# Determinants of Banking System Fragility: A Regional Perspective

**Hans Degryse***

*KU Leuven, CentER, EBC, TILEC - Tilburg University, and CEPR*

Naamsestraat 69, 3000 Leuven, Belgium

E-mail: h.degryse@uvt.nl

**Muhammad Ather Elahi**

*CBER, Institute of Business Administration*

Karachi, Pakistan

E-mail: matherelahi@gmail.com

**María Fabiana Penas**

*CentER, EBC, TILEC - Tilburg University*

PO Box 90153, 5000 LE Tilburg, the Netherlands

E-mail: m.penas@uvt.nl

February 2012

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* Corresponding author. The authors thank Fabio Castiglionesi, Olivier De Jonghe, Falko Fecht, Iman van Lelyveld, Gyongyi Lóránth, Rafael Repullo, Wolf Wagner and seminar participants at the 2010 VWEC conference in Ghent and the 2011 CEPR-WU-OeNB conference in Vienna on "Bank Supervision and Resolution" for helpful comments. We thank Stijn Claessens and Neeltje van Horen for providing the data on foreign bank ownership.

# Determinants of Banking System Fragility - A Regional Perspective


## ABSTRACT

Banking systems are fragile not only within one country but also within and across regions. We study the role of regional banking system characteristics for regional banking system fragility. We find that regional banking system fragility reduces when banks in the region jointly hold more liquid assets, are better capitalized, and when regional banking systems are more competitive. For Asia and Latin-America, a greater presence of foreign banks also reduces regional banking fragility. We further investigate the possibility of contagion within and across regions. Within region banking contagion is important in all regions but it is substantially lower in the developed regions compared to emerging market regions. For cross-regional contagion, we find that the contagion effects of Europe and the US on Asia and Latin America are significantly higher compared to the effect of Asia and Latin America among themselves. Finally, the impact of cross-regional contagion is attenuated when the host region has a more liquid and more capitalized banking sector.



JEL Classification Codes: G15, G20, G29
Keywords: Banking system stability, cross-regional contagion, financial integration

# 1 INTRODUCTION

Banks often face shocks both on their asset and liability side. A shock that initially affects only a few institutions can become systemic and infect the larger local economy. The globalization of banking further implies that shocks affecting a particular bank or country now can affect not only the local real economy but also the financial system and real economy in other countries. Peek and Rosengren (1997, 2000), for example, show that shocks hitting Japanese banks generate supply side effects on the real economy in the US. Similarly, Puri, Steffen and Rocholl (2011) document the transmission of the U.S. financial crisis to the behavior of linked German savings banks in Germany.

The current academic literature on financial fragility, however, has mainly focused on stability of individual banks or individual countries' banking systems (see e.g., Allen et al. (2009) for a review) but has disregarded regional banking system fragility. In this paper we study the determinants of *regional* banking system fragility. The 2007-2009 financial crisis has shown that a nation with a fragile banking system may affect countries in the region through cross-border linkages and common exposures, and raise concerns for regional banking system fragility. We study which banking characteristics in a region alleviate regional banking fragility and which regional banking characteristics help in attenuating the impact of cross-regional contagion. We refer to regional banking system fragility as a situation when countries' banking stock indices in a region have jointly very low returns. Furthermore, banking fragility in one region may lead to contagion in other regions – cross-regional contagion.

Prudently regulating the banking system is undoubtedly a major objective for financial regulators because of the enormous cost of banking system instability. Hoggarth, Reis and Saporta (2002) for example estimate fiscal costs incurred in the resolution of 24 banking crisis in the last two decades and find that the cumulative output losses incurred during crisis periods are 15-20%, on average, of annual GDP. Therefore, a thorough understanding of the underlying causes of systemic banking crisis is a foremost challenge for a prudent financial regulator. In the extant academic literature , various imbalances that may lead to a banking crisis are studied (see De Bandt and Hartmann (2002) for a comprehensive survey on systemic risk). Admittedly, even though each banking crisis is unique, at the core they share similarities in the behavior of a number of economic variables and banking system characteristics. To address the core issues we need to focus on the behavior of the banking system as a whole because what may appear sound

at the micro level may be quite fragile and flawed at the macro level (Hellwig (1994)). Acharya (2009) models systemic risk stemming from correlation of returns on assets held by banks. He argues that the limited liability of banks and the presence of a negative externality of one bank's failure on the health of other banks gives rise to a systemic risk-shifting incentive where all banks undertake correlated investments, thereby increasing economy-wide aggregate risk. Regulatory mechanisms, such as bank closure policy and capital adequacy requirements that are commonly based on a bank's own risk, fail to mitigate aggregate risk-shifting incentives, and can in fact accentuate systemic risk.

Our approach analyzes which key regional banking system characteristics – liquidity, capitalization, concentration, diversification, and foreign bank presence – determine regional banking system fragility controlling for common macro factors. We are also interested in the extent of banking system contagion within region and across regions. We follow the methodology in Bae, Karolyi and Stulz (2003), and we study regional banking system fragility through joint occurrences of negative extreme returns in banking system indices of multiple countries in the region. The joint occurrences of negative extreme returns are called 'coexceedances'. A higher number of coexceedances is strongly associated with the timing of the financial crises that took place during our sample period (1994-2008). This is reassuring as it suggests that our fragility measure proxies for periods of banking system stress.

We study whether regional banking system characteristics determine regional banking system fragility (i.e. the number of banking systems having joint occurrences of extreme negative returns on a particular day) after controlling for common variables, in a multinomial logistics settings. We further study cross-regional contagion by evaluating the effect of coexceedances in one region on banking system fragility in other regions. We are particularly interested in which key regional banking system characteristics in the host region help to dampen the impact of contagion from the triggering region.

This paper contributes to the existing literature in the following dimensions. First, we investigate contagion in the banking sector across *regions* whereas the literature mainly deals with within-country contagion, cross-border contagion, or contagion across individual banks. Second, we assess the role of key regional banking system characteristics — liquidity, capitalization, concentration, diversification of banking activities, and the degree of foreign bank presence, in attenuating regional banking fragility. Third, we study cross-regional contagion and

identify a host region's banking characteristics that attenuate contagion stemming from other regions. Finally, we study four different regions – Asia, Latin America, US and Europe. This allows us to investigate contagion among developed and developing economies.

We find that a region's banking system characteristics play a significant role in explaining regional banking system fragility next to the effects of common macro factors. Among the banking system characteristics, higher liquidity reduces regional banking system fragility in all regions whereas higher capitalization reduces regional banking system fragility in all regions with the exception of Asia and Europe, where it has no effect. A possible explanation is that average capital ratios during the sample period were lower in Asia and Europe (5.3% and 4.7% respectively), compared to Latin America and the US (8.7% and 7% respectively). Our results suggest therefore that increases in capital do have an effect in reducing bank fragility but only when capital levels are higher than a threshold of around 7%. Regarding the impact of banking competition, our findings are supportive of the competition-stability view in most regions as an increase in competition in the banking industry significantly reduces the probability of joint occurrences of extreme negative returns. We further find that a focus on traditional loan making activities increases the likelihood of a single country in the bottom tail, but there is no significant impact on joint occurrences of extreme negative returns in the region. Finally, for Asia and Latin-America, a greater presence of foreign banks also reduces regional banking fragility. We note that these results are robust to employing an alternative measure of coexceedances based on abnormal returns (i.e., return on the banking index minus the return on the market).[1]

We also find evidence for contagion in all regions. Within region contagion is higher in emerging market regions, compared to developed regions, and is stronger in Latin America than in Asia. For cross-regional contagion, we find that the contagion effects of Europe and the US on Asia and Latin America are significantly higher compared to the effect of Asia and Latin America among themselves. More specifically, in Asia, the contagion effect is higher when the triggering region is the US, whereas in Latin America, the effect from Europe and the US is almost identical.

[1] The number of days that have the same number of coexceedances under both measures ranges from 63% to 95% depending on the region.

Finally, we find that a higher level of aggregate liquidity and higher capital ratios in the host region attenuate significantly the contagion effects from other regions.

The remainder of the paper is organized as follows. In the next Section, we discuss our empirical hypotheses. Section 3 describes the data and variables used in the paper and provide descriptive statistics. Section 4 explains methodology and the use of multinomial logit model. Section 5 presents our results. Subsection 6 discusses a few robustness tests. Finally, Section 7 concludes the paper.

# 2 DETERMINANTS OF REGIONAL BANKING SYSTEM FRAGILITY

Regional banking system fragility is determined by economic fundamentals and key characteristics of the regional banking system. Following Bae, Karolyi and Stulz (2003), we include three common variables as a proxy for economic fundamentals, "regional conditional volatility", changes in the exchange rate, and interest rates. We discuss those in the first subsection. In subsection 2, we motivate our regional banking system characteristics. These include banking system liquidity, capitalization, concentration, diversification, and the presence of foreign banks. Finally, in the last subsection, we discuss the impacts of cross-regional contagion. We briefly motivate each of our variables in the following subsections.

## 2.1 REGIONAL MACRO FACTORS

There is an extensive literature that explores the relationship between stock markets and common macro variables. A number of recent studies assert that *stock market volatility* should be negatively correlated with stock returns (e.g., Bekaert and Wu (2000), Whitelaw (2000), Wu (2001) and Brandt and Kang (2004) theoretically and empirically argue that increases in stock market volatility increase risk and decrease stock returns. According to this strand of literature, a higher conditional volatility corresponds to a higher probability of a declining market that has a negative impact on portfolio returns in general. In our analysis, we therefore expect that an increase in regional conditional stock market volatility results in a higher number of joint occurrences of extreme negative returns of banking indices. A second motivation to include

stock market volatility is that it affects bank profitability through the increased likelihood of non-performing loans because of the higher leverage during volatile stock markets (see e.g., Ho-Mou (2009) for details on the relationship between financial leverage and market volatility; and Ghosh (2005) for the relationship between financial leverage and banks' non-performing loans).

Banks are often exposed to different currencies. There is significant evidence that *exchange rate risk* exacerbates banking system fragility during crises (Kaminsky (1999), (Kaufman (2000), Hutchison and Glick (2000)). We therefore include the average of daily exchange rate changes of all countries in the region as an independent variable in our model to study its effect on the probability of coexceedances in banking stock indices.

Banks typically borrow short-term and originate long-term loans leading to interest rate risk. In particular, an increase in interest rates deteriorates banks' balance sheets as a higher interest rate to depositors in the short run cannot be compensated by higher rates on long-term loans or may lead to increased non-performing loans. Therefore, ceteris paribus, an increase in interest rates is likely to increase banking fragility (see e.g., Flannery and James (1984)). The interest rate further controls for the effect of business cycle variables including domestic inflationary pressures, increase in foreign interest rates, shift towards tight monetary policy and lax regulatory framework owing to financial liberalization (Galbis (1995)). We introduce the *interest rate* as a regional macro control variable in our model.

### 2.2 REGIONAL BANKING SYSTEM CHARACTERISTICS

The structural characteristics of the region's banking sector play a role in the fragility of the region's banking sector. We now motivate why the following characteristics of the region's banking system are important – liquidity, capitalization, concentration, diversification, and presence of foreign banks.

#### *2.2.1 Liquidity*

Banks provide liquidity to both depositors and lenders (see e.g., Kashyap, Rajan and Stein (2002) or Gatev and Strahan (2006)). Individual banks maintain liquidity in order to withstand "normal" liquidity withdrawals from their customers. When their individual liquidity holdings are insufficient, banks rely on the interbank market or turn to the central bank. Liquidity in the interbank market therefore serves as a first line of defense against liquidity shocks. From a macro perspective, banks should maintain adequate levels of liquidity such that they are able to

absorb shocks to the banking system (see e.g., Cifuentes, Shin and Ferrucci (2005)). Allen and Gale (2000) and Freixas et al. (2000) consider the case where banks may face regional liquidity shocks stemming from consumers who are uncertain about where they will consume. A common implication is that greater regional banking system liquidity enhances the stability of the regional banking system. Further, a region's aggregate banking system liquidity effectively mitigates coordination failures in the interbank market and ensures financial stability (Karas, Schoors and Lanine (2008)). We therefore include a region's banking system liquidity in our analysis to investigate its impact on regional banking system fragility.

### *2.2.2 Capitalization*

Ceteris paribus, a greater capitalized banking system is more stable because a higher capital base provides a cushion against insolvency. Prudential regulation in the past was designed at the level of the individual bank and therefore failed to incorporate the systemic risk from correlated portfolio positions in the banking system or from domino effects from interbank exposures.[2] We use the capital base of the region's banking system instead of focusing on capital of each individual bank. Our motivation comes from Freixas et al. (2000) and Allen and Gale (2000) who argue that a better capitalized banking system helps in reducing possible contagion effects from individual bank failures in the same country or region.

### *2.2.3 Concentration*

The relationship between the degree of banking competition and financial stability is complex (see e.g., Carletti and Hartmann (2003) for an overview). The "Competition-Fragility" theories - based on the idea of 'charter/franchise value' of the institutions, argue that more bank competition erodes market power, leading to more bank risk-taking. This attitude of bank owners increases fragility of the banking system (Marcus (1984); Keeley (1990); Demsetz, Saidenberg and Strahan (1996)). Alternatively, the "Competition-Stability" view suggests that more market power in the loan market may result in higher bank risk. The reasoning is that borrower moral hazard is exacerbated when banks charge higher loan rates to borrowers (e.g. Boyd and De Nicolo (2005)). Competition is good for financial stability because more competition leads to

[2] Liu, X., and A. S. Mello, 2008, The capital structure of financial institutions and liquidity crises, *SSRN eLibrary*. argue that fulfilling the capital requirements at individual bank level is not sufficient to prevent systemic crisis. They provide evidence from the recent financial 2007-2009 financial crisis, when financial institutions like Northern Rock, Bear Stearns and Lehman Brothers collapsed even though these institutions had capital ratios that appeared adequate before collapsing.

lower interest rates, which in turn lead to lower probability of loan default, and hence safer banks. Furthermore, concentration results in few large financial institutions that possibly engage in more risky activities because they believe they are too-big-to-fail.

Recent papers combine those two views. Berger, Klapper and Turk-Ariss (2009) for example argue that these views need not necessarily yield opposing predictions regarding the effect of competition and market power on stability in banking. Even if market power in the loan market results in riskier loan portfolios, the overall risks of banks need not increase if banks protect their franchise values by increasing their equity capital or engage in other risk-mitigating techniques. Similarly, adequate policies – such as risk-adjusted deposit insurance premiums – could mitigate any trade-off between competition and bank stability. Martinez-Miera and Repullo (2010) argue that there is a U-shaped relationship between competition and the risk of bank failure: the competition-stability view identified by Boyd and De Nicolo (2005) tends to dominate in monopolistic markets whereas competition-fragility view dominates in competitive markets.

The existing empirical work is mainly about competition in national banking systems and its impact on individual bank soundness or national banking system stability (see e.g., Beck, Demirguc-Kunt and Levine (2003), Cihák, Schaeck and Wolfe (2006), Boyd, De Nicoló and Jalal (2007), De Nicolo and Loukoianova (2007), Uhde and Heimeshoff (2009), or Jiménez, Lopez and Saurina (2010)). We study competition in the region's banking system and its impact on regional banking system fragility. We motivate this approach as follows: several banks are active across borders and therefore the region's degree of competition may be a more relevant statistic than the national degree of competition (see also Liu, Molyneux and Wilson (2010)).

#### *2.2.4 Diversification*

Diversification of bank activities may improve or deteriorate banking stability. Financial conglomeration, for example, allows banks to move away from traditional commercial banking activities and offer a range of financial instruments according to their customers' needs. Whether diversification in banking activities create or destroy shareholders' value and leads to financial stability or not is an intriguing question addressed in many research studies; see e.g., Laeven and Levine (2007), van Lelyveld and Knot (2009), Schmid and Walter (2009), Stiroh (2004), Baele, De Jonghe and Vander Vennet (2007). Laeven and Levine (2007) find evidence of a 'diversification discount', that is, financial conglomerates have lower market value than would

be the case if those conglomerates were broken down into financial intermediaries that specialize in the individual activities. More recently, De Jonghe (2010) finds that banking system fragility, measured through an increase in bank's tail beta, aggravates when a bank engages in non-traditional activities. Since interest income is less risky than other revenue streams, it is argued that specialization in traditional activities result in lower systemic banking risk. Wagner (2006) and Wagner (2010) theoretically argue that even though diversification may reduce risk of the individual bank, from the financial system's point of view it may increase the likelihood of systemic crisis as diversifying banks become more similar. Therefore, a shock that previously affected only a small part of the financial system now affects a large portion of the system. Given all the arguments above, we test whether diversification in banking activities increases or decreases regional banking fragility.

#### *2.2.5 Foreign banks*

The presence of foreign banks in a region may impact the fragility of the regional banking system in different ways. On the one hand, for some regions like Asia and Latin America, a greater foreign bank presence may lead to greater banking efficiency and competition in the domestic financial systems. Claessens and Van Horen (2011) for example find that individual characteristics of the domestic banking system may influence the performance of foreign banks. Specifically, foreign banks tend to perform better when it is headquartered in a developed country and the regulation is relatively weak in the host country. On the other hand, foreign banks may provide a channel for cross-border contagion when they transmit shocks from one region to another (e.g., Peek and Rosengren (2000) or Bruno and Shin (2011)).

### 2.3 CROSS-REGIONAL CONTAGION

The re-emergence of crises during the 1990s (Mexican Peso Devaluation of 1994, 1997 Asian Crisis and 1998 Russian Crisis) already established the need for a better understanding of the mechanisms of cross-border contagion (Claessens and Forbes (2001)). The recent 2007-2009 financial crisis further endorses that cross-border contagion is a phenomenon that can include not only neighboring countries in the region but also countries across regions (i.e. cross-regional contagion). The contagion can be fundamentals-based (i.e. via trade or finance links) or 'pure' contagion, which arises when common shocks and all channels for potential interconnection are either not present or controlled for (Calvo and Reinhart (1996)).

The recent literature has started to investigate cross-border contagion in banking systems and stock markets in general. In particular, some authors have simulated idiosyncratic shocks in one national banking system to all banking systems in the region to investigate regional and worldwide banking system stability. A shock can be transmitted via direct balance sheet interlinkages between financial systems. For example, Degryse, Elahi and Penas (2010) investigate contagion through direct cross-border linkages. They find that the failure of a banking system (hit by an exogenous default on foreign claims that are in excess of aggregate bank equity) can trigger domino effects in other countries that raise serious concerns for global financial stability.

There are empirical studies that explore cross-border contagion through co-movement of asset prices and test whether a change in asset prices in country A has some effect on asset prices in country B, using a number of econometric techniques (Baig and Goldfajn (1999); Forbes and Rigobon (2002); Bae, Karolyi and Stulz (2003); Corsetti, Pericoli and Sbracia (2005)). Bae, Karolyi and Stulz (2003) explore cross-regional contagion in stock market indices with focus on Asia and Latin America. They find significant evidence for the propagation of large negative returns across regions. Latin America triggers more significant cross-regional contagion than Asia; and the US is largely insulated from contagion from Asia. Some recent studies that concentrate on bank level data, also find evidence for cross-border contagion through co-movement of banking stocks (Gropp, Duca and Vesala (2009)). We also use co-movement of asset prices and follow the methodology of Bae, Karolyi and Stulz (2003) to extend the previous work on cross-border banking contagion towards cross-regional contagion. We focus on cross-regional banking contagion after controlling for common shocks and banking characteristics at the regional level.

In this paper, we investigate contagion both within region and across regions. We define contagion within region as the portion of regional banking system fragility (joint occurrences of extreme negative returns) that is not explained by the banking system characteristics and the regional common variables. For contagion across regions, we include indicators of regional banking system fragility in other regions as an explicit independent variable in our model, to assess the impact of fragility in different triggering regions on the host region.

# 3 DATA, DEFINITION OF VARIABLES AND DESCRIPTIVE STATISTICS

In our analysis we use countries' banking indices from Datastream starting from July 1, 1994 to December 31, 2008 (3784 daily observations). Datastream uses Industry Classification Benchmarks (ICB) for the construction of these indices. We include 10 Asian and 7 Latin American countries, following Bae, Karolyi and Stulz (2003). Moreover, we include the United States and Europe (as one entity) in our analysis to study the extent to which banking crisis in these regions affect banking system fragility in Asia and Latin America.

<please insert table 1 here>

Table 1 shows the number of banks included in the banking indices from each country. It also provides sample statistics including correlations for the full sample period. We find that the marginal daily return on banking indices varies across countries. The marginal daily return in the US is 0.041% and 0.035% in Europe. In Asia, China has the highest average daily return (0.089%), followed by Pakistan (0.073%) and India (0.072%). On the other hand, Indonesia has been the most volatile market in Asia with the highest daily return standard deviation i.e. 3.322%. In Latin America, Mexico led with 0.095% average daily return followed by Venezuela (0.085%) and Brazil (0.081%). Mexico and Argentina are among the most volatile markets in Latin America with standard deviations of 2.342% and 2.371% respectively.

Correlations among banking indices vary across countries. Within region we find that some countries exhibit higher correlations than others; for example, Thailand, Philippines and Malaysia have high correlations (averaged around 0.14) in Asia. Overall the daily returns on banking index in Asian countries have an average correlation coefficient of 0.10 among themselves compared to 0.13 in Latin America. Moreover, we find that the correlation of the average banking returns of Asian countries with Latin America, the US and Europe are 0.05, 0.03 and 0.13 respectively. The low correlation coefficient may be due to difference in trading timings; therefore, we use previous trading day return in Latin America, the US and Europe and current day return in Asia. Results are shown in italics in the upper right matrix of table 1. We find that average correlation of daily return in Asian markets with the previous day's daily return in the US becomes 0.14. There is a minor increase in case of Latin America (0.05 to 0.06),

whereas average correlation declines from 0.13 to 0.12 in case of Europe (the trading timing overlap in Asia and Europe, such that contemporaneous correlations make more sense).

### 3.1 EXCEEDANCES AND COEXCEEDANCES

We follow the view that extremely low (negative) market returns on banking indices reflect fragility of the banking sector. To put things in a quantitative framework, we define an extreme event when the banking index return on that day lies below the 5th percentile of daily return distribution and refer to this as an exceedance of the return on the banking index. The distribution of the daily banking index return is directly observed from our dataset (3784 daily observations). From the distribution of 3784 daily observations of return on banking indices, we calculate 5th percentile value for each country and region and then use this value as a standard to decide whether a country or region on a particular day exceed or not. Moreover, we refer to coexceedances as a phenomenon when the banking indices of more than 1 country in the same region exceed on the same day. In table 2, we report the number of days for 0, 1, 2, 3, and 4 or more joint occurrences of extreme return (coexceedances) within a region on a particular day. We also indentify which countries "participate" in those extreme events and how often.

<please insert table 2 here>

As we are interested in banking system fragility, our focus is on joint occurrences of low extreme returns (negative coexceedances), but we also display the joint occurrences of high extreme returns (positive coexceedances) separately. We have found an asymmetry between negative and positive extreme returns distribution in Asia and Latin America. In our sample, we find that there are 2497 trading days when there is no negative extreme return compared to 2451 trading days when there is no positive extreme return in Asia. Similarly, there are 908 and 943 trading days when only one country witness extreme negative and positive returns in Asia respectively. In Latin America, there are 2832 and 2744 trading days of no negative and positive coexceedance respectively, whereas there are 719 and 829 trading days with one country in negative and positive tail respectively. The asymmetry in the distribution of extreme return is evident with 55 trading days when 4 or more countries in Asia are in bottom tail compared to 41 trading days when 4 or more countries in top tail. The asymmetry is even more in Latin America where 40 trading days when 4 or more countries in bottom tail compared to 21 trading days in top tail. Thailand has been the most recurring participant of the group of 4 or more countries in

bottom as well as top tail. In Latin America, Argentina and Brazil are the most recurring countries in the group of 4 or more countries in the bottom or top tail. Beside Argentina and Brazil, Mexico often included in extreme events. On the other hand, Pakistan appears least number of times in negative extreme events within Asia. Venezuela is the least recurring country in extreme events in Latin America. We also report the daily return on the day of extreme event (4 or more countries coexceed) for all countries in our sample. We find that, in Asia, Indonesia, Korea, Pakistan, Thailand and India have above average negative return during negative extreme events. In Latin America, Argentina and Mexico have high negative returns during negative extreme events.

We also find that there is clustering of negative coexceedances in 1998 and 2008 for Asia, and in 1995, 1998 and 2008 in Latin America, when different financial crises hit both regions. This is shown in Figure 1, and indicates that increases in regional systemic risk are actually reflected in higher number of days with a high number of negative coexceedances.

<please insert figure 1 here>

As banks are more interconnected in international markets compared to firms in other sectors, we next investigate whether banking indices are more prone to contagion, i.e. a larger number of negative coexceedances, than general stock market indices.[3] To do this, we count the frequency of negative coexceedances in banking indices and total market indices; then we subtract the number of coexceedances in total market indices from the number of coexceedances in banking system indices for each daily observation in both Asia and Latin America. We find that there are 520 days in Asia, when coexceedances in total market indices are greater than coexceedance in banking system indices; whereas there are 595 days when the coexceedances in banking indices are greater than coexceedances in total market indices. Similarly, in Latin America, we find 459 days when coexceedances in total market indices are higher; compared to 524 days when coexceedances in banking indices are higher. Therefore we can conclude that banking stocks tend to coexceed more than other stocks.

[3] In our sample banking institutions represent 20-35 percent of the total market capitalization.

### 3.2 REGIONAL MACRO FACTORS

As we discussed in Section 2, stock market volatility is expected to have an influence on regional banking system fragility. To investigate this econometrically, we estimate regional stock market volatility through indices that are representative of the capitalization of stocks that foreign investors can hold. More specifically, we use the International Finance Corporation (IFC) indices from Asia and Latin America, and the S&P 500 index for the United States and Datastream International Europe Index for Europe in order to examine stock market volatility in each of these regions. For each region, we estimate the conditional volatility of the respective stock indices using a GARCH (1, 1) model of the form:

$$\sigma_{c,t}^2 = \alpha + \beta_1 \varepsilon_{c,t-1}^2 + \beta_2 \sigma_{c,t-1}^2 \qquad (1)$$

using maximum likelihood, where $\sigma_{c,t}^2$ represents the conditional variance of the stock market index in country c in period t, and ε represents stock market returns in that market. In the first column of Table 3, we report the mean and standard deviation of conditional volatility of all countries in the region as well as the regional conditional volatility over the entire sample period. Individual countries conditional volatility is calculated through their respective total market stock indices, whereas the regional conditional volatility is computed with IFC indices, S&P 500 and Datastream International Europe Index as reported earlier. We find that Korea has the highest and Sri Lanka has the lowest conditional volatility in Asia. In Latin America, Venezuela has the highest and Chile the lowest conditional volatility. At the regional level, we find that the stock market in Latin America is more volatile with conditional volatility of 23.39 percent compared to 21.19 percent in Asia, 15.84 percent in the US and 15.03 percent in Europe.

<please insert table 3 here>

The second common factor that affects regional banking system fragility is the daily change in exchange rate. We calculate the daily change in exchange rate against US dollar for each country in Asia and Latin America. In the case of the US, we use a basket of four currencies (i.e. GBP, JPY, CHF and EUR) to evaluate exchange rate changes. For Europe, since EUR and GBP are the two major currencies, we take equal-weighted average of EUR and GBP exchange

rates changes against USD.[4] We report mean and standard deviation of daily changes in exchange rates of individual countries and regions in the second column of table 3. We find that all currencies except Chinese Yuan in Asia and Latin America depreciated in our sample period. The most depreciated currency in Asia is the Pakistani Rupee (0.026% daily) and the Venezuelan Bolivar is the most depreciated currency (0.080% daily) in Latin America. We use an equal-weighted average of the daily changes in exchange rate of all countries in the region to get the regional change in exchange rate on that particular day. We find that Asian currencies, on average, depreciated less compared to currencies in Latin America, whereas, the US dollar and European currencies are appreciated, on average, during the sample period.

Finally, we explore the impact of the interest rate on regional banking system fragility. For the regional interest rate, we compute an equal-weighted average of 1-year interbank interest rate in countries within each region. We present the mean and standard deviation of interest rates of individual countries and region as the third column of table 3. We find a high degree of heterogeneity in interest rates across countries in Asia and Latin America. In Asia, the lowest interest rate is observed in Taiwan (3.938% on average) and the highest in Indonesia (13.361% on average). In Latin America, the interest rate is 0.498% in Chile and 21.488% in Argentina. At the regional level, we find that the average interest rate is higher in Latin America than in Asia, and that it is significantly lower in US and Europe with respect to the both Asia and Latin America.

In terms of time series behavior, we find that the conditional volatility increases significantly in all regions during crisis periods (Asian crisis, dot com bubble and the 2007-9 financial crisis), which is expected due to the turbulence in stock markets. The average daily change in exchange rate remains under 0.05 percent in all regions except during crises period in Asia (Asian crisis 1997) and Latin America (Argentinian crisis 2002). Lastly, even though interest rates decline in all regions, they are significantly higher in Latin America compared to other regions (it remains in double digit until 2003). Interest rates in Asia were also in double digit untill late 1990s, but they were lower than in Latin America. In the US and Europe, we find that interest rate averaged around 5 percent, with a particularly low interest-rate environment in

[4] Since our sample starts from June 1994; therefore, we use country-weighted average of exchange rate against USD of euro currencies for daily observations prior to the introduction of the euro.

the early 2000s. Moreover, we find interest rates hike in Asia and Latin America only in response to subprime crisis; whereas the US and Europe further lowered their interest rates.

### 3.3 REGIONAL BANKING SYSTEM CHARACTERISTICS

Regional banking system fragility may hinge upon a region's banking characteristics including liquidity, capitalization, concentration, diversification of bank's activities and the degree of foreign bank presence. We evaluate the effect of these banking characteristics on regional banking system fragility using annual balance sheet data for banks in each individual country from Bankscope. These variables are available on an annual basis; therefore, we use the annual value of the preceding year for all daily observations of the current year. Moreover, the regional values are calculated by averaging individual country level data. We use the ratio of total banking assets of a country to the total banking assets of the region as the weight. This captures the relative size and strength of a country's banking system in the region; therefore, the bigger the banking system of a country the more influence it would have at the regional level.

<please insert table 4 here>

Table 4 shows the mean and standard deviation for banking characteristics for each country as well as for the regions during the whole sample period. In order to gauge the effect of banking system liquidity we use a narrow definition of liquidity, which is the ratio of cash and cash equivalent assets to total assets. We call this variable *liquidity* hereafter. We find that the banking system in India and Pakistan are holding high cash reserves relative to total assets. The cash holdings of India and Pakistan are 12.55 percent and 11.56 percent of the total assets respectively compared to 2.8 percent on average in Asia. Similarly, in Latin America, Venezuela holds 10.6 percent of the total asset as cash or cash equivalent compared to a regional average of 2.88 percent. At the regional level, Asia and US have the largest average liquidity ratios (2.8%) during the sample period, while Europe has the lowest(1.8%).

Secondly, the ability of banking systems to absorb foreign shocks depends on the degree of capitalization of the banking system. Our measure of capital is total equity that includes common shares, retained earnings, reserves for general banking risks and statutory reserves, loss absorbing minority interests, net revaluation of AFS securities, FX reserves included in equity and revaluations other than securities deemed to be equity capital. We find that the banking

systems in Asia, on average, maintain low capital to total assets ratio (5.3%), compared to Latin America (8.7%), and that Europe has on average lower capital ratios (4.7%) than the US (7%) .

In order to measure competition in banking industry, we use the ratio of total assets of the biggest five banks to total assets of all banks (i.e. C5 measure) for each country in the region. We label it as *concentration* in our analysis. The regional measure of concentration is the weighted average of the individual country's concentration measures in the region using banking system total assets as relative weights. We find that banking systems in Asia are, on average, relatively more concentrated than the ones in Latin America. Sri Lanka, China and Pakistan are among the most concentrated banking systems in Asia, whereas Peru, Venezuela and Chile are highly concentrated banking systems in Latin America.

We also evaluate whether banking systems that are primarily involved in traditional loan-making activities are more or less prone to regional banking system stability. In order to measure the extent to which banks are involved in traditional loan-making activities compared to non-traditional activities, we calculate the ratio of net loans to total earning assets for each country and label it as *loan ratio* in our results. We find that net loans are about half of the total earning assets in almost all countries. Latin America has the lowest ratio (44%) with respect to all other regions.

Finally, we explore the impact of the degree of foreign bank presence in Asia, Latin America, the US and Europe. We use the database of Claessens and Van Horen (2011) reporting the direct ownership of foreigners in the domestic financial system. This dataset includes 5377 banks active at least one year in 137 countries during the period 1995-2009, and encompasses commercial banks, savings banks, cooperative banks, and bank holding companies. Based on direct ownership, the database classifies a bank as foreign bank if 50 percent or more of its shares are owned by foreigner for each year. All countries in our sample are included in the database except for Taiwan. Moreover, the database reports zero presence of foreign banks in Sri Lanka throughout the sample period. Within Asia, Indonesia and Malaysia have higher presence of foreign banks in the domestic financial systems. In general, the database also provides evidence for highest degree of foreign ownership in Latin America and lowest in Asia among the four regions we consider. Specifically, foreign ownership is about half of the domestic banking systems in Peru, Mexico and Chile during the sample period, on average.

In terms of time series behavior, during our sample period we observe a mixed trend in liquidity across regions. In particular, we find a declining trend in the US and Asia, stable in Europe and volatile in Latin America. Towards the end of our sample period, liquidity tends towards 2 percent (cash as percentage of total assets) in all regions except for Latin America (around 3 percent). Capitalization has always been higher in Latin America (around 8 – 10 percent), followed by the US (6 – 7 percent), Asia (5 percent) and Europe (4 – 5 percent). Concentration is typically higher in underdeveloped regions compared to developed regions. We find that top-5 banks in Asia and Latin America typically hold 60 – 80 percent of total assets of the banking system (though ratio declines during our sample period). On the other hand, top-5 banks in the US and Europe hold around 15 percent and 10 percent of total assets respectively. Regarding diversification, there is a declining trend in traditional banking activities (loan business). The data reveal that there is an increasing trend in foreign ownership in all regions over time. The percentage of foreign banks among total banks has increased from 11 percent to 24 percent in Asia; from 27 percent to 40 percent in Latin America; from 15 percent to 32 percent in the US; and from 28 percent to 39 percent in Europe.

# 4 METHODOLOGY

The central question in the financial contagion literature is whether financial markets become more interdependent during a financial crisis. Formally, financial contagion occurs when a shock to one country (or a group of countries) results in the propagation of the shock to a wide range of markets and countries in a way that is hard to explain only on the basis of changes in fundamentals. During the nineties, researchers primarily investigated whether cross-market correlation increased significantly during financial crisis (Bertero and Mayer (1990), King and Wadhwani (1990), Calvo and Reinhart (1996), Baig and Goldfajn (1999)). Boyer, Gibson and Loretan (1999) and Forbes and Rigobon (2002) challenge the approach of contagion based on structural shifts in correlation. They argue that the estimated correlation coefficient between the realized extreme values of two random variables will likely suggest structural change, even if the true data generation process has constant correlation. They also point out the biases in tests of changes in correlation that do not take into account conditional heteroskedasticity. This motivated researchers to study contagion as a nonlinear phenomenon and introduce new techniques such as markov switching models (Ramchand and Susmel (1998) and Ang and

Bekaert (2002)); extreme value theory (Longin and Solnik (2001) and Hartmann, Straetmans and Vries (2004)); and multinomial logistics model (Bae, Karolyi and Stulz (2003)).

We follow the approach in Bae, Karolyi and Stulz (2003) and use a multinomial logistic model to assess how various banking systems are affected simultaneously following an external shock. The dependent variable in our model is the number of coexceedances in one region (the number of banking systems simultaneously in the tail) on a given day. The explanatory variables of our base model are macro shocks and banking characteristics. We also use the number of coexceedances in other regions (to capture cross-regional contagion effect) as an explanatory variable in an extended model. The general multinomial logistics can be illustrated as:

$$P_i = \frac{G(\beta_i' x)}{1+\sum_{j=1}^{m-1} G(\beta_j' x)} \qquad (2)$$

where $x$ is the vector of covariates and $\beta_i$ the vector of coefficients associated with the covariates, $G(\beta_i' x)$ is a logistic distribution and $m$ is the number of categories in the multinomial model. The model is estimated using maximum log-likelihood function for a sample of $n$ observations as follows:

$$logL = \sum_{i=1}^{n} \sum_{j=1}^{m} I_{ij} log P_{ij} \qquad (3)$$

where $I_{ij}$ is an indicator variable whose value is equal to 1 if the $i^{th}$ observation falls $j^{th}$ category and 0 otherwise.

In our model there are five categories, i.e. 0, 1, 2, 3, and 4 or more banking systems coexceed in a region. Following the convention we define category 0 (i.e. no banking system exceed on a given day) as the base category and all coefficients are estimated relative to this base category. Therefore, for each variable introduced in the model, we need to estimate four parameters.

While we use a multinomial logistic model for Asia and Latin America, we use a logit model for US where the dependent variable is one if the US banking index is in the tail on a given day, 0 otherwise. For comparability purposes with the US, we use the same methodology for Europe.

# 5 RESULTS

We evaluate the state of banking system fragility in a region through the number of coexceedances in that region. A higher number of coexceedances (i.e. joint occurrences of extreme negative returns in banking indices) reflects more banking system fragility. In Section 3 we report the number of coexceedances in Asia and Latin America. We now assess how banking system characteristics and macro factors affect the occurrence of such coexceedances. For comparison purposes, we also report results for the occurrence of exceedances for US and Europe.[5] We also explore the extent of contagion *within* region and *across* regions.

<please insert table 5 here>

Table 5 provides estimation results of the number of coexceedances within a region with macro control covariates using a multinomial logistic model for Asia and Latin America, and a logit model for US and Europe. Panel A provides estimates for Asia and Panel B shows results for Latin America. In the first column of each panel we report the number of negative coexceedances and relative frequencies. Since there are no covariates, the relative frequencies represent the probabilities of the respective outcomes. We find that during our sample period there is a probability of 65.99% that no Asian country has an extreme negative return on a given day, whereas the extreme event when 4 or more countries coexceed has a probability of 1.45%. Latin America, where negative extreme returns are relatively fewer, has slightly higher probability of no exceedances (i.e. 74.84%) and relatively lower probability of 4 or more coexceedances (i.e. 1.06%). We should be cautious with comparing the number of coexceedances in Asia and Latin America as the number of countries included in our analysis is different for the two regions (i.e., the sample includes 10 countries from Asia and 7 countries from Latin America).[6]

## 5.1 EFFECT OF REGIONAL MACRO FACTORS

[5] We treat Europe in the same way as the US. Therefore we use a logit model where the dependent variable is 1 if the European banking index is in the lower tail, zero otherwise.

[6] For US and Europe the frequencies simply reflect our methodology: the dependent variable takes a value of one when the banking index return on that day lies below the 5th percentile of daily return distribution.

A higher number of coexceedances reflects banking system fragility. In this section we evaluate whether macro regional factors are important in explaining banking system fragility. Table 5 shows that an increase in the conditional volatility significantly increases the probability of all exceedances in all regions. For example in Asia, a one standard deviation increase in conditional volatility (see Table 3 for the magnitude of standard deviation) increases the probability of one exceedance by 0.048 and the probability of four or more coexceedances by 0.007. In relative terms the economic effect is larger for four or more coexceedances as the frequency for 1 exceedance is 66% and the one for four or more coexceedances is 1.5%. All the partial derivatives are significant at 1% level and pseudo-$R^2$ is 6.58%. Similarly, in Latin America, one standard deviation increase in conditional volatility increase the probability of 1 exceedance by 0.025 and the probability of four or more coexceedances by 0.004 (compared to a frequency for 1 exceedance of 74.8% and for four or more coexceedances of 1.1%). All marginal probabilities are significant at 1% level and pseudo-$R^2$ is 5.55%. For US and Europe we also find that conditional volatility increases the probability that the banking index will be in the lower tail.

Exchange rate fluctuations and monetary policy conditions, reflected in the interest rate level, are crucial elements for banking system fragility. We test the hypothesis that the fall in domestic currencies and higher interest rate level on average, lead to more coexceedances in the region. The estimates are shown in Table 5. We find that currency depreciation aggravates banking system fragility in all regions. Specifically, we find that a 1 standard deviation fall in domestic currency value increases the probability of 1 exceedance by 0.018 and 0.025 in Asia and Latin America respectively. For the extreme event of four or more coexceedances, a 1 standard deviation increase in the average exchange rate in the region increases the probability by 0.003 and 0.001 in Asia and Latin America respectively. Similarly to conditional volatility, relative to the events frequencies, the economic effect is larger for four or more coexceedances.

Also, tight monetary policy in the region tends to deteriorate banks' balance sheets. Therefore, we expect that higher level of interest rates increases the probability of joint occurrences of negative extreme returns in banking indices. Our results are in line with our expectations in Asia and Latin America. In terms of economic magnitude, we find that 1 standard deviation increase in interest rate level increases the probability of 1 exceedance by 0.032 and 0.027 in Asia and Latin America respectively. In the case of four or more

coexceedances, the increase in the probability is 0.004 and 0.001 in Asia and Latin America respectively.

We also report the results for US and Europe, where we focus on the probability that the banking index is in the lower tail. As well as conditional volatility, depreciation of the domestic currency is also a significant determinant. However, interest rates do not play any role for US and Europe. The explanation may lie in the fact that interest rates have been at least half in US and Europe compared to emerging markets for most of the sample period (see Table 3), indicating that only at high levels of interest rates, further interest rate hikes affect banking fragility.

In sum, we find that an increase in regional conditional stock market volatility, and a fall in domestic currencies increase banking system fragility in all regions, while a rise in interest rate levels significantly increase banking system fragility in Asia and Latin America only. Compared to the effect of our explanatory variables on total market indices as reported in Bae et al. (2003), we find that conditional volatility and exchange rate changes play a similar role.[7] However, our results uncover an important difference with Bae et al. (2003). Interest rate changes are only statistically significant (and economically relevant) when analyzing banking fragility. They do not seem to affect fragility reflected in the general stock market index.

### 5.2 EFFECT OF REGIONAL BANKING SYSTEM CHARACTERISTICS

The central question of this paper is whether the regional banking system characteristics matter in safeguarding banking system stability. In particular, we assess the role of banking system liquidity, capitalization, concentration, diversification in banking activities and presence of foreign banks. We build proxies for these characteristics using information obtained from banks' balance sheets on an annual basis and from the database of Claessens and Van Horen (2011) in the case of foreign banks. As the frequency of our dependent variable is daily, we repeat the values of banking characteristics of the preceding year for all daily observations in the current year. We first add these regional banking system characteristics to the regression model of Section 5.1 one by one, as correlation among them may introduce multicollinearity problems.

[7] We also compute the response of probability measures to the *full range of values* of independent variables (instead of focusing on the average value, as is the case in the marginal effects reported in the Tables). We produce coexceedances response curves which give a more complete picture, as probabilities are not linear functions of the explanatory variables. Our response curves are very similar to the ones in Bae, K., G. A. Karolyi, and R. M. Stulz, 2003, A new approach to measuring financial contagion, *The Review of Financial Studies* 16, 717-763.(2003). Therefore we choose not to report them.

Table 6 shows these results in Models 1, 2, 3, 4, and 5 (i.e., one for each banking characteristic). We also report Model 6 that includes all banking explanatory variables.

<please insert table 6 here>

### *5.2.1 Liquidity*

In Section 2.2 we have argued that banking system liquidity serves as a buffer against liquidity shocks. A reasonable level of aggregate banking system liquidity is important for individual banks to get funds from the market without paying extraordinary premiums. This also discourages parking of funds for short-term benefits and improves market participants' reliance on interbank activities. As a result this improves the efficiency of the interbank market at the country and regional level, thus reduces the chances of coexceedances. We test this hypothesis by investigating whether regional liquidity significantly affects the probability of joint occurrences of extreme negative returns. We use a narrow definition of liquidity that includes cash and cash equivalent as a ratio of total assets, and label it as *liquidity*.

We find that a higher *liquidity* significantly reduces the probability of coexceedances in all regions. In the case of Asia, Model 1 shows that the effect is statistically significant for all coexceedances. Specifically, a one standard deviation increase in *liquidity* reduces the probability of 2 coexceedances by 0.011 and the probability of 3 coexceedances by 0.004. For Latin America a one standard deviation increase in *liquidity* decreases the probability of 2 coexceedances by 0.011 and the probability of 3 coexceedances by 0.003. Moreover, Model 1 shows that including *liquidity*, raises the pseudo-$R^2$ from 6.5% and 5.5% (Table 5) to 8% and 7% (Model 1, Table 6) in Asia and Latin America respectively. *Liquidity* also decreases significantly the probability of being in the tail both for US and Europe.

We also check the robustness of our results, employing a broader definition of liquid assets that includes not only cash and cash equivalents, but also listed securities, treasury bills, other bills, bonds and equity investments. We report these results in Section 6.

### *5.2.2 Capitalization*

Bank capital provides a cushion against insolvency at the individual bank level. But from a macro perspective, the capital adequacy regulations for individual banks fail to incorporate the systemic risk from correlated portfolio positions in the banking system, and potential domino

effects as a consequence of interbank exposures (see e.g., Liu and Mello (2008)). With this notion we investigate whether regions with a higher aggregate degree of bank capital exhibit less banking system fragility. We use the total equity of the region-wide banking system instead of focusing on bank capital for each bank. We label it as *capitalization* in our analysis. The results are reported in Model 2 and Model 6 in Table 6. For Asia, *capitalization* is not a significant determinant of financial fragility. For Latin America, a higher *capitalization* significantly decreases the likelihood of almost all categories of coexceedances in Model 2. However in Model 6 we find a positive significant effect for 2 and 3 coexceedances. But we should mention here that capitalization is strongly correlated with concentration in Latin America (almost -0.70), so the results in Model 6 may be misleading as a consequence of high multicollinearity.

We also find mixed evidence for US and Europe. While capitalization reduces the likelihood of being in the tail for the US banking system, it has no effect for Europe. However, we note that average capital ratios during the sample period were lower in Asia and Europe (5.3% and 4.7% respectively), compared to Latin America and the US (8.7% and 7% respectively). Our results suggest therefore that increases in capital do have an effect in reducing bank fragility but only when capital levels are higher than a threshold of around 7%.

#### *5.2.3 Concentration*

The literature on the effect of banking competition on banking system stability is inconclusive. As discussed in Subsection 2.2, two views exist, the competition-fragility view and the competition-stability view. We gauge competition in the banking industry through the C5 measure of the level of concentration, which is the ratio of total assets of the largest five banks to total assets of all banks. We label it as *concentration* in our analysis. The estimates are shown in Model 3 and Model 6 in Table 6.

We find that a higher level of *concentration* in the banking industry significantly increases the probability of 1 and 2 coexceedances in Asia, and the probability of 1, 2 and 4 coexceedances in Latin America. Specifically, the estimates of Model 3 indicate that a 1 standard deviation increase in *concentration* raises the probability of 1 exceedance by 0.041 in Asia, and by 0.043 in Latin America. Less competition also increases the probability that the US and Europe will experience very low returns in their banking index. Our evidence therefore seems to support the competition-stability view. However, it may still be consistent with Martinez-Miera and Repullo (2010) U-shaped relationship between competition and the risk of bank failure.

They argue that the competition-stability view identified by Boyd and De Nicolo (2005) tends to dominate in monopolistic markets; whereas competition-fragility view dominates in competitive markets. The monopolistic market structure in Asia and Latin America (the five largest banks in the majority of the countries in Asia and Latin America hold 60 percent of total assets of the banking system), may require increased competition for banking system stability as predicted in their model. We may therefore be unable to identify the upward leg of the U-shaped relationship.

### *5.2.4 Diversification*

Recent empirical research provides evidence that banking system stability is more vulnerable when banks engage in non-traditional activities in addition to their core commercial banking activities, both for US and Europe (De Jonghe (2010), Stiroh (2004)). Noninterest income, particularly trading income, is quite volatile and the correlation between net interest income and noninterest income rises as product lines blur and banks increasingly substitute nontraditional sources of income for interest income. This means that the banking industry may not realize the reduction in volatility and risk that some expect (Stiroh (2004)). Therefore, it is argued that specialization in traditional activities results in lower systemic banking risk. Also Wagner (2006) provides a model where diversification in activities is unable to reduce systemic risk. In his framework, bank diversification reduces risk at the individual institution level, but from the financial system's point of view, it just reallocates risks among institutions within the financial system and tends to expose each institution to the same external shock.

We use the ratio of loans to total earning assets as a proxy for banks' focus on traditional loan-making activities. We label it as *loan ratio* in our analysis. Model 4 and Model 6 in Table 6 report the effect of the regional level of concentration in traditional activities on the joint occurrences of extreme negative returns in the region. The results are not conclusive. For Asia, we do not find a consistent effect across Model 4 and 6. For Europe we do not find an effect. Finally for Latin America and US, there is some evidence for an increase in the probability of being in the lower tail when the *loan ratio* increases, a result that is different from the evidence for Europe in De Jonghe (2010) and for the US in Stiroh (2004).

### *5.2.5 Foreign banks*

The results on foreign banks are reported in Model 5 and Model 6 in Table 6. We find that a larger presence of foreign banks decreases the likelihood of coexceedances both for Asia and Latin America. Specifically, a one standard deviation increase in foreign banks reduces the probability of 2 coexceedances by 0.014 in Asia and by 0.009 in Latin America. On the contrary, in the case of the US, a larger presence of foreign banks increases the likelihood of being in the low tail. We find no effect for Europe.

<please insert figure 2 here>

Finally, Figure 2 reports the coexceedances response curves corresponding to each of the banking system characteristics for Asia and Latin America. These graphs show the response of the probability measures for the *full range* of values of each banking characteristic, instead of focusing on the average value as is the case in the marginal probabilities reported in the Tables 5 and 6. On the left side of Figure 2 we report the curves for Asia and on the right side the ones for Latin America. Consistent with our previous analysis, the response curves show that *liquidity* reduces the probability of coexceedances over the entire range of values in Asia and Latin America, though the effect seems more accentuated for Asia. In the case of *capitalization*, the curve is flat for Asia, whereas for Latin America it shows that more capital reduces the probability of coexceedances. As explained above, this seems to be due to the higher average capital ratios in Latin America compared to Asia. In the case of *concentration*, the effect is stronger for Latin America, but in both cases it implies that higher levels of concentration lead to increases in the probability of coexceedances. Finally, the response curves also show that *foreign banks* reduce the probability of coexceedances in Asia and Latin America.

## 5.3 CONTAGION WITHIN REGION AND ACROSS REGIONS

We now investigate whether there is any evidence for contagion within region and across regions. We define contagion *within region* as the portion of regional banking system fragility (joint occurrences of extreme negative returns) that is not explained by the region's banking

system characteristics and regional macro variables. In the case of *cross-regional contagion*, we capture its impact by including the number of coexceedances in the triggering region as an explanatory variable, while controlling for macro factors and banking characteristics in the host region. In all models, when the triggering region is Asia or Latin America we use the number of coexceedances as explanatory variable, and when the triggering region is US (or Europe) we use a dummy variable equal to 1 if the US (or European) banking index was in the tail, 0 otherwise.

In Table 6, we reported the McFadden pseudo-$R^2$ with our estimations for the effect of banking system characteristics and macro factors on banking system fragility, which is around 8% in Asia and 7% in Latin America. This shows that there is a considerable portion of joint occurrences of extreme negative return that is not explained by banking characteristics and common macro factors together. These numbers indicate that contagion within regions is stronger in Latin America than in Asia. This evidence is similar to the one for within region contagion reflected in the *general stock market* reported in Bae et al. (2003). However an important difference from Bae et al. (2003) is that within region *banking* fragility, is substantially lower in US and Europe (pseudo-$R^2$ are around 14%) compared to the emerging market regions.[8]

<please insert table 7 here>

In Table 7 we report results of cross-regional contagion for Asia, Latin America, US and Europe. We add to Model 5 in Table 6, three measures of financial fragility in three triggering regions as explanatory variables. To make the test stronger we also add new control variables: the conditional volatility of the triggering regions. If the coefficients of the financial fragility variables of the triggering regions are positive and significant after controlling for the host region's banking system characteristics, common macro factors, and the conditional volatility of the triggering regions, then we interpret this as the evidence of contagion from that particular triggering region. Following Bae, Karolyi and Stulz (2003), we use 1 day lag for the US and Latin American fragility measures when explaining contagion to Asia. For contagion to all other regions fragility measures from triggering regions correspond to the preceding trading session on the same day. We note that when the triggering region is Asia or Latin America, the financial fragility variable is a categorical variable that takes 5 possible values: 0 exceedance, 1

[8] Note that this is also the case in Table 5 when we only control for macro factors.

exceedance, 2 coexceedances, 3 coexceedances, and 4 or more. On the other hand, when the triggering region is US or Europe the financial fragility variable is a dummy variable that takes value one on those days when the respective banking index is in the lower tail, zero otherwise.

In the case of Asia (Panel A), contagion triggered from the US is significant for all number of coexceedances and the marginal effects are almost always higher than when contagion is triggered from Europe. The economic impact of contagion from Latin America does not seem to be very important for Asia. In Panel B we report the results for Latin America. In this case, cross-regional contagion from the three other regions is statistically significant. However, the economic impact is low in the case of contagion from Asia compared to the US and Europe, probably due to closer geographic and economic ties of Latin America with the US and Europe.

Finally, Panel C and D, show that while Europe is affected by all three regions, the US is only affected by Latin America and Europe.

### 5.4 CAN REGIONAL BANKING SYSTEM CHARACTERISTICS REDUCE CONTAGION FROM OTHER REGIONS?

Another interesting issue to investigate is whether the regional banking characteristics in the host region have any role in affecting the magnitude of contagion from other regions. We specifically study whether the level of liquidity, capitalization, concentration and diversification of the host region attenuate or exacerbate the effect of cross-regional contagion. We expect that higher liquidity and capitalization provide better resilience against cross-regional contagion; whereas the effect of diversification in banking activities, competition in the banking industry, and the presence of foreign banks on cross-regional contagion is ambiguous.

In order to test these effects econometrically, we simplify our model for Asia and Latin America by using a logit specification with a dependent variable that takes the value of one when 2 or more coexceedances occur in the host region, zero otherwise. For US and Europe we use the same model as before.[9] We add to the explanatory variables in Model 5 in Table 7, three interaction terms of a banking characteristic with the three cross-regional contagion variables.

[9] For US and Europe we use a logit model where the dependent variable is one if the US (Europe) banking index is in the lower tail, zero otherwise.

We do this separately for each banking characteristic, and for each of the four regions. We report the results in Table 8.

<please insert table 8 here>

The measurement of the interaction effect in nonlinear models is not straightforward. Ai and Norton (2003) present a method to correctly calculate the magnitude and standard errors of interaction terms in nonlinear models. We note that the magnitude and statistical significance of the interaction effect varies with the values of the covariates. In fact, the value of the interaction term can even change sign for different data points. In Table 8 we report the *average* interaction effect from the Ai and Norton methodology (2003) and its statistical significance. Moreover, for the regions where the average effect is significant for *liquidity* and *capitalization* we also show the Norton and Ai (2003) graphs in Figure 3. These graphs show the values of the interaction term for all data points. The continuous line is the marginal effect of the interaction term computed by the standard procedure; whereas the dots show the correct interaction effect. The statistical significance of the interaction effect is shown in the adjacent graph. The interaction effect is statistically significant whenever the z-value lies above or below the confidence interval lines.

<please insert Figure 3 here>

Table 8 shows that whenever the average interaction terms of the host region *liquidity* and *capitalization* are significant, they always present a negative sign, suggesting that they are important in attenuating the contagion effect from other regions. For *concentration*, the signs differ across regions and for the *loan ratio* the interaction terms are rarely significant. For *foreign bank*, the signs differ across regions. These different effects could depend on the origin of the foreign banks, as they may help to reduce the contagion from other regions, only as long as they are not themselves headquartered in the triggering regions. Unfortunately, we do not have data on the headquarters location of the foreign banks to test this conjecture.

Specifically, liquidity in Asia attenuates significantly the risk of contagion from Latin America, liquidity in Latin America reduces contagion effects from the US, and liquidity in Europe helps to reduce contagion from Latin America. Capitalization is also an important attenuating factor. In Latin America, it reduces the impact of contagion from the US, and in

Europe it attenuates contagion from both Asia and Latin America. Figure 3 shows that in all of these cases, the interaction term is negative and significant for most of the data points. We should also note that in other cases where the *average liquidity* interaction term or the *capitalization* interaction term is not significant, there are still a fraction of the data points for which they play a significant role in reducing cross-regional contagion.

# 6 ROBUSTNESS

In this section we analyze the robustness of earlier analysis using alternative indicators for banking characteristics and alternative model specifications for fragility. We do not report regression results however.

First, as already announced in Section 5, we also employ a broader measure of liquidity including not only cash and cash equivalents, but also listed securities, treasury bills, other bills, bonds and equity investments. Our (unreported) results on this broader liquidity measure are very much in line with those of our narrower definition.

Second, we investigate the robustness of our findings to using (i) alternative model specifications and (ii) employing abnormal bank stock index returns to compute our coexeedances. We first discuss the robustness when employing a probit model. In our main analysis we capture banking system fragility through the number of coexceedances in the region on a particular day. We have five categories that are 0, 1, 2, 3 and 4 or more; which represents the number of countries having joint extreme negative returns on that day. Higher number of coexceedances is thus referred to more fragile regional banking system. Due to the nature of our dependent variable we use multinomial logistics model. We also consider a simpler approach using a probit model where the binary variable has value 1 (representing regional banking fragility) when 2 or more countries coexceed in the region, else 0 (representing stability in regional banking system). We find that all common variables and banking characteristics significantly affect the probability of banking system fragility in the region. We find that conditional stock market volatility, currency depreciation, and increase in interest rate level increase the probability of regional banking system fragility in Asia and Latin America. Similarly, we find that the increase in liquidity and competition reduces the probability of regional banking system fragility in both regions; whereas capitalization diminishes the

probability of regional banking system fragility in Latin America only. Diversification in banking activities fails to affect the probability of banking system fragility in any region. We also investigate the cross-regional contagion and once again we find that both Asia and Latin America are affected significantly by cross-regional contagion from all other regions. The economic magnitude of cross-regional contagion effect from Europe is the highest, followed by the contagion effect from the US in both Asia and Latin America.

As a second exercise, we compute the coexceedances based upon the abnormal returns of the banking index relative to the stock market index, i.e., banking index return on day *t* in country *i* – stock market index return on day *t* in country *i*. An exceedance takes place when this abnormal return is in the left tail and coexeedances happen when on the same day several countries have abnormal returns which are in the left tail. Abnormal returns could be a more appropriate proxy of fragility to the extent they capture movements that are specific to banking returns which may be of greater interest for financial stability. We begin by comparing the proportion of days on which the number of coexeedances is the same under both measures. We find that in Asia, 2376 out of 3784 trading days (63%) have the same number of coexceedances under both measures. In Latin America, the share is higher: 2684 out of 3784 trading days (71%) have the same number of coexceedances under both measures. For the US and Europe, the exceedances under both measures overlap in about 95% of trading days. We replicate Tables 5 and 6. The results are mostly similar to the ones reported in the main text. The macro variables remain significant, but now also the interest rate becomes significant in explaining exceedances in Europe. Greater liquidity reduces the likelihood of coexceedances with the exception of Europe where it is insignificant. A more capitalized banking system reduces coexceedances but is not significant for the US. A more concentrated banking system leads to more coexceedances and is now also significant in explaining three coexceedances for Asia and Latin America. The results for the loan ratio and degree of foreign banks are similar to the ones of our main model, but are in general now also significant in explaining a higher number of coexceedances.

Finally, we check robustness with respect to our measure of cross-regional contagion. In our main analysis, we follow Bae, Karolyi and Stulz (2003) and use the number of coexceedances in triggering region as contagion indicator. This however differs across regions since the regions include a different number of countries. To enhance comparability across the four regions, we construct a binary cross-regional contagion variable for Asia and Latin

America, whose value is 1 when the daily regional banking index return lies below 5th percentile on a particular day. Our main results are robust to using this alternative cross-regional contagion variable.

# 7 CONCLUSION

In this paper we investigate regional banking system fragility and explore contagion within and across regions. We measure regional banking system fragility through the number of joint occurrences of extreme negative returns in banking system indices. We find that regional banking system fragility reduces when banks in the region jointly hold more liquid assets, are better capitalized, and for more competitive regional banking systems. For Asia and Latin-America, a greater presence of foreign banks also reduces regional banking system fragility. We further investigate the possibility of contagion within and across regions. Within region banking contagion is important in all regions but it is substantially lower in the developed regions compared to emerging market regions. For cross-regional contagion, we find that the contagion effects of Europe and the US on Asia and Latin America are significantly higher compared to the effect of Asia and Latin America among themselves. Finally, the impact of cross-regional contagion is attenuated when the host region has a more liquid or better capitalized banking sector.

All in all our paper shows that regional banking system characteristics such as higher liquidity and capital help in attenuating regional banking system fragility and reduce the impact of cross-regional contagion. Therefore, national supervisors should not only take into account their own banking system's characteristics but the banking system characteristics of the entire region.

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**Table 1: Summary Statistics of Daily Returns on Banking Stock Indices**

| | CHN | KOR | PHL | TWN | INA | IND | MAL | PAK | SRI | THA | ARG | BRA | CHI | COL | MEX | PER | VEN | USA | EUR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of banks | 14 | 17 | 15 | 11 | 40 | 27 | 11 | 28 | 14 | 11 | 7 | 26 | 7 | 11 | 8 | 13 | 18 | 38 | 172 |
| Mean (%) | 0.089 | 0.028 | 0.019 | 0.020 | 0.072 | 0.038 | 0.039 | 0.073 | 0.024 | 0.000 | 0.034 | 0.081 | 0.050 | 0.047 | 0.095 | 0.065 | 0.085 | 0.041 | 0.035 |
| Std. Dev. (%) | 2.379 | 2.787 | 1.430 | 2.033 | 2.282 | 3.322 | 1.834 | 2.249 | 1.590 | 2.566 | 2.371 | 1.914 | 1.188 | 1.233 | 2.342 | 1.400 | 1.615 | 1.826 | 1.389 |
| Median (%) | 0.004 | 0.000 | 0.006 | 0.000 | 0.006 | 0.005 | 0.013 | 0.015 | 0.008 | 0.000 | 0.007 | 0.013 | 0.015 | 0.021 | 0.003 | 0.022 | 0.018 | 0.014 | 0.068 |
| Minimum (%) | -17.065 | -14.899 | -11.006 | -9.863 | -13.955 | -20.202 | -20.321 | -11.951 | -14.882 | -19.437 | -27.682 | -27.730 | -21.266 | -9.926 | -13.832 | -11.850 | -17.525 | -17.583 | -10.813 |
| Maximum (%) | 25.428 | 17.629 | 16.300 | 13.869 | 14.571 | 27.308 | 32.269 | 16.602 | 28.180 | 20.238 | 33.333 | 42.566 | 10.830 | 11.737 | 28.538 | 14.020 | 17.917 | 19.357 | 16.065 |
| Correlations | CHN | KOR | PHL | TWN | INA | IND | MAL | PAK | SRI | THA | ARG | BRA | CHI | COL | MEX | PER | VEN | USA | EUR |
| CHN | 1.00 | | | | | | | | | | *0.06* | *0.03* | *0.01* | *0.04* | *0.03* | *0.01* | *-0.01* | *0.09* | *0.07* |
| KOR | 0.09 | 1.00 | | | | | | | | | *0.07* | *0.14* | *0.07* | *0.04* | *0.10* | *0.06* | *0.03* | *0.21* | *0.19* |
| PHL | 0.07 | 0.14 | 1.00 | | | | | | | | *0.14* | *0.19* | *0.12* | *0.11* | *0.15* | *0.07* | *0.03* | *0.25* | *0.24* |
| TWN | 0.06 | 0.18 | 0.16 | 1.00 | | | | | | | *0.06* | *0.09* | *0.07* | *0.06* | *0.08* | *0.04* | *0.02* | *0.16* | *0.12* |
| INA | 0.08 | 0.14 | 0.11 | 0.12 | 1.00 | | | | | | *0.06* | *0.12* | *0.08* | *0.09* | *0.08* | *0.01* | *0.00* | *0.14* | *0.09* |
| IND | 0.03 | 0.08 | 0.19 | 0.09 | 0.09 | 1.00 | | | | | *0.11* | *0.08* | *0.10* | *0.05* | *0.10* | *0.05* | *0.02* | *0.12* | *0.11* |
| MAL | 0.05 | 0.15 | 0.17 | 0.13 | 0.11 | 0.16 | 1.00 | | | | *0.09* | *0.05* | *0.07* | *0.05* | *0.09* | *0.04* | *0.03* | *0.17* | *0.11* |
| PAK | 0.02 | 0.03 | 0.05 | 0.06 | 0.08 | 0.03 | 0.07 | 1.00 | | | *0.03* | *0.04* | *0.04* | *0.05* | *0.01* | *0.02* | *0.00* | *0.04* | *0.04* |
| SRI | 0.01 | 0.00 | 0.03 | 0.03 | 0.01 | 0.01 | 0.03 | 0.06 | 1.00 | | *0.04* | *0.03* | *0.05* | *0.03* | *0.00* | *0.03* | *-0.01* | *0.05* | *0.05* |
| THA | 0.06 | 0.21 | 0.21 | 0.16 | 0.14 | 0.19 | 0.29 | 0.06 | 0.04 | 1.00 | *0.09* | *0.11* | *0.07* | *0.05* | *0.13* | *0.06* | *0.03* | *0.17* | *0.14* |
| **Asia** | | | | | **0.10** | | | | | | | | | ***0.06*** | | | | ***0.14*** | ***0.12*** |
| ARG | -0.02 | 0.05 | 0.09 | 0.05 | 0.03 | 0.04 | 0.07 | 0.02 | 0.02 | 0.11 | 1.00 | | | | | | | | |
| BRA | 0.04 | 0.04 | 0.07 | 0.09 | 0.13 | 0.05 | 0.07 | 0.02 | 0.01 | 0.11 | 0.28 | 1.00 | | | | | | | |
| CHI | 0.02 | 0.11 | 0.09 | 0.08 | 0.10 | 0.07 | 0.08 | 0.02 | 0.04 | 0.10 | 0.14 | 0.23 | 1.00 | | | | | | |
| COL | 0.05 | 0.05 | 0.08 | 0.06 | 0.07 | 0.06 | 0.05 | 0.04 | 0.04 | 0.08 | 0.09 | 0.13 | 0.13 | 1.00 | | | | | |
| MEX | 0.00 | 0.08 | 0.07 | 0.05 | 0.06 | 0.07 | 0.07 | 0.04 | -0.01 | 0.10 | 0.31 | 0.28 | 0.15 | 0.08 | 1.00 | | | | |
| PER | 0.06 | 0.04 | 0.08 | 0.07 | 0.07 | 0.06 | 0.04 | 0.00 | 0.02 | 0.07 | 0.15 | 0.14 | 0.12 | 0.08 | 0.13 | 1.00 | | | |
| VEN | 0.01 | 0.01 | 0.02 | -0.01 | 0.00 | 0.02 | 0.02 | -0.01 | -0.01 | 0.05 | 0.03 | 0.05 | 0.02 | 0.03 | 0.03 | 0.03 | 1.00 | | |
| **Latin America** | | | | | | | | | | | | | | **0.13** | | | | | |
| **United States** | -0.01 | 0.03 | 0.01 | 0.05 | 0.09 | 0.04 | 0.02 | 0.00 | -0.01 | 0.07 | 0.25 | 0.31 | 0.16 | 0.11 | 0.27 | 0.06 | 0.03 | 1.00 | |
| | | | | | **0.03** | | | | | | | | | **0.17** | | | | | |
| **Europe** | 0.07 | 0.16 | 0.18 | 0.14 | 0.18 | 0.13 | 0.16 | 0.04 | 0.04 | 0.23 | 0.23 | 0.31 | 0.25 | 0.21 | 0.23 | 0.14 | 0.06 | 0.39 | 1.00 |
| | | | | | **0.13** | | | | | | | | | **0.20** | | | | | |

We report data from 10 Asian countries, 7 Latin American countries, the USA and European block. Asian countries include China (CHN), Korea (KOR), Philippines (PHL), Taiwan (TWN), India (INA), Indonesia (IND), Malaysia (MAL), Pakistan (PAK), Sri Lanka (SRI) and Thailand (THA). Whereas, Latin American countries include Argentina (ARG), Brazil (BRA), Chile (CHI), Colombia (COL), Mexico (MEX), Peru (PER) and Venezuela (VEN).We report number of banks from each country/region. Summary statistics include mean, standard deviation, median, minimum, maximum and correlations of daily returns on banking stock indices as reported in Datastream during the sample period (July 01, 1994 to December 31, 2008). The correlations in italic font at upper right matrix are adjusted for 1 day lag in western hemisphere; therefore, these numbers are correlation coefficients between daily returns of Asian countries in day *t* and those of Latin America, the United States and Europe in day *t-1*. Averages of correlations that are presented in **bold,** represents regional correlations of block above and adjacent to the statistics.

**Table 2: Coexceedances of Daily Return on Banking Stock Indices**

| | Number of Negative Coexceedances | | | | | | Number of Positive Coexceedances | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean return when >=4 | >=4 | 3 | 2 | 1 | 0 | 0 | 1 | 2 | 3 | >=4 | Mean return when >=4 |
| CHN | -4.69% | 19 | 17 | 41 | 113 | 2497 | 2451 | 121 | 45 | 17 | 7 | 7.32% |
| KOR | -7.40% | 28 | 34 | 54 | 74 | 2497 | 2451 | 78 | 61 | 27 | 24 | 7.42% |
| PHL | -4.16% | 33 | 31 | 54 | 72 | 2497 | 2451 | 89 | 57 | 21 | 23 | 3.35% |
| TWN | -4.66% | 30 | 26 | 42 | 92 | 2497 | 2451 | 109 | 47 | 16 | 18 | 5.52% |
| INA | -5.74% | 25 | 22 | 53 | 90 | 2497 | 2451 | 97 | 56 | 23 | 14 | 6.83% |
| IND | -7.77% | 29 | 22 | 52 | 87 | 2497 | 2451 | 84 | 57 | 26 | 23 | 10.07% |
| MAL | -4.21% | 35 | 41 | 55 | 59 | 2497 | 2451 | 74 | 59 | 28 | 29 | 5.29% |
| PAK | -7.18% | 11 | 18 | 38 | 123 | 2497 | 2451 | 100 | 58 | 20 | 12 | 5.43% |
| SRI | -3.87% | 12 | 8 | 43 | 127 | 2497 | 2451 | 115 | 55 | 14 | 6 | 3.70% |
| THA | -6.06% | 38 | 33 | 48 | 71 | 2497 | 2451 | 76 | 57 | 27 | 30 | 8.58% |
| Total | -5.57% | 55 | 84 | 240 | 908 | 2497 | 2451 | 943 | 276 | 73 | 41 | 6.35% |
| | | | | | | | | | | | | |
| ARG | -7.07% | 33 | 29 | 41 | 87 | 2832 | 2744 | 102 | 55 | 16 | 17 | 8.39% |
| BRA | -4.91% | 33 | 30 | 48 | 79 | 2832 | 2744 | 97 | 56 | 19 | 18 | 6.25% |
| CHI | -3.34% | 25 | 17 | 39 | 109 | 2832 | 2744 | 103 | 55 | 16 | 16 | 4.30% |
| COL | -4.00% | 19 | 17 | 41 | 113 | 2832 | 2744 | 136 | 39 | 7 | 8 | 4.03% |
| MEX | -6.28% | 32 | 23 | 44 | 91 | 2832 | 2744 | 121 | 38 | 17 | 14 | 6.87% |
| PER | -3.66% | 24 | 15 | 39 | 112 | 2832 | 2744 | 122 | 41 | 13 | 14 | 3.74% |
| VEN | -4.67% | 11 | 13 | 38 | 128 | 2832 | 2744 | 148 | 34 | 5 | 3 | 3.94% |
| Total | -4.85% | 40 | 48 | 145 | 719 | 2832 | 2744 | 829 | 159 | 31 | 21 | 5.36% |

We define an extreme event when the banking index return on that day lies below the 5th percentile of daily return distribution and refer to this as an *exceedance* of the return on the banking index. The distribution of the daily banking index return is directly observed from our dataset (3784 daily observations from July 01, 1994 to December 31, 2008). From the distribution of 3784 daily observations of return on banking indices, we calculate $5^{th}$ percentile value for each country and region and then use this value as a standard to decide whether a country or region on a particular day exceed or not. The lowest 5% observations correspond to negative exceedance and highest 5% are labeled as positive exceedances. Moreover, we say *coexceedances* when the banking indices of more than 1 country in the region exceed on the same day (i.e. joint occurrences of extreme returns). In this table we report the number of days for 0, 1, 2, 3, and 4 or more joint occurrences of extreme return (coexceedances) within a region on a particular day. A 0 exceedance means no country exceed on a given day and we observed 2497 such days in Asia and 2832 days in Latin America. Similarly, any number (1, 2, ... n; where n is the total number of countries in that region) of coexceedances can be observed on a given day. We have stratified the number of coexceedances into four groups (1, 2, 3, >=4). At the bottom of each block, the total number of days is reported for each number of coexceedance. For example, out of 3784 trading days we have observed 908 days when only 1 country negatively exceed in Asia. Similarly, we find 240 days when two countries coexceed (negative) and 55 days when 4 or more countries coexceed in Asia. Within each region, we also mentioned how often a particular country exceed. For instance, we find that China is the only country on 113 days out of 908 days when 1 country has lowest extreme returns. Similarly, there are 19 days out of 55 days when China is among those 4 or more countries coexceed. The first (last) column give mean returns when 4 or more countries have negative (positive) coexceedance. The bottom row 'Total' provide mean return irrespective of which countries are included, whereas numbers associated with country are mean return of that particular country when it is among those 4 or more countries. for example, in Asia, the average daily return of all countries in those 55 days is -5.57 percent. Whereas, the average daily return for china in those 19 out of 55 days is -4.69 percent.

**Table 3: Summary Statistics of Macro Variables**

| Common Factors | Conditional Volatility | | Exchange Rate Changes | | Interest Rate Level | |
|---|---|---|---|---|---|---|
| % | Mean | Std Dev. | Mean | Std Dev. | Mean | Std Dev. |
| CHN | 29.289 | 13.844 | -0.0060 | 0.056 | 4.345 | 3.093 |
| KOR | 33.741 | 18.996 | 0.0163 | 0.959 | 7.619 | 3.678 |
| PHL | 21.974 | 6.977 | 0.0166 | 0.561 | 10.370 | 3.820 |
| TWN | 24.230 | 6.969 | 0.0058 | 0.304 | 3.938 | 2.075 |
| INA | 23.034 | 8.617 | 0.0120 | 0.283 | 8.392 | 2.630 |
| IND | 26.331 | 11.182 | 0.0112 | 0.876 | 13.361 | 7.504 |
| MAL | 18.157 | 12.171 | 0.0108 | 0.659 | 4.785 | 2.225 |
| PAK | 26.635 | 9.733 | 0.0258 | 0.436 | 9.600 | 3.909 |
| SRI | 17.617 | 20.879 | 0.0223 | 0.257 | 13.319 | 3.721 |
| THA | 27.627 | 9.358 | 0.0116 | 0.606 | 9.191 | 3.145 |
| **Asia** | **21.188** | **9.949** | **0.0135** | **0.226** | **8.492** | **2.838** |
| | | | | | | |
| ARG | 24.744 | 8.816 | 0.0431 | 1.667 | 21.488 | 22.034 |
| BRA | 24.047 | 10.137 | 0.0320 | 0.935 | 1.072 | 0.770 |
| CHI | 12.544 | 4.960 | 0.0145 | 0.807 | 0.498 | 0.210 |
| COL | 14.418 | 7.278 | 0.0282 | 0.568 | 16.399 | 10.325 |
| MEX | 19.380 | 7.427 | 0.0422 | 0.974 | 16.485 | 10.714 |
| PER | 18.431 | 6.591 | 0.0101 | 0.337 | 12.793 | 2.934 |
| VEN | 38.986 | 19.974 | 0.0802 | 1.869 | 17.529 | 9.145 |
| **Latin America** | **23.389** | **10.842** | **0.0356** | **0.458** | **12.140** | **4.863** |
| | | | | | | |
| **United States** | **15.841** | **7.910** | **-0.0003** | **0.443** | **4.131** | **1.722** |
| **Europe** | **15.030** | **7.665** | **-0.0002** | **0.544** | **4.431** | **1.476** |

We estimate conditional volatility of individual countries through their respective total market stock indices. Whereas, regional stock market volatility is estimated through International Finance Corporation (IFC) indices from Asia and Latin America, and the S&P 500 index for the United States and Datastream International Europe Index for Europe. For each region, we estimate the conditional volatility of the respective stock indices using a GARCH (1, 1) model with maximum likelihood method. In first column, we report mean and standard deviation of conditional volatility of all countries as well as region. Similarly, We calculate the daily change in exchange rate against US dollar for each country in Asia and Latin America. In case of the US, we use a basket of four currencies (i.e. GBP, JPY, CHF and EUR) to evaluate exchange rate changes. For Europe, since EUR and GBP are the two major currencies, we take equal-weighted average of EUR and GBP exchange rates changes against USD. Since our sample starts from June 1994; therefore, we use country-weighted average of exchange rate against USD of euro currencies for daily observations prior to the introduction of EUR. Second column represents mean and standard deviation of daily percentage change in exchange rate for each country. For regional values, we take equal-weighted average of daily changes in exchange rate of all countries in the region. Lastly, third column shows mean and standard deviation of annual interest rates in each country and regional interest rate is the equal-weighted average of interest rate in all countries in the region. In Europe, we took equal-weighted average of 1-year LIBOR and EURIBOR.

**Table 4: Summary Statistics of Banking Characteristics**

| Banking System | Liquidity | | Capitalization | | Concentration | | Loan-Ratio | | Foreign Banks | |
|---|---|---|---|---|---|---|---|---|---|---|
| Characteristics | Mean | Std Dev. | Mean | Std Dev. | Mean | Std Dev. | Mean | Std Dev. | Mean | Std Dev. |
| CHN | 0.021 | 0.022 | 0.035 | 0.012 | 0.800 | 0.083 | 0.538 | 0.092 | 0.098 | 0.027 |
| KOR | 0.054 | 0.010 | 0.051 | 0.011 | 0.464 | 0.064 | 0.584 | 0.034 | 0.116 | 0.098 |
| PHL | 0.037 | 0.015 | 0.118 | 0.011 | 0.597 | 0.049 | 0.432 | 0.065 | 0.142 | 0.015 |
| TWN | 0.022 | 0.005 | 0.077 | 0.010 | 0.490 | 0.110 | 0.492 | 0.049 | N/A | N/A |
| INA | 0.125 | 0.019 | 0.065 | 0.006 | 0.495 | 0.062 | 0.480 | 0.080 | 0.086 | 0.016 |
| IND | 0.050 | 0.022 | 0.079 | 0.092 | 0.693 | 0.096 | 0.536 | 0.132 | 0.327 | 0.058 |
| MAL | 0.022 | 0.014 | 0.088 | 0.015 | 0.442 | 0.063 | 0.601 | 0.035 | 0.283 | 0.029 |
| PAK | 0.116 | 0.025 | 0.062 | 0.040 | 0.789 | 0.138 | 0.475 | 0.077 | 0.150 | 0.088 |
| SRI | 0.017 | 0.006 | 0.077 | 0.025 | 0.825 | 0.118 | 0.532 | 0.041 | 0.000 | 0.000 |
| THA | 0.024 | 0.004 | 0.065 | 0.022 | 0.603 | 0.065 | 0.637 | 0.050 | 0.127 | 0.036 |
| **Asia** | **0.028** | **0.009** | **0.053** | **0.003** | **0.625** | **0.043** | **0.540** | **0.052** | **0.148** | **0.032** |
| | | | | | | | | | | |
| ARG | 0.025 | 0.010 | 0.111 | 0.013 | 0.593 | 0.075 | 0.469 | 0.147 | 0.328 | 0.047 |
| BRA | 0.015 | 0.004 | 0.078 | 0.007 | 0.545 | 0.073 | 0.355 | 0.032 | 0.329 | 0.042 |
| CHI | 0.058 | 0.016 | 0.047 | 0.013 | 0.746 | 0.076 | 0.617 | 0.074 | 0.464 | 0.040 |
| COL | 0.033 | 0.013 | 0.201 | 0.046 | 0.571 | 0.085 | 0.576 | 0.131 | 0.263 | 0.029 |
| MEX | 0.039 | 0.023 | 0.087 | 0.024 | 0.648 | 0.133 | 0.629 | 0.083 | 0.467 | 0.066 |
| PER | 0.080 | 0.114 | 0.073 | 0.014 | 0.807 | 0.047 | 0.472 | 0.066 | 0.536 | 0.098 |
| VEN | 0.106 | 0.030 | 0.158 | 0.060 | 0.758 | 0.085 | 0.362 | 0.134 | 0.223 | 0.051 |
| **Latin America** | **0.029** | **0.005** | **0.087** | **0.009** | **0.593** | **0.053** | **0.444** | **0.031** | **0.373** | **0.042** |
| | | | | | | | | | | |
| **United States** | **0.028** | **0.007** | **0.070** | **0.004** | **0.146** | **0.010** | **0.508** | **0.031** | **0.199** | **0.038** |
| **Europe** | **0.018** | **0.002** | **0.047** | **0.002** | **0.093** | **0.009** | **0.500** | **0.024** | **0.335** | **0.038** |

The table report mean and standard deviation of banking system characteristics during the sample period for each country from July 01, 1994 to December 31, 2010. Liquidity is the ratio of cash and cash equivalent to total assets of the banking system. Capitalization is the ratio of total equity (that includes common shares and premium; retained earnings; reserves for general banking risks and statutory reserves; loss absorbing minority interests; net revaluation of AFS securities; FX reserves included in equity and revaluations other than securities deemed to be equity capital) to total assets of the banking system. Concentration is the ratio of total assets of biggest five banks to total assets of all banks (i.e. C5 measure) for each country in the region. Finally, loan ratio is calculated as net loans to total earning assets for each country. Regional variables for Asia and Latin America are obtained by weighted-average of individual country using total assets of banking system as weights. Whereas, the US is a single country case and for Europe we include all active banks that are covered in the Datastream.

**Table 5: Macro Factors and Regional Banking System Fragility**

| Negative Coexceedances | | No. of Coex. | Relative Frequency | Panel A: Asia Coeff | Chg Prob | No. of Coex. | Relative Frequency | Panel B: Latin America Coeff | Chg Prob |
|---|---|---|---|---|---|---|---|---|---|
| Base Case | 0 | 2497 | 0.660 | | | 2832 | 0.748 | | |
| Constant | 1 | 908 | 0.240 | -2.422 [a] | | 719 | 0.190 | -2.350 [a] | |
| | 2 | 240 | 0.063 | -5.758 [a] | | 145 | 0.038 | -5.472 [a] | |
| | 3 | 84 | 0.022 | -6.943 [a] | | 48 | 0.013 | -6.962 [a] | |
| | >=4 | 55 | 0.015 | -8.594 [a] | | 40 | 0.011 | -8.304 [a] | |
| Conditional Volatility | 1 | | | 0.033 [a] | 0.005 | | | 0.018 [a] | 0.002 |
| | 2 | | | 0.066 [a] | 0.003 | | | 0.054 [a] | 0.001 |
| | 3 | | | 0.077 [a] | 0.001 | | | 0.070 [a] | 0.001 |
| | >=4 | | | 0.104 [a] | 0.001 | | | 0.089 [a] | 0.000 |
| Exchange Rate Changes | 1 | | | 0.602 [a] | 0.080 | | | 0.388 [a] | 0.054 |
| | 2 | | | 1.420 [a] | 0.061 | | | 0.533 [a] | 0.013 |
| | 3 | | | 2.169 [a] | 0.032 | | | 0.593 [a] | 0.004 |
| | >=4 | | | 2.363 [a] | 0.015 | | | 0.788 [a] | 0.003 |
| Interest Rate Level | 1 | | | 0.084 [a] | 0.011 | | | 0.040 [a] | 0.005 |
| | 2 | | | 0.217 [a] | 0.010 | | | 0.075 [a] | 0.002 |
| | 3 | | | 0.192 [a] | 0.003 | | | 0.064 [b] | 0.000 |
| | >=4 | | | 0.220 [a] | 0.001 | | | 0.079 [b] | 0.000 |
| Log-Likelihood | | | | -3,107.02 | | | | -2,423.92 | |
| Pseudo-$R^2$ | | | | 0.0658 | | | | 0.0555 | |
| | | | | **Panel C: US** | | | | **Panel D: Europe** | |
| Base Case | 0 | 3594 | 0.950 | | | 3594 | 0.950 | | |
| Constant | 1 | 190 | 0.050 | -4.6121 [a] | | 190 | 0.050 | -4.5596 [a] | |
| Conditional Volatility | | | | 0.0840 [a] | 0.0032 | | | 0.0913 [a] | 0.0033 |
| Exchange Rate Changes | | | | -0.3820 [b] | -0.0145 | | | 0.2094 [b] | 0.0077 |
| Interest Rate Level | | | | 0.0216 | 0.0008 | | | -0.0101 | -0.0004 |
| Log-Likelihood | | | | -669.23 | | | | -651.01 | |
| Pseudo-$R^2$ | | | | 0.1118 | | | | 0.1359 | |

First column shows the number of coexceedances and relative frequency in our data sample for each region. We use the number of coexceedances of daily returns as dependent variable in multinomial logistics model for Asia and Latin America with five categories for number of coexceedances I.e. 0, 1, 2, 3, and >=4 on a given day. In case of the US and Europe, we use binomial logistic model with binary dependent variable of whether exceedance or not on a given day. [a, b,] and [c] denotes significance level of 1%, 5% and 10% respectively.

**Table 6: Banking System Characteristics and Regional Banking System Fragility**

| | | Model 1 | | Model 2 | | Model 3 | | Model 4 | | Model 5 | | Model 6 | | Model 1 | | Model 2 | | Model 3 | | Model 4 | | Model 5 | | Model 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Negative Coexceedances** | | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob | Coeff | Chg Prob |
| | | **Panel A: Asia** | | | | | | | | | | | | **Panel B: Latin America** | | | | | | | | | | |
| Liquidity | 1 | -14.590 [c] | -2.011 | | | | | | | | | 15.417 | 2.630 | -51.980 [a] | -7.042 | | | | | | | | | -66.338 [a] | -8.506 |
| | 2 | -31.030 [b] | -1.305 | | | | | | | | | 16.343 | 0.619 | -100.500 [a] | -2.369 | | | | | | | | | -168.471 [a] | -4.001 |
| | 3 | -36.470 [c] | -0.502 | | | | | | | | | 11.356 | 0.111 | -99.980 [b] | -0.663 | | | | | | | | | -193.374 [b] | -1.300 |
| | >=4 | -83.240 [a] | -0.520 | | | | | | | | | -25.271 | -0.211 | -212.600 [a] | -0.603 | | | | | | | | | -759.643 [a] | -1.216 |
| Capitalization | 1 | | | 9.014 | 1.327 | | | | | | | 2.829 | -0.293 | | | -32.980 [a] | -4.587 | | | | | | | 17.090 | 1.656 |
| | 2 | | | 14.390 | 0.570 | | | | | | | 41.589 | 1.987 | | | -50.560 [a] | -1.188 | | | | | | | 120.583 [b] | 3.019 |
| | 3 | | | 46.590 | 0.701 | | | | | | | 58.801 | 0.901 | | | -34.100 | -0.209 | | | | | | | 120.116 | 0.837 |
| | >=4 | | | -17.290 | -0.155 | | | | | | | 24.530 | 0.145 | | | -71.670 [b] | -0.239 | | | | | | | 423.784 [a] | 0.683 |
| Concentration | 1 | | | | | 5.773 [a] | 0.966 | | | | | 8.702 [a] | 1.382 | | | | | 5.822 [a] | 0.820 | | | | | 3.413 | 0.465 |
| | 2 | | | | | 6.403 [a] | 0.238 | | | | | 12.010 [b] | 0.475 | | | | | 7.746 [a] | 0.181 | | | | | 6.698 | 0.157 |
| | 3 | | | | | 4.206 | 0.041 | | | | | 11.249 | 0.135 | | | | | 3.350 | 0.016 | | | | | -2.131 | -0.022 |
| | >=4 | | | | | -1.850 | -0.028 | | | | | 13.396 | 0.073 | | | | | 11.150 [c] | 0.038 | | | | | 31.981 [C] | 0.051 |
| Loan Ratio | 1 | | | | | | | 5.992 [a] | 1.105 | | | -4.268 | -0.471 | | | | | | | 5.338 [a] | 0.766 | | | -0.448 | -0.075 |
| | 2 | | | | | | | 1.581 | 0.007 | | | -17.012 [b] | -0.776 | | | | | | | 5.576 | 0.126 | | | 2.024 | 0.055 |
| | 3 | | | | | | | 1.568 | 0.002 | | | -13.008 | -0.176 | | | | | | | 1.972 | 0.006 | | | 3.885 | 0.029 |
| | >=4 | | | | | | | -16.780 | -0.134 | | | -25.750 | -0.165 | | | | | | | 4.177 | 0.012 | | | -21.053 | -0.035 |
| Foreign Banks | 1 | | | | | | | | | -7.029 [a] | -1.183 | 1.272 | 0.238 | | | | | | | | | -3.472 [a] | -0.450 | 0.788 | 0.175 |
| | 2 | | | | | | | | | -10.450 [a] | -0.443 | -3.790 | -0.216 | | | | | | | | | -8.979 [a] | -0.221 | -8.866 [b] | -0.233 |
| | 3 | | | | | | | | | -0.783 | 0.025 | 6.054 | 0.095 | | | | | | | | | -8.436 [b] | -0.060 | -11.597 | -0.085 |
| | >=4 | | | | | | | | | 12.133 | 0.100 | 12.514 | 0.086 | | | | | | | | | -12.083 [b] | -0.040 | 0.180 | 0.001 |
| Constant | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | | |
| Macro Factors | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | | |
| Log-Likelihood | | -3076.3 | | -3082.3 | | -3063.9 | | -3074.8 | | -2979.5 | | -2963.6 | | -2396.92 | | -2406.9 | | -2409.4 | | -2418.9 | | -2303.9 | | -2276.8 | |
| Pseudo-$R^2$ | | 0.08 | | 0.07 | | 0.08 | | 0.08 | | 0.08 | | 0.08 | | 0.07 | | 0.06 | | 0.06 | | 0.06 | | 0.06 | | 0.08 | |
| | | **Panel C: US** | | | | | | | | | | | | **Panel D: Europe** | | | | | | | | | | | |
| Liquidity | | -34.954 [b] | -1.316 | | | | | | | | | -344.065 [a] | -12.094 | -73.173 [a] | -2.653 | | | | | | | | | -149.090 | -5.668 |
| Capitalization | | | | -46.513 [b] | -1.748 | | | | | | | -531.415 [a] | -18.679 | | | -2.642 | 0.097 | | | | | | | 67.438 | 2.564 |
| Concentration | | | | | | 32.830 [a] | 1.199 | | | | | -6.018 | -0.212 | | | | | 38.664 [a] | 1.338 | | | | | 49.878 [a] | 1.896 |
| Loan Ratio | | | | | | | | -3.187 | 0.121 | | | 29.768 [a] | 1.046 | | | | | | | -2.898 | 0.106 | | | 6.226 | 0.237 |
| Foreign Banks | | | | | | | | | | 5.901 [b] | 0.254 | -0.012 | 0.000 | | | | | | | | | 0.213 | 0.009 | 7.421 | 0.282 |
| Constant | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | |
| Macro Factors | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | | YES | |
| Log-Likelihood | | -666.6 | | -668.2 | | -657.6 | | -668.7 | | -656.0 | | -627.6 | | -650.2 | | -651.0 | | -644.6 | | -650.6 | | -633.5 | | -627.0 | |
| Pseudo-$R^2$ | | 0.12 | | 0.11 | | 0.13 | | 0.11 | | 0.10 | | 0.14 | | 0.14 | | 0.14 | | 0.14 | | 0.14 | | 0.13 | | 0.14 | |

We use the number of coexceedances of daily returns as dependent variable in multinomial logistics model for Asia and Latin America with five categories for number of coexceedances I.e. 0, 1, 2, 3, and >=4 on a given day. Independent variables include regional banking system characteristic one at a time (except for model 5 when we include them all simultaneously) beside controlling for common macro factors. In case of the US and Europe, we use binomial logistic model with binary dependent variable of whether exceedance or not on a given day; whereas, independent variables include banking system characteristics and common macro factors as described earlier. a, b, and c denotes significance level of 1%, 5% and 10% respectively.

**Table 7: Cross-Regional Contagion**

| | | Panel A: Asia | | Panel B: Latin America | |
|---|---|---|---|---|---|
| | | Coeff | Chg Prob | Coeff | Chg Prob |
| **Contagion Triggers from Asia** | 1 | | | 0.186 [a] | 0.026 |
| | 2 | | | 0.417 [a] | 0.009 |
| | 3 | | | 0.495 [a] | 0.002 |
| | >=4 | | | 0.618 [a] | 0.001 |
| **Contagion Triggers from Latin America** | 1 | 0.041 | 0.004 | | |
| | 2 | 0.122 | 0.005 | | |
| | 3 | 0.318 [b] | 0.005 | | |
| | >=4 | 0.528 [a] | 0.002 | | |
| **Contagion Triggers from the US** | 1 | 0.642 [a] | 0.095 | 0.653 [a] | 0.086 |
| | 2 | 1.174 [a] | 0.065 | 1.555 [a] | 0.059 |
| | 3 | 1.008 [a] | 0.015 | 2.111 [a] | 0.025 |
| | >=4 | 1.489 [a] | 0.009 | 3.080 [a] | 0.013 |
| **Contagion Triggers from Europe** | 1 | -0.011 | -0.025 | 0.636 [a] | 0.093 |
| | 2 | 0.655 [b] | 0.036 | 1.206 [a] | 0.038 |
| | 3 | 0.950 [a] | 0.020 | 1.731 [a] | 0.017 |
| | >=4 | 2.353 [a] | 0.031 | 2.533 [a] | 0.008 |
| Constant | | YES | | YES | |
| Control for Common Factors | | YES | | YES | |
| Control for Banking Characteristics | | YES | | YES | |
| Control for Conditional Volatility in Triggering Country | | YES | | YES | |
| Log-Likelihood | | -2977.7 | | -2287.1 | |
| Pseudo-$R^2$ | | 0.1046 | | 0.1088 | |
| | | **Panel C: US** | | **Panel D: Europe** | |
| **Contagion Triggers from Asia** | | -0.147 | -0.004 | 0.492 [a] | 0.013 |
| **Contagion Triggers from Latin America** | | 0.716 [a] | 0.019 | 0.657 [a] | 0.018 |
| **Contagion Triggers from the US** | | | | 1.535 [a] | 0.083 |
| **Contagion Triggers from Europe** | | 1.680 [a] | 0.094 | | |
| Constant | | YES | | YES | |
| Control for Common Factors | | YES | | YES | |
| Control for Banking Characteristics | | YES | | YES | |
| Control for Conditional Volatility in Triggering Country | | YES | | YES | |
| Log-Likelihood | | -557.6 | | -537.0 | |
| Pseudo-$R^2$ | | 0.2461 | | 0.2711 | |

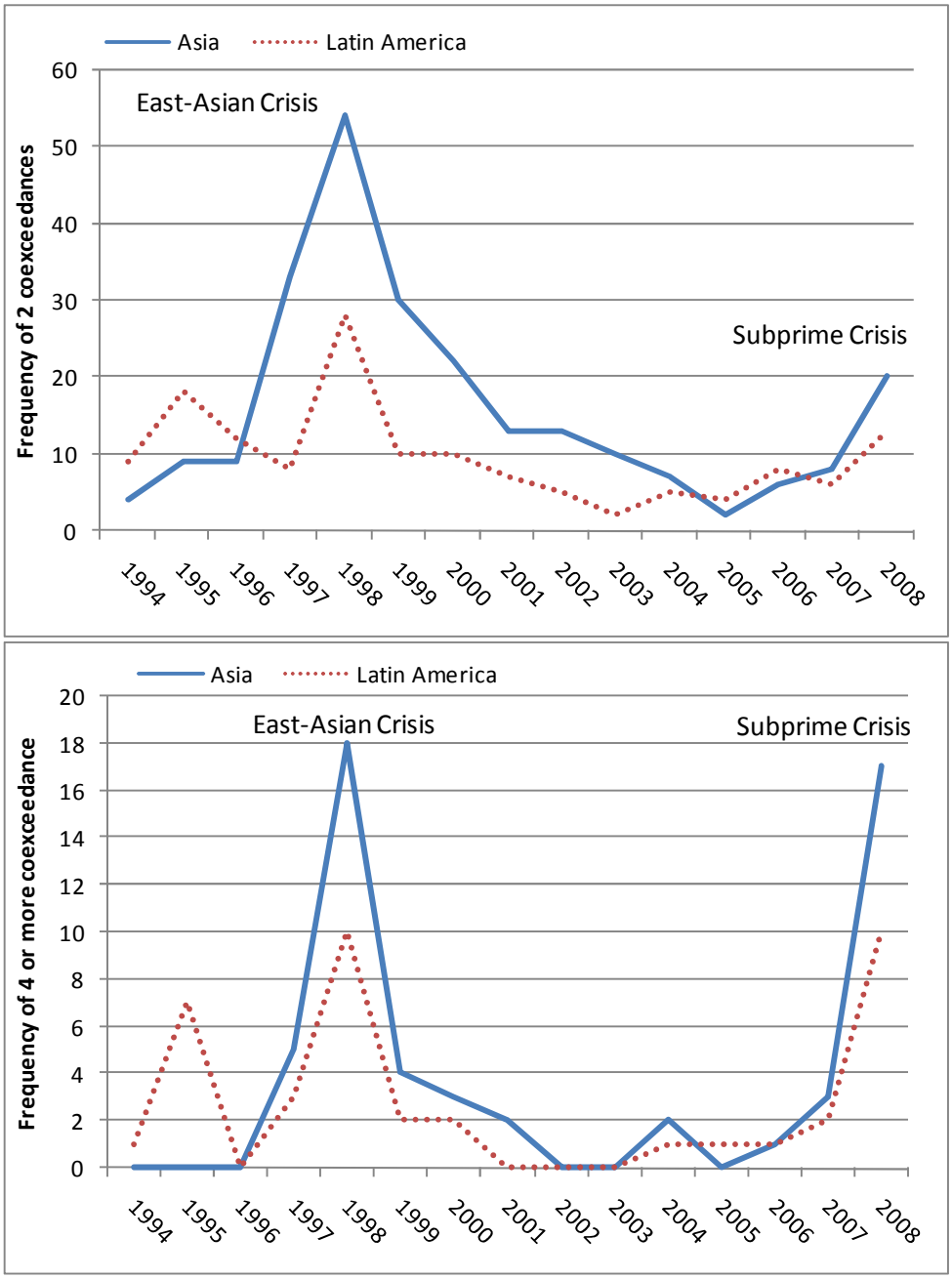
We introduce the number of coexceedances in other regions as an explanatory variable to gauge cross-regional contagion beside controlling for all common macro factors and banking system characteristics. For Asia and Latin America we still use multinomial logistics model and for the US and Europe we use binomial model. [a, b, c] Denotes significance levels at the 1%, 5% and 10% respectively.

**Table 8: Banking System Characteristics and the Impact of Cross-Regional Contagion**

| Interaction Effect | Liquidity | Capitalization | Concentration | Loan Ratio | Foreign bank | Liquidity | Capitalization | Concentration | Loan Ratio | Foreign bank |
|---|---|---|---|---|---|---|---|---|---|---|
| | Panel A: Cross-Regional Contagion to Asia | | | | | Panel B: Cross-Regional Contagion to Latin America | | | | |
| **Neg. Coex. In Asia** | | | | | | -1.932 | -0.379 | -0.059 | -0.786 | -0.315 |
| **Neg. Coex. In Latin America** | -7.924 [b] | 0.713 | -0.789 | -1.452 | 0.180 | | | | | |
| **Neg. Coex. In USA** | -0.811 | 0.492 | -0.782 | -0.546 | 0.351 | -20.964 [a] | -15.214 [a] | 2.173 [a] | 1.253 | -2.637 [a] |
| **Neg. Coex. In Europe** | -2.658 | 0.761 | -1.654 [a] | -1.995 | 0.927 [a] | -9.471 | -4.463 | 0.855 | -0.332 | -2.593 [a] |
| | Panel C: Cross-Regional Contagion to US | | | | | Panel D: Cross-Regional Contagion to Europe | | | | |
| **Neg. Coex. In Asia** | 0.586 | -1.026 | -1.725 [a] | 0.107 | -0.024 | 1.566 | -22.440 [a] | 1.534 [c] | -1.645 | 0.972 [a] |
| **Neg. Coex. In Latin America** | 0.551 | -8.159 | -1.500 [a] | -0.214 | -0.591 [b] | -3.809 [b] | -26.163 [a] | 1.102 [b] | -1.642 | 0.335 |
| **Neg. Coex. In USA** | | | | | | -15.409 | 4.569 | -10.579 [a] | 1.001 | -0.085 |
| **Neg. Coex. In Europe** | -0.986 | -4.118 | -0.813 [a] | -0.477 | 0.245 | | | | | |

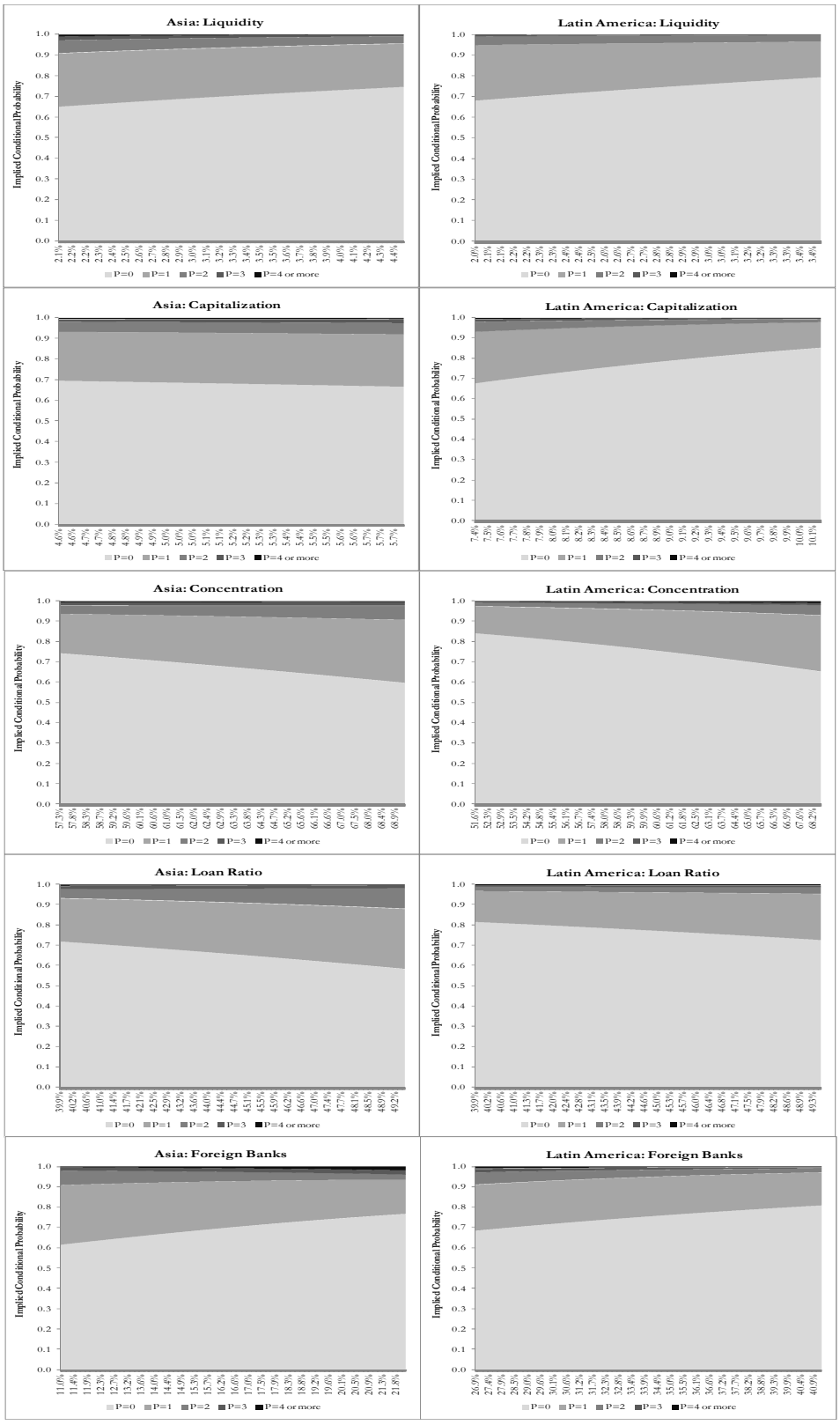
Interaction Effect of Contagion from Other Regions and Banking Characteristics in Host Region is measured using Ai and Norton's algorithm with logit model specification. [a, b, c] Denotes significance levels at the 1%, 5% and 10% respectively.

**Figure 1: Clustering of Negative Extreme Events in the Sample Period**



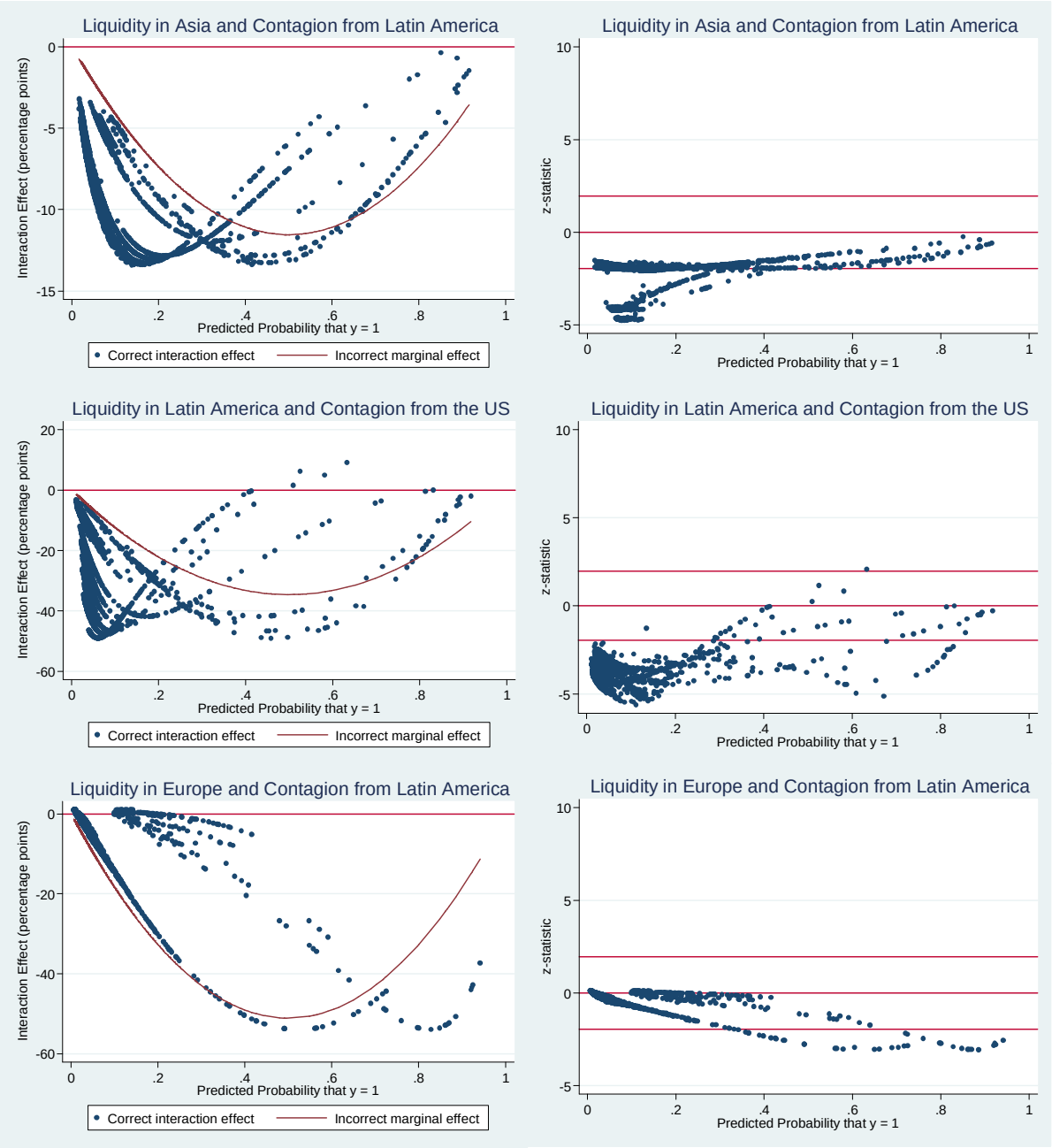

We measure the frequency of coexceedances in calendar year in our sample period. Upper graph reports the frequency of 2 coexceedances (i.e. how frequent are 2 countries have negative extreme returns on banking indices on the same day). Lower graph shows the joint occurrences more extreme shocks when 4 or more countries have negative extreme returns on banking indices on the same day.

**Figure 2: Coexceedance Response Curve of Banking Characteristics in Asia and Latin America**



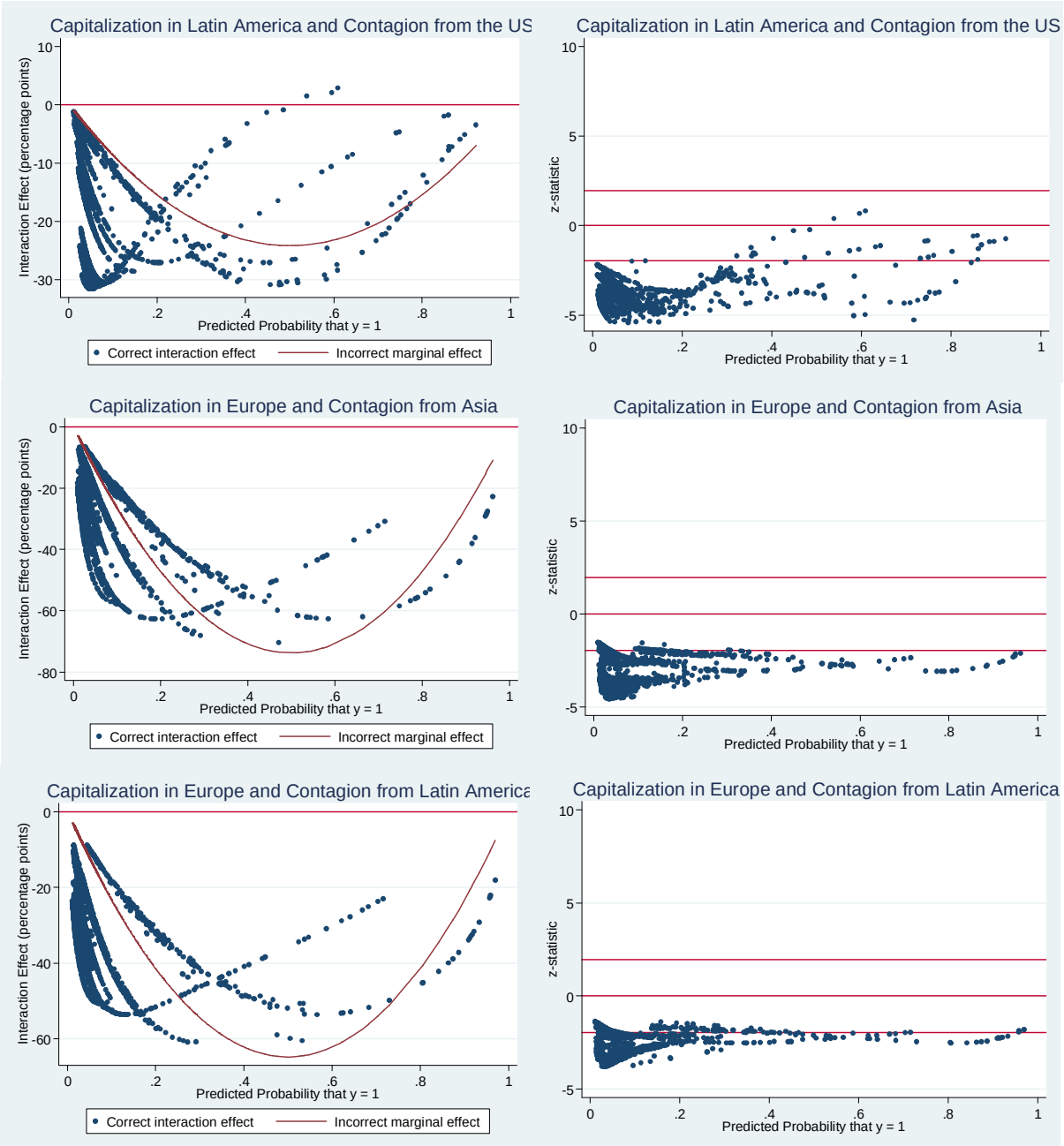

This shows the response of the probability measures for the *full range* of values of each banking characteristic, instead of focusing on the average value as is the case in the marginal probabilities reported in the Tables 5 and 6

**Figure 3: Interaction Effect of Cross-Regional Contagion and Liquidity in the Host Region**




These graphs show the values of the interaction term for all data points using Ai and Norton (2003). The continuous concave line is the marginal effect of the interaction term computed by the standard procedure; whereas the dots show the correct interaction effect. The statistical significance of the interaction effect is shown in the adjacent graph. The interaction effect is statistically significant whenever the z-value lies above or below the confidence interval lines.

**Figure 3 (cont'd): Interaction Effect of Cross-Regional Contagion and Capitalization in the Host Region**




These graphs show the values of the interaction term for all data points using Ai and Norton (2003). The continuous concave line is the marginal effect of the interaction term computed by the standard procedure; whereas the dots show the correct interaction effect. The statistical significance of the interaction effect is shown in the adjacent graph. The interaction effect is statistically significant whenever the z-value lies above or below the confidence interval lines.