which a group of fundamentals and a measure of financial integration are included as explanatory variables; this is followed by a brief explanation of the estimation methodology; the empirical implementation and results are then presented; the final part sets forth possible policy implications and the main conclusions of the analysis.

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An Overview of the Literature

Literature in the field of sovereign risk emerged in the 1970s with the pioneering work of Frank and Cline[1] who applied discriminant analysis to determine indicators that allow us to identify debt servicing difficulties of developing countries. Basically, this technique was used to detect the set of independent variables that could better explain a dichotomous dependent variable that took the value of 1 if a country rescheduled its debt or 0 otherwise. The 1980s literature was strongly influenced by the international debt crisis, after Mexico's announcement of its debt moratorium in 1982. This strand of literature emphasized the huge external debt obligations of many developing countries and their ability and willingness to repay loans. Thus, theories on debt repudiation and defaults, renegotiation, and reputation were developed.[2] Most of the literature in this period focused on explaining how domestic factors increase the country's possibility to default in the medium and long

[1] Charles R. Frank, William R. Cline: Measurement of Debt Servicing Capacity: An Application of Discriminant Analysis, in: Journal of International Economics, Vol. 1, 1971, pp. 327-344.

[2] See W. Cline: A Logit Model of Debt Rescheduling, 1967-1982, Institute For International Economics, Working Article, June 1983; S. Edwards: LDC Foreign Borrowing and Default Risk: An Empirical Investigation, 1976-1980, in: American Economic Review, Vol. 74, No. 4, June 1983, pp. 726-734; D. Gale, M. Hellwig: Repudiation and Renegotiation: The Case of Sovereign Debt, in: International Economic Review, Vol. 30, No. 1, 1989, pp. 3-31.

term, and few of the studies concentrated on explaining short-term irregularities in the market for external-debt instruments.[3]

In the 1990s, studies of sovereign risk focused on country as well as non-country specific variables, due to more opened capital accounts in the developing countries, and the integration of global financial markets. Various studies show that fundamentals are important in determining the changes in sovereign premium. Cantor and Packer[4] studied sovereign credit ratings for 49 countries, relating spreads to macro-economic indicators (per capita income, GDP growth, inflation, fiscal balance, external balance, and external debt) and to the average of Moody's and Standard & Poor's country credit ratings. They conclude that credit ratings have a significant explanatory power in explaining the spreads. A limitation of this study is the existence of high correlation among the macro and credit ratings variables used to explain spreads. In a similar study, Haque, Kumar, Mark and Mathienson[5] showed that credit ratings are mostly explained by economic fundamentals. More recently, Reisen and Maltzan[6] explored whether the sovereign credit rating agencies lead or lag market events with respect to sovereign risk and also investigated the effects of these ratings on bond market and stock market volatility. They found that negative announcements of credit ratings (which depend on fundamentals) can amplify panic sentiment among investors and therefore have the potential to dampen excessive capital inflows. On the other hand positive announcements seem to explain the reduction of the volatility in both bond and stock markets.

Other studies show that external factors are highly significant and argue that the movement in sovereign debt is insensitive to changes in fundamentals. Dornbusch[7] argued that the impact of the world economy on borrowers operated through inflation, interest rates and the dollar value of world trade. Dooley, Fernández-Arias and Kletzer[8] found that international interest rates are the key underlying factor that explain changes in debt prices in the secondary market among 18 countries. Speidel-Walz[9] studied sudden jumps in sovereign premia for 13 emerging markets and found that US forward rates are highly significant and that indicators like debt-to-GDP, current account-to-GDP and deficit-to-GDP show some explanatory power.

Finally, other studies take into account "spillover effects" by stating that the variation of the price of a particular debt instrument depends on the variations in similar instruments. Most studies that incorporate these effects suggest that the changes in prices of a particular debt instrument can be better explained by investors' behavior. It is in this context that notions of "contagion" and "market sentiment" have emerged. Doukas[10] tested the pricing process that determines sovereign interest rate spreads on three countries with euro-syndicated loans (Brazil, Argentina, Mexico) by using the "expected news" (domestic fundamentals) and "unexpected news", obtained from the residuals of the estimation of the economic-growth output adjustment model. The "expected news" variable was statistically insignificant in explaining changes in spreads, while the "unexpected news" variable, a measure of contagion from non-domestic variables, proved to be significant in all cases. He concluded that individual country interest rate spreads are influenced not only by the creditworthiness of the country itself, but also by the creditworthiness of other borrowing countries. Agénor[11] developed a theoretical model of the contagion based on the "Tequila" effect as a temporary increase in the risk premium faced by domestic private borrowers on world capital markets. After the collapse of the Mexican peso in December 1994, a sudden loss of investors' confidence in Argentina's economic prospects triggered massive net capital outflows. He studied the effects of this shock in an intertemporal optimizing framework where firms' demand for working capital is financed by bank credit. The model

[3] For more information on sovereign risk literature in the 1980s see: Y. S. Al-Anssi: Country Economic Risk Analysis, University of Colorado at Boulder, Ph. D. Dissertation, July 1992; D. F. Babble: Insuring Sovereign Debt against Default, World Bank Discussion Papers, No. 328, Washington 1996.

[4] R. Cantor, F. Packer: Determinants and Impact of Sovereign Credit Ratings, in: Federal Reserve Bank of New York, Economic Policy Review, Vol. 2, No. 2, October 1996.

[5] N. Haque, M. S. Kumar, N. Mark, D. J. Mathienson: The Economic Content of Indicators of Developing Countries Creditworthiness, IMF Staff Article, Vol. 43, No. 4, December 1996.

[6] H. Reisen, J. von Maltzan: Sovereign Credit Ratings, Emerging Market Risk and Financial Market Volatility, Hamburg Institute of International Economics (HWWA) Discussion Paper No. 55, 1998.

[7] R. Dornbusch: Our LDC Debts, NBER Working Article No. 2138, 1988.

[8] M. P. Dooley, E. Fernández-Arias, K. M. Kletzer: Recent Private Capital Flows to Developing Countries: Is the Debt Crisis History?, NBER Working Article No. 4793, 1994.

[9] E. Speidel-Walz: Early Warning Indicators for Financial Market Risks – Bond Market Risks, Deutsche Morgan Grenfell, Focus Eastern Europe, 11 August 1997, pp. 12-15.

[10] J. Doukas: Contagion Effect on Sovereign Interest Rate Spreads, Concordia University, Economic Letter 29 (1989), North Holland.

[11] P. Ágénor: Borrowing Risk and the Tequila Effect, IMF Working Article, WP/97/86, July 1997.

was shown to be capable of reproducing some of the main features of Argentina's economic downturn in 1995. A contagious shock, viewed as an increase in the volatility of aggregate shocks impinging on the domestic economy, increases financial spreads as well as the producer's cost of capital, resulting in lower output, lower employment, and higher incidence of defaults. Valdés[12] found a strong cross-country correlation of debt prices in the secondary market after controlling for macroeconomic fundamentals. Moreover, higher correlation was found after events such as the announcement of a Brady Plan restructuring. This evidence of contagion in the markets for developing countries' debt is stronger than analogous evidence for the US corporate bond market and for a group of medium-sized OECD countries, where fundamentals essentially explain all of the observed correlation across bond issues and credit ratings. Finally, Eichengreen and Mody[13] studied the determinants of launch spreads on emerging market debt using bond characteristics, global economic conditions, issuer characteristics and country characteristics as explanatory variables. Their main finding is that changes in market sentiments that are not necessarily related to fundamentals play a dominant role in both the issue decision of debtors and the pricing decision of investors.

Next a basic model of sovereign risk is introduced in which a group of fundamentals and a contagion measure are specified as the main explanatory variables.

Definition of the Model

As a first step, the dependent variable is defined as the volatility of the spread of external-market debt instruments, which can be considered a measure of sovereign risk attributed to individual countries by financial markets. This variable is approximated by first subtracting a weekly risk free rate (estimated from the three month US Treasury Bill) from the weekly returns on the J. P. Morgan Emerging Market Bond Index (EMBI+) for specific countries. Additionally, in order to collect all possible information about the evolution of weekly excess returns, this difference is computed on a daily basis.[14] However, a problem inherent to the sample size and frequency of the explanatory variables arises when determining the volatility of the spread. In principle, the estimation of an augmented GARCH model that includes different explanatory variables would be convenient, but the fact that the sample size is also dictated by the availability of data for fundamentals (which in most cases is quarterly data) limits our possibilities of using this approach.[15]

However, there is a way we try to overcome this problem while keeping the objective of explaining the changes in spreads of external-market debt. First, we estimate a standard GARCH(1,1) model with the mean and variance equations,

$$SPREAD_t = c + \beta \cdot SPREAD_{t-1} + \varepsilon_t$$
$$\sigma_t^2 = \omega + \phi\varepsilon_{t-1}^2 + \tau\sigma_{t-1}^2$$

and create the series for the conditional variance as the dependent variable. Since this series contains daily information, we take the maximum value of the conditional variances registered in each quarter as a measure of quarterly variability of spreads. By doing so, it is possible to capture values that represent sudden jumps through the period. Furthermore, the idea of using a GARCH(1,1) variance and not a historical volatility from the ordinary sample variance is that the former models more accurately the behavior of investors, giving more weight to most recent observations, while the latter gives each of the past observations an equal weight.[16]

Regarding the explanatory variables, we selected a group of fundamentals and a variable for contagion. With respect to the fundamentals we could expect that their deterioration provokes a negative effect on the debt servicing capacity, eventually increasing the probability of default. The following group of fundamentals were selected:[17]

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[12] R. O. Valdés: Emerging Market Contagion: Evidence and Theory, unpublished manuscript, MIT 1996.

[13] B. Eichengreen, A. Mody: What Explains changing Spreads on Emerging-Market Debt: Fundamentals or Market Sentiment?, NBER Working Article 6408, February 1998.

[14] The EMBI+ tracks total returns for traded external debt instruments in the emerging markets. Specifically, this index is constructed as a composite of four markets: Brady bonds, Eurobonds, US dollar local markets, and loans. Claude, Campbell and Tadas have also used a similar index (EMBI) in order to explain the relation between country risk and the emerging market bond spreads for the period January 1991- September 1998. They find that there is a highly significant negative relation between these two variables. For more information on these issues see: T. Vandersteel, E. Bartholomew: Introducing the Emerging Markets Bond Index Plus (EMBI+), JPMorgan, July 1995; B. E. Claude, R. H. Campbell, E. V. Tadas: New perspectives on Emerging Market Bonds: Looking Beyond The Current Crisis, in: The Journal of Portfolio Management, Winter 1999.

[15] See J. Y. Campbell, A. W. Lo, A. C. MacKinlay: The Econometrics of Financial Markets, Princeton University Press, 1997, pp. 481-488.

[16] However, it is convenient to mention that both measures for the dependent variable were tested in the empirical analysis, but the results were not significantly different.

[17] The data for the fundamentals were obtained from the International Financial Statistics, the Bank for International Settlements and Data Stream.

Seignorage (SA), defined as the change in reserve money as a percentage of GDP. The idea is that a higher monetization of a government deficit is important to explain drastic changes in the exchange rates. This would persuade investors and eventually higher spreads would be demanded to compensate an increase in the risk of default. A positive relation with changes in spreads should be expected.

M2/International Reserves (LNM2R). This variable reflects the vulnerability of the central bank to possible runs against the currency; eventually this increases the probability of default of sovereign bonds, and therefore a higher volatility in returns. To reduce dispersion in this variable, we use it in log forms. A positive relation should be expected.

Change Current Account / GDP (CAA). The idea is that the larger the current account deficit of a country the higher is the risk that borrowers cannot or are unwilling to repay their debt. A negative relation of this variable should be expected.

Change Credit to Private Sector / GDP (CEA), which reflects the state of health of the financial system. In many emerging markets it has been common to see that bank lending has expanded rapidly, particularly for consumer loans. This could lead to an increase in credit risk and eventually to a banking crisis. Therefore, the possibility that governments stop external debt payments increases. A positive relation should be expected.

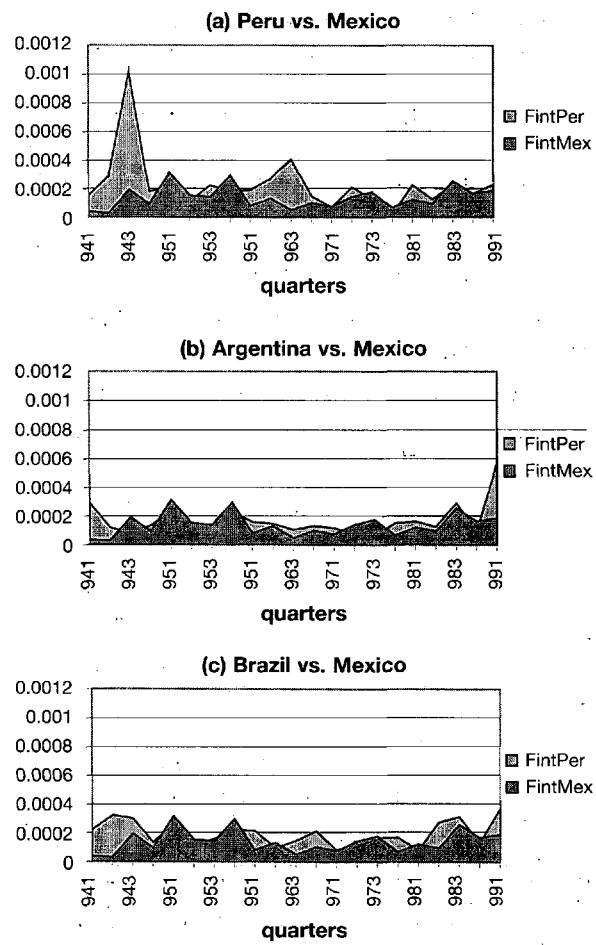
Real Exchange Rate Misalignment (MIS1). The idea is that a currency that is constantly overvaluated, will eventually lead to a collapse in exchange rates. This would affect directly the debt servicing capacity. A positive relation should be expected.

External Debt / GDP (TD). If a country has accumulated large amounts of foreign currency-denominated debt, the probability of default will increase substantially in a period of financial turbulence, making investors demand higher returns in compensation for the higher risk. A positive relation should be expected.

Finally, in order to complete the set of explanatory variables, we define the following measure which is expected to capture the "contagion effect":

Financial Integration Measure (FINT). Various studies over the last few years have attempted to analyze the reasons and sources of the spread of financial crises across countries.[18] When we look at abrupt changes in the spreads of external market debt instruments for emerging countries, we can see that all these jumps match with episodes of financial turbulence. This is not surprising since it is reasonable to expect that traumatic devaluations, pressures on domestic interest rates and potential losses of international reserves play an important role in investors' portfolio allocation decisions. As mentioned above, there seems to be a consensus that in order to understand the transmission mechanisms in these episodes it is necessary to include a notion of "contagion". Therefore, in an attempt to capture a contagion component in the volatility of spreads, we include a measure of financial market integration. The aim is to track the degree of integration among the selected markets in order to test whether this variable played an important role during the Mexican crisis. The logic is that a financial market that is highly/little integrated into a specific region is more/less vulnerable to external shocks which originated in another country of

Figure 1
Asset's Average Mispricing



[18] More explanations and literature on recent financial crises can be found on Nouriel Roubini's website: http://www.stern.nyu.edu/~nroubini/

the same region. In this article we use a measure of stock market integration developed by Korajczyk.[19] Unlike many other empirical studies that use dummy variables to define contagion, this measure does not choose arbitrarily the markets that are believed to be more affected either because they belong to a particular region or because they are financially integrated with other markets in the world. Instead, the advantage of this measure is that it allows us to analyze the time-varying integration, i.e. it takes into account the dynamics of the "contagion" component over time for different markets. Korajczyk's approach is to measure deviations from integration by measuring the deviations of asset returns from an equilibrium model of returns constructed assuming market integration. Specifically, the model he uses to measure deviations is the Arbitrage Pricing Theory[20] in which it is assumed that returns are generated by the following k-factor model:

(1) $R_{i,t} = E(R_{1,t}) + B_{1,i}f_{1,t} + B_{2,i}f_{2,t} + \ldots + B_{k,i}f_{k,t} + \varepsilon_{i,t}$

$i = 1,\ldots, n$ assets, and
$t = 1,\ldots, t$ time periods,

$R_{i,t}$ = the return on asset "i" in period "t" ;
$E(R_{i,t})$ = the expected return on asset "i" in period "t";
$B_{j,i}$ = the jth factor sensitivity for asset "i", j = 1,..., k;
$f_{j,t}$ = the realisation of the jth factor in period "t", j = 1,..., k; and,
$\varepsilon_{i,t}$ = the idiosyncratic (asset specific) return for asset "i" in period "t".

Further, if a risk-free asset exists then the equilibrium version of the APT is given by:

(2) $E(R_{i,t}) = R_{F,t} + B_{1,i}\gamma_{1,t} + B_{2,i}\gamma_{2,t} + \ldots + B_{k,i}\gamma_{k,t}$

$R_{F,t}$ = the return on the risk-free asset in period "t" ; and,

$\gamma_{j,t}$ = the realised risk premium for factor "j" in period "t".

Upon substitution of the second equation into the first one, and rearranging, the empirical specification of the APT in excess returns form becomes:

(3) $r_{i,t} = B_{1,i}F_{1,t} + B_{2,i}F_{2,t} + \ldots + B_{k,i}F_{k,t} + \varepsilon_{i,t}$

$r_{i,t} = (R_{i,t} - R_{F,t})$, that is, the excess return for asset "i" in period "t"; and,

$F_{j,t} = (\gamma_{j,t} + f_{j,t})j = 1,\ldots, k$, that is, the realized risk premium plus the factor realization for factor "j" in period "t".

Using matrix notation, equation (3) can be rewritten as:

(4) $r^n = b^nF + \varepsilon^n$

where r^n is the n x T matrix of excess returns on the assets; F the k x T matrix of realized factors plus risk premiums ($f + \gamma$); b^n the n x T matrix of sensitivities (factor loadings); and ε^n the n x k matrix of idiosyncratic returns. It is also assumed that $E(F\varepsilon^{n\prime}) = 0$, $E(\varepsilon^n) = 0$ and $E(\varepsilon^{n\prime}\,\varepsilon^n/T) = V^n$.

According to the above model, there exists a restriction when estimating the following multivariate regression:

(5) $r^n = \alpha^n + b^nF + \varepsilon^n$

that is, the vector of intercept terms containing the pricing deviations should be equal to zero. In conclusion, under the assumption that the Arbitrage Pricing Theory is an appropriate pricing model in a "financially integrated world", the mispricing parameter α provides an approximation for the degree of integration among countries.

Before estimating equation (5) it is necessary to determine the matrix F. One approach is to use macroeconomic and financial market variables as well as more specific variables for characteristics of the firms that capture the systematic risks of the economy and the firms' sensitivity to this systematic risk, respectively.[21] A second approach involves the use of Factor Analysis and Principal Components on samples of asset returns in order to allow the con-

Table 1

D-W	1.897271	
Lagrange Multiplier Test for Serial Correlation		White Heteroskedasticity Test:
Lags	F-statistic	F-statistic
1	0.271640	3.126438*
2	0.247100	
3	2.164038	
4	1.603187	
5	1.2269252	
H0: no serial correlation		H0: no heterosketasticity

* Indicates the rejection of the null hypothesis at the 1 per cent level.

[19] R. Korajczyk: A Measure of Stock Market Integration for Developed and Emerging Markets, in: The World Bank Economic Review, Vol. 10, No. 2, 1996, pp. 267-289.

[20] Stephen A. Ross: The Arbitrage Theory of Capital Asset Pricing, in: Journal of Economic Theory, Vol. 13, 1976, pp. 341-360.

[21] In an application of the APT model for US asset returns Chen, Roll and Ross proposed a five-factor model that consists of the following variables: yield spread between long and short interest rates for US government bonds, expected inflation, unexpected inflation, industrial production growth, and the yield spread between corporate high- and low-grade bonds. See N. Chen, R. Roll, S. A. Ross: Economic Forces and the Stock Market, in: Journal of Business, Vol. 59, No. 3, July 1986, pp. 383-403.

struction of portfolios that represent factors. In this article we use the asymptotic principal components approach developed by Connor and Korajczyc.[22] They propose taking the eigenvectors associated with the K largest eigenvalues of the (T x T) centered return cross-product matrix Ω ($\Omega = r^{n'} r^{n} / n$) as the matrix F of true factor realizations. In our study, we determined F according to the following steps:

(a) Form the centered returns cross-product matrix Ω.

(b) Calculate the eigenvectors for the cross-product matrix. Determine the first k eigenvectors that can better represent proxies for the independent variables (F's) in equation 4.

(c) For each individual asset run a regression of excess returns on the first k eigenvectors obtained in (b) and calculate the standard deviation of residuals.

(d) Scale the excess return of each asset by its associated residual standard deviation obtained in (c) and form a new scale matrix Ω.

(e) Repeat steps (b), (c) and (d) until convergence is achieved.[23]

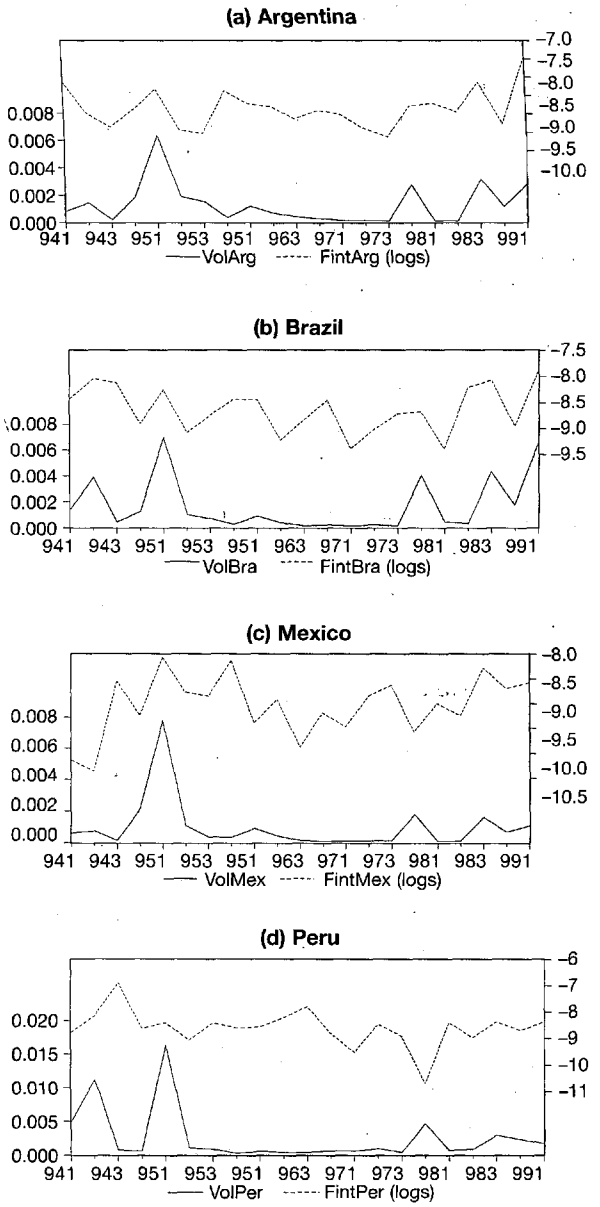
Having determined F, we proceeded to estimate equation (5) for each asset, using quarterly subsamples for the period 1994:1 – 1999:1, and obtained the correspondent intercepts which were used to form a vector of approximated mispricing parameters for each country (α^s). In order to facilitate comparison of this variable among countries, we use an average of asset's mispricing for each country ($\alpha^{s'}$ α^s/s) and for each period. Notice that the smaller the average ($\alpha^{s'}$ α^s/s), the higher the degree of integration of a "specific" stock market with respect to the "regional" stock market (which in this case consists of the four countries selected). Figure 1 shows the average mispricing of the selected markets, for the period under consideration; whereas Figure 2 shows the relation between the dependent variable and the financial integration measure for each country.

There are some interesting points that can be inferred from Figure 1:

☐ It is clear that through the period studied all the financial markets have tended to become more integrated at the regional level, due to processes of financial liberalization undertaken by all the countries.

☐ The Peruvian financial market seems to be the

Figure 2
Average Mispricing (Fint) vs. Volability of Spreads (Vol)



[22] For a detailed explanation refer to G. Connor, R. Korajczyk: Performance Measurement with the Arbitrage Pricing Theory: a new framework for analysis, in: Journal of Financial Economics, Vol. 15, March 1986, pp. 373-94; G. Connor, R. Korajczyk: Risk and Return in an Equilibrium APT: application of a new test methodology, in: Journal of Financial Economics, Vol. 21, February 1988, pp. 255-289.

[23] We applied this iterative approach for each sub-sample (quarters). We first collected historical daily data on equity prices for individual stocks from Data Stream. Ninety stocks (14, 15, 26 and 35 stocks for Argentina, Peru, Mexico and Brazil, respectively) were selected according to their volume of capitalization as well as frequency of negotiation in each market. In order to avoid survivorship bias in the sample the stocks selected must have been traded through the complete period under consideration. The data, adjusted for dividends and stock splits, were transformed into US dollars using daily exchange rates. Then, "rolling weekly returns" were computed for each day.

Table 2
GLS (Cross Section Weights) Regression Results for the Model (N = 80)
(Dependent Variable: Volatility of the Spread on External-Market Debt Instruments)

Variable	Intercept	LNM2R(-1)	SA(-1)	CAA(-1)	CEA(-1)	TD(-1)	MIS1(-1)	FINT
Coefficients	0.0105*	0.0002	–0.0024	–0.0298*	0.0070*	–0.0005	0.0014	0.0012*
t-statistic	2.6986	0.4788	–0.2895	–2.9387	2.0504	0.0695	0.4428	3.0633
R-squared	0.3141							
Durbin-Watson	1.8603							

* Indicates the rejection of the null hypothesis at the 1 per cent level.

least integrated in the region, particularly at the beginning of the period under consideration. This is expected if we consider - among many other reasons - that its financial market is still small compared to the others.

□ Even though the Mexican financial market is the most integrated on average, there is a period in which all other markets seem to be more integrated to the "regional" market (or put in other words the Mexican market becomes less integrated), starting in the last quarter of December 94 and lasting almost one year. This period has been vastly studied, since it corresponds to the Mexican crisis and the so called "Tequila effect".

Moreover, according to Figure 2, there seems to be a contemporaneous positive relation between the financial integration measure and the volatility of spreads for each country. However, some differences can be observed in the Peruvian variables. Taking into account these characteristics, this variable is entered without lags in the model.

As a summary to this section, the model to be estimated looks like:

$$(6)\quad \sigma_t^2 = \phi + \beta_i FUN_{i,t-1} + \delta FINT_t + \varepsilon_t$$

where σ_t^2 represents the volatility of the spread on external-market debt instruments in quarter t; $FUN_{i,t-1}$ refers to the fundamental i in quarter $t-1$; and $FINTt$ can be read as "degree of financial integration in quarter t". The use of lags in the fundamentals responds to theoretical issues. In fact, it is reasonable to think that changes in volatilities are a consequence of past and not current information and it is also possible to believe that this holds for the frequency of data used in the empirical analysis.[24]

Estimation Methodology

Since most of the explanatory variables run from 1994:1 to 1998:4 and the dependent variable runs from 1994:2 to 1999:1, a sample of only 20 observations for each country is generated, and therefore, a separate time series OLS estimation of the model could be inappropriate.[25] In this case, we try to overcome the problem of small sample size by organizing the data in both cross-sectional and time series dimensions, in other words, by country and by quarter. This would then result in a panel data set of 20 quarters for 4 countries, which makes a total of 80 potential observations. Before explaining the methodology used to estimate the model, it is convenient to mention that the use of data sets that combine time series and cross section are common in econometrics, and by now a fairly large number of empirical studies on financial markets rely on multi-country analyses using both dimensions of data set.[26]

In general, the class of models for this type of data set can be written as:

$$Y_{it} = \beta_1 X_{it,1} + \beta_2 X_{it,2} + \ldots + \beta_K X_{it,K} + \varepsilon_{it} \quad (i = 1,2,\ldots N; t = 1,2,\ldots,T)$$

that is, the sample data are represented by N cross-section units (four countries) over T periods of time (quarters from 1994:1 to 1999:1); K is the number of explanatory variables.

[24] However, it can be argued that the model would not necessarily do well using lags because many of the explanatory variables might change very rapidly in the months preceding an abrupt change in the spreads. This can be even more crucial when using annual data. A similar consideration has been suggested in: Ma. Soledad Martínez-Peria: Understanding Devaluations in Latin America: A 'Bad Fundamentals' Approach, CIDER Working Article 97-86, University of California, Berkeley, May 1997.

[25] That the significance of a relation between variables depends on the size of the sample follows from the fact that if there are very few observations, then there are also correspondingly few possible combinations of the values of the variables, and thus the probability of obtaining by chance a combination of those values indicative of a strong relation is relatively high.

[26] W. Greene: Econometric Analysis, 3rd edition, Prentice Hall, New Jersey 1997, pp. 613-614.

Table 3
GLS (Cross Section Weights) Regression Results for the Model (N = 80)
(Dependent Variable: Volatility of the Spread on External-Market Debt Instruments)

Variable	Intercept	LNM2R(-1)	SA(-1)	CAA(-1)	CEA(-1)	TD(-1)	MIS1(-1)
Coefficients	0.0092*	0.0026*	0.0079	-0.0199*	0.0098**	-0.0030	0.0051***
t-statistic	2.3263	2.7764	0.6029	-1.8132	2.6356	-0.3613	1.6598
R-squared	0.357706						
Durbin-Watson	2.185194						

Cross-section specific coefficients (fixed effects in FINT)

Variable	FINTARG(-1)	FINTMEX(-1)	FINTBRA(-1)	FINTPER(-1)
Coefficients	0.0010*	0.0014*	0.0014*	0.0008***
t-statistic	2.6252	3.6485	3.2940	1.7188

* Indicates the rejection of the null hypothesis at the 1 per cent level.
** Indicates the rejection of the null hypothesis at the 5 per cent level.
*** Indicates the rejection of the null hypothesis at the 10 per cent level.

Table 4
GLS (Cross Section Weights) Regression Results for the Model (N = 80)
(Dependent Variable: Volatility of the Spread on External-Market Debt Instruments)

Variable	Intercept	LNM2R(-1)	SA(-1)	CAA(-1)	CEA(-1)	TD(-1)	MIS1(-1)	FINT
Coefficients	0.0088**	0.0003	0.0083	-0.0346**	-0.0091	0.0062	-0.0001	0.0011*
t-statistic	2.4775	0.7356	1.0549	-2.2944	-0.8932	0.8315	0.0224	3.3258

Dummy Variables (Dum-)

Variable	Intercept	LNM2R(-1)	SA(-1)	CAA(-1)	CEA(-1)	TD(-1)	MIS1(-1)	FINT
Coefficients		-0.0017**	-0.0325	-0.0252***	0.0194***	0.0185*	0.0045	0.0001
t-statistic		-2.2142	-0.9942	-1.7191	1.7312	2.8767	0.6292	1.2999
R-squared	0.5651							
Durbin-Watson	2.2336							

* Indicates the rejection of the null hypothesis at the 1 per cent level.
** Indicates the rejection of the null hypothesis at the 5 per cent level.
*** Indicates the rejection of the null hypothesis at the 10 per cent level.

There are two main assumptions that must be considered before estimating this type of model: the existence of cross-sectional heteroskedasticity and time-series autocorrelation among the disturbances. In order to overcome this we must first find consistent estimates for the elements of the variance-covariance matrix that relates the different elements of ϵ and then replace them into the Aitken's formula, accounting in this way for potential heteroskedasticity and autocorrelation and obtaining consistent estimates of the regression coefficients. For a more detailed discussion on different models designed to deal with pooled cross-section and time-series observations, the reader can refer to Kmenta[27] and Greene.[28]

Empirical Implementation and Results

Before discussing results, it is important to analyze whether the main assumptions of the estimation methodology hold. Table 1 presents the results for the Durbin-Watson and Lagrange Multiplier tests as well as for the White test after estimating the model without taking into account heteroskedasticity and autocorrelation among disturbances. The first two tests indicate no potential time-series autocorrelation

[27] J. Kmenta: Elements of Econometrics, 1st edition, The MacMillan Company, New York 1986, pp. 508-517.

[28] W. Greene, op. cit.

among disturbances. However, as is expected in cross-sectional data, the presence of heteroskedasticity is supported by the White test.

Therefore, the Tables 3 and 4 present the final regression results after accounting for heteroskedasticity. Various sensitivity tests, such as changing variables definitions were conducted and confirmed the robustness of the estimations.[29]

The results confirm findings in previous studies; among the fundamentals, the coefficients of the lag of the deficit of the current account and the credit expansion are significant and have the right sign. The main finding, however, is that the financial integration measure (among the four countries) is highly significant. This confirms the hypothesis that there exists a regional component that affects the volatility of the spread of external-market debt instruments, and consequently, the sovereign risk in these countries.

In order to measure the degree to which the contagion component affected each country's external debt instruments, Table 3 presents the results of the model, using specific coefficients for the financial integration variable (which is analogous to estimation with "fixed effects").

In general, the results confirm the previous ones; among the fundamentals, the lag of the deficit of the current account, the credit expansion, the real exchange rate misalignment and the measure of variations in international reserves are highly significant. In the case of the financial integration measure a key result is that, in fact, this variable plays an important "explanatory" role in Mexico, Brazil and Argentina but has "less explanatory power" in Peru. This result is supported by the graphs presented above in which, on average, the Peruvian financial market has been little integrated with the other economies and, therefore, less vulnerable to "contagion" effects.

As an additional "exploratory" analysis, we introduced an interactive dummy for the period in which the Mexican crisis took place (Dec 94-March 95). Since most of the explanatory variables are in lag form, this variable has a value of zero for the whole sample, except for the period 94:3 – 95:1. By doing so, we try to determine whether there was a notorious difference in the significance of the explanatory variables during this crisis. The results are shown in Table 4.

Essentially, the dummy variables for fundamentals are highly significant whereas the dummy for the integration measure is not. This suggests that in this episode, mainly economic fundamentals play a role in explaining changes in sovereign risk across countries. In fact it is well known that Argentina – one of the most affected countries – had to reduce international reserves significantly in order to defend its currency board. This result also confirms previous evidence found by Fratzscher,[30] who determined that while the Thai crisis in 1997 was transmitted to other Asian countries mainly by herding and institutional contagion, the Mexican crisis was spread to other Latin American countries due to similarity of fundamentals.

Policy Issues and Conclusions

In general, the analysis presented in this article confirms the presence of a "contagion" component in the behavior of external-market debt instruments for the selected countries. Among the fundamentals, the measures of current account deficit, private credit expansion, real exchange rate misalignment and variation of international reserves seem to justify changes in sovereign risk. These fundamentals assign an important role to the monetary and fiscal policies. Since countries are interested in reducing the level and volatility that their external-market debt instruments face in the international financial markets, a straight way to reach this objective is to implement sound economic policies which investors can perceive as effective and sustainable. However, it might not be enough since it might be beyond a government's control to prevent abrupt changes in other countries' economic variables from affecting their own instruments and, moreover, their own economic growth. This is so because in many cases investors take global or regional decisions based on portfolio allocation considerations, even without explicitly differentiating among individual countries (herding and institutional contagion). In this sense, measures that promote a higher cooperation among closely related countries in order to define credible monetary and fiscal policies and the implementation of international regulations in the region's financial systems might help to reduce the probability of financial crises in one specific country and the impact of contagion on the sovereign risk of neighboring countries.

[29] Two different measures were tested for some explanatory variables: annual and quarterly changes in seignorage (SA), current account (CAA) and credit expansion (CEA). For the misalignment measure (MIS1) changes with respect to six, three and one year were tested. In general, the measure of annual changes yielded better results for all these variables.

[30] M. Fratzscher: Why Are Currency Crises Contagious?: A Comparison of the Latin American Crisis of 1994-1995 and the Asian Crisis of 1997-1998, in: Weltwirtschaftliches Archiv, Vol. 134, No. 4, 1998.