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DETERMINANTS OF BANKING SYSTEM FRAGILITY

A REGIONAL PERSPECTIVE

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In 2013 all ECB publications feature a motif taken from the €5 banknote.

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ABSTRACT

We study the role of regional banking system characteristics for regional banking system fragility in Asia, Europe, Latin America and the US. 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 and more wholesale funded banks also reduces regional banking fragility. In contrast, regional banking fragility increases in foreign bank presence and wholesale funding in the US. We further investigate the possibility of contagion across regions. 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

Non-technical summary

It is well-known that banks may face shocks both on their asset and liability side. A shock that initially affects one institution can become systemic and infect the larger local economy. The globalization of banking implies further that shocks affecting a particular bank or country can now affect not only the local real economy but also the financial system and real economy in other countries. Up to now, the literature on financial fragility has mainly focused on stability of *individual banks* or stability of *individual countries' banking systems*. This working paper investigates the determinants of *regional* banking system fragility, which is referred to as a situation when countries' banking stock indices in a region have jointly very low returns. The 2007-2009 financial crisis has shown that a nation with a fragile banking system may affect the fragility of the financial system in countries in the same region through cross-border linkages and common exposures, and raise concerns for regional banking system fragility.

What are the likely effects of a region's banking system characteristics? Which banking characteristics play a role? We consider regional liquidity, capitalization, competition, diversification, presence of foreign banks, and wholesale funding. The economic motivation for them is as follows. The *liquidity* on a bank's balance sheet serves as a first line of defence against liquidity shocks. Allen and Gale (2000) and Freixas et al. (2000) model banks facing 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. A higher *capital* base provides a cushion against insolvency. Our motivation to use the capital base of the region's banking system 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. The relationship between *competition* and financial stability is complex. The "Competition-Fragility" theories - based on the idea of 'charter/franchise value' argue that more bank competition erodes market power, leading to more bank risk-taking. Alternatively, the "Competition-Stability" view suggests that more market power in the loan market may result in higher bank risk. In terms of the geographical scope of the competition measure, a region's degree of competition may be a more relevant statistic than the national degree of competition. *Diversification* of bank activities may improve or deteriorate banking stability. The presence of

foreign banks in a region may impact the fragility of the regional banking system in different ways. On the one hand, a greater foreign bank presence may lead to greater banking efficiency and competition in the domestic financial system. On the other hand, foreign banks may provide a channel for cross-border contagion when they transmit shocks from one region to another. Finally, reliance on non-core deposits as a funding source, *wholesale funding*, could prove to be a more volatile source of funding that may accentuate regional banking fragility.

We measure regional banking system fragility by the joint occurrences of negative extreme returns in the banking system indices of multiple countries in the region. The joint occurrences of negative extreme returns are called 'coexceedances'. A region's banking system is then more fragile when there are more 'coexceedances' on a particular day as this implies that more countries banking systems simultaneously face a negative shock. Our first research question is whether regional banking system characteristics determine regional banking system fragility. Furthermore, we 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.

In our analysis we use countries' banking indices starting from July 1, 1994 to December 31, 2008 and cover 4 regions – Asia (10 countries), Latin America (7 countries), Europe and the United States, to compute exceedances and coexeedances. Our main findings can be summarized as follows. A region's banking system characteristics play a significant role in explaining regional banking system fragility. A higher liquidity reduces regional banking system fragility in all regions whereas a higher capitalization reduces regional banking system fragility in all regions with the exception of Asia and Europe, where it has no effect. Our findings are supportive of the competition-stability view in most regions as an increase in competition in the banking industry significantly reduces exceedances or coexceedances. 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. A greater presence of foreign banks reduces regional banking fragility in Asia and Latin-America. Finally, while more wholesale funding increases financial fragility in the US, it has the opposite effect for Latin America.

We also study cross-regional contagion, and 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. Importantly, a higher level of regional liquidity or higher regional capitalization in the host region, attenuates significantly the contagion effects from other regions.

This working paper therefore 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 monitor not only the domestic banking system but also the other banking systems in the region. Finally, the working paper highlights the importance of coordinating supervisory policies at the regional level. This can be implemented more easily by establishing a single supervisory mechanism at the regional level.

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 other 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 simultaneously 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. Reinhart and Rogoff (2009) find that banking crisis are associated with profound declines in output and employment with the unemployment rate rising an average of 7 percentage points and output falling an average of 9 percent. 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 (2000) 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 individual 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, foreign bank presence and wholesale funding – have an impact on regional banking system fragility, after controlling for regional macro factors. We follow the methodology in Bae, Karolyi and Stulz (2003), and we measure 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), which corroborates that our fragility measure proxies for periods of stress in the banking system.

We study whether regional banking system characteristics have an impact on regional banking system fragility (i.e. the number of banking systems having joint occurrences of extreme negative returns on a particular day) using a multinomial logistic approach. Furthermore, we 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 by studying contagion in the banking sector across *regions* whereas the literature mainly deals with within-country contagion, cross-border contagion, or contagion across individual banks. We study four different regions – Asia, Latin America, US and Europe. This allows us to investigate cross-regional 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 regional 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's banking index return being in the left 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 and more wholesale funding also reduces regional banking fragility, whereas both increase regional fragility in the US. We note that all 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 strong evidence of cross-regional contagion, i.e. the transmission of negative shocks across regions. Specifically, 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. In particular, 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. We note that all these results hold after controlling for common shocks that may affect both the triggering regions and the host 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. The next Section describes the data, variables used in the paper, and provides descriptive statistics. Section 3 explains the

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

methodology. Section 4 presents results for the base model that includes the macro factors and the regional banking characteristics. Section 5 extends the model to study cross-regional contagion. Section 6 presents some robustness tests and Section 7 concludes the paper.

2 DATA 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.

2.1 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 identify 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 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>

2.2 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 $\sigma^2_{c,t}$ 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 macro 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.[2] 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

[2] Our sample starts in June 1994. Therefore, for daily observations prior to the introduction of the Euro, we use a country-weighted average of the exchange rate against USD for the countries partaking in the Euro.

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.

2.3 REGIONAL BANKING SYSTEM CHARACTERISTICS

We study the effect on regional fragility of six regional banking system characteristics: liquidity, capitalization, concentration, diversification of bank's activities, the degree of foreign bank presence and the degree of wholesale funding. We evaluate these effects 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%).

Our measure *capitalization* is the ratio of total equity to total assets. Total equity 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.

To evaluate 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.

We also 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.

Finally, we introduce the variable *wholesale funding*, that is equal to the ratio of Net loans to the bank's customer deposits and short-term funding. As in De Haas and van Lelyveld (2013), we use this variable as a proxy for the amount of lending funded by non-deposit sources. While Asia presents the highest regional levels of wholesale funding with a lot of variation across countries, the US shows the lowest level.

3 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. [3] 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

[3] A potential straightforward alternative is a linear probability model using the fraction of countries coexceeding as dependent variable. Such an approach, however, disregards the possible non-linear nature of having many countries in the left tail.

of our base model are macro factors 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:

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

where x is the vector of covariates and β_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:

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

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.

4 DETERMINANTS OF REGIONAL BANKING FRAGILITY

We evaluate 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 the first subsection, we assess how macro factors affect the occurrence of such coexceedances. For comparison purposes,

we also report results for the occurrence of exceedances for US and Europe.[4] In the second subsection, next to the macro factors, we also include a region's banking system characteristics. For all variables included in our model, we first motivate them and then discuss our empirical findings.

4.1 REGIONAL MACRO FACTORS

<please insert table 5 here>

Table 5 provides estimation results of the number of coexceedances within a region with regional macro factors as 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).[5] Panels C and D display results for the US and Europe, respectively.

Following Bae et al. (2003), we include three regional macro factors – stock market volatility, exchange rate changes and the interest rate level. 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

[4] 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.

[5] 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.

higher probability of a declining market that has a negative impact on portfolio returns in general. 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). 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.

Table 5 shows that an increase in the conditional stock market 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 the 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 24% 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 19% 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.

A second macro factor is *exchange rate changes*. Banks are often exposed to different currencies and empirical evidence shows that exchange rate risk exacerbates banking system fragility during crises (e.g., Kaminsky (1999), Hutchison and Glick (2000), and Kaufman (2000)). We therefore include the average of daily exchange rate changes of all countries in the region as an independent variable in our model. The results 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. For the US and Europe, depreciation of the domestic currency is also a significant determinant.

Finally, monetary policy conditions, reflected in the *interest rate level*, are crucial elements for banking system fragility. 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 shown in Table 5 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. Interest rates do not play any role for US and Europe. The explanation may lie on 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.[6] 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.

[6] 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 et al. (2003). Therefore we choose not to report them.

4.2 REGIONAL BANKING SYSTEM CHARACTERISTICS

The central question of this paper is whether a region's 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, presence of foreign banks and wholesale funding. 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 add these regional banking system characteristics to the regression model of Subsection 4.1 one by one, as correlation among them may introduce multicollinearity problems. For each of the variables, we first provide a short motivation and then discuss the results as shown in Table 6.

<please insert table 6 here>

4.2.1 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. 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. 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)). A common implication is that greater regional banking system liquidity enhances the stability of the regional banking system. Further, a region's banking system liquidity may mitigate coordination failures in the interbank market and improve financial stability (Karas, Schoors and Lanine (2008)). We therefore hypothesize that a region's banking system liquidity

serves as a buffer against liquidity shocks. We use a narrow definition of liquidity that includes cash and cash equivalent as a ratio of total assets, and label it as *liquidity*.

Model 1 in Table 6 reveals the results. 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 the 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 briefly discuss these results in Section 6.

4.2.2 Capitalization

Ceteris paribus, a greater capitalized banking system is expected to be more stable because a higher capital base provides a cushion against insolvency. Freixas et al. (2000) and Allen and Gale (2000) further argue that a better capitalized banking system helps in reducing possible contagion effects from individual bank failures in the same country or region. With this notion we investigate whether regions with a higher aggregate degree of bank capital exhibit less banking system fragility. 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.[7] 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 of Table 6. For Asia, *capitalization* is not a significant determinant of financial fragility. For Latin America, a higher *capitalization*

[7] Liu and Mello (2008) argue that fulfilling the capital requirements at individual bank level is not sufficient to prevent systemic crisis. They provide evidence from the 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.

significantly decreases the likelihood of almost all categories of coexceedances in Model 2. 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%.

4.2.3 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 (e.g., Marcus (1984), Keeley (1990), or 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 as borrower moral hazard is exacerbated when banks charge higher loan rates to borrowers (e.g., Boyd and De Nicoló (2005)). Furthermore, concentration results in few large financial institutions that possibly engage in more risky activities because they believe they are too-big-to-fail.[8]

The existing empirical work is mainly about competition in national banking systems and its impact on either 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 Nicoló 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 (see also Liu, Molyneux and Wilson (2010)). We motivate

[8] Recent papers combine those two views. Berger, Klapper and Turk-Ariss (2009) for example argue that 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. Martínez-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 Nicoló (2005) tends to dominate in monopolistic markets whereas competition-fragility view dominates in competitive markets.

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.

We employ 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*. The results are shown in Model 3 in Table 6. We find that a higher level of *concentration* 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 Martínez-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 Nicoló (2005) tends to dominate in monopolistic markets, whereas the 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.

4.2.4 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., Stiroh (2006), Baele, De Jonghe and Vander Vennet (2007), Laeven and Levine (2007), van Lelyveld and Knot (2009), or Schmid and Walter (2009). 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 (2011) 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.

We test whether diversification in banking activities increases or decreases regional banking fragility. 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 in Table 6 reports the effect of the loan ratio on the joint occurrences of extreme negative returns in the region. The results suggest that the loan ratio is not a significant determinant. For Asia and Latin America we find that the loan ratio increases the probability of one exceedance, but has no effect for a larger number of coexceedances. For US and Europe we do not find any effect.

4.2.5 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 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)).

The results on foreign banks are reported in Model 5 in Table 6. We find that a larger presence of foreign banks provides more financial stability for Asia and Latin America as it decreases the likelihood of coexceedances for both regions. 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. The mixed results are consistent

with the conclusions from De Haas and van Lelyveld (2013). While multinational banks may contribute to financial stability when the origin of the crisis is domestic (i.e., subsidiaries receive the support of the parent bank), they may also increase the risk of importing negative shocks from other regions.

4.2.6 Wholesale funding

The funding structure of banks may play a role in the resilience of a financial system. Wholesale funding may be a less stable source of funding. Huang and Ratnovski (2009) for example find that Canadian banks that rely less on wholesale funding are a more stable source of lending during the crisis. De Haas and van Lelyveld (2013) find a differential impact of wholesale funding before and during the 2007-2009 crisis. Whereas before the crisis a greater reliance on wholesale funding allowed to dampen shocks, the opposite results applied during the crisis with retail deposits being a more stable source of funding.

Model 6 in Table 6 reports the results for *wholesale funding*. The evidence for the US suggests that a larger percentage of lending financed by non-deposit sources may lead to more financial fragility. However, for Europe we find no effect. And while for Asia higher wholesale funding increases the likelihood of four or more coexcedances, higher wholesale funding *decrease*s significantly the likelihood of one exceedance and two coexceedances. Larger percentage of wholesale funding also seems to reduce financial fragility in Latin America, where there is a significance fall in the probability of two and four coexceedances. This is consistent with the findings by Rojas-Suarez and Weisbrod (1995) and Rojas-Suarez (2002). They show that, during the early phases of a banking crisis, Latin American countries experience larger falls in the ratio of deposits to GDP than industrialized countries. They conclude that depositors in Latin America, due to a long history of recurrent crises, fear that they will suffer a real financial loss following a banking crisis, while depositors in other countries who do not have a history of so many crises, take more time to react.

<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. The response curves also show that *foreign banks* reduce the probability of coexceedances in Asia and Latin America. Finally, for *wholesale funding*, the graphs do not support the conjecture that wholesale funding increases financial fragility, neither for Asia nor for Latin America.

5 CROSS-REGIONAL CONTAGION

5.1 THE EXTENDED MODEL

We now investigate whether there is any evidence for contagion across regions. We capture the impact of cross-regional contagion by including a measure of financial fragility in the triggering regions as explanatory variables while controlling for *all* macro factors and *all* banking characteristics in the host region. Furthermore, to account for common factors that may affect both the triggering regions and the host region we also control for the conditional volatility of *all* triggering regions.

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 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. 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.

<please insert table 7 here>

In Table 7 we report the results of cross-regional contagion for Asia, Latin America, US and Europe. 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, the host region's macro factors, and the conditional volatility of all the triggering regions, then we interpret this as the evidence of contagion from that particular triggering region.

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.

5.2 CROSS-REGIONAL CONTAGION AND BANKING SYSTEM CHARACTERISTICS

We now turn to investigate 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, diversification, presence of foreign banks, and wholesale funding 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, the presence of foreign banks and the amount of lending funded by non-deposit sources 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 of the specifications in Table 7, an interaction term of one banking characteristic with the financial fragility measure of one of the triggering regions. Therefore, for each host region, we run 18 regressions (i.e., one for each banking characteristic and for each triggering region's financial fragility measure). 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.

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

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, capitalization reduces the impact of contagion from the US, in Europe it attenuates contagion from Asia, and in the US capitalization reduces contagion from 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.

For *concentration* and for the *loan ratio*, Table 8 shows that the signs differ across regions providing no conclusive evidence. 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. Finally, for *wholesale funding*, the signs also differ across regions. For Europe, when the average effect is significant, it is positive; suggesting that reliance on non-deposit sources of funds exacerbates the probability of contagion. However, for Latin America and the US, more wholesale funding *decreases* the probability of being in the lower tail.

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 coexceedances. 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 macro 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 coexceedances 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 coexceedances 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 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 and a higher reliance on non-deposit sources also reduces regional banking system fragility. In contrast, regional banking fragility increases in the US when there is a larger presence of foreign banks and when wholesale funding is higher. We further investigate the possibility of contagion across regions. 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						**0.05**								**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 Europe. 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). Latin American countries include Argentina (ARG), Brazil (BRA), Chile (CHI), Colombia (COL), Mexico (MEX), Peru (PER) and Venezuela (VEN).We report the 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 the 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 are presented in **bold,** and are associated with the block of correlations above the statistic.

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 the 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 the 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 exceedances and highest 5% are labeled as positive exceedances. Moreover, *coexceedances* happen 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 exceeds. 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 coexceeding. The first (last) column give mean returns when 4 or more countries have negative (positive) coexceedance. The bottom row 'Total' provides mean return irrespective of which countries are included, whereas numbers associated with a country are the 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. 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 the 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, we use country-weighted average of exchange rate against USD of Euro currencies for daily observations prior to the introduction of the Euro. The second column represents mean and standard deviation of daily percentage change in exchange rate for each country. To obtain regional values, we take an equal-weighted average of daily changes in exchange rate of all countries in the region. Lastly, the 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		Wholesale Funding	
Characteristics	Mean	Std Dev.	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	0.763	0.105
KOR	0.054	0.010	0.051	0.011	0.464	0.064	0.584	0.034	0.116	0.098	0.820	0.099
PHL	0.037	0.015	0.118	0.011	0.597	0.049	0.432	0.065	0.142	0.015	0.688	0.093
TWN	0.022	0.005	0.077	0.010	0.490	0.110	0.492	0.049	N/A	N/A	0.999	0.192
INA	0.125	0.019	0.065	0.006	0.495	0.062	0.480	0.080	0.086	0.016	0.737	0.166
IND	0.050	0.022	0.079	0.092	0.693	0.096	0.536	0.132	0.327	0.058	0.954	0.311
MAL	0.022	0.014	0.088	0.015	0.442	0.063	0.601	0.035	0.283	0.029	0.695	0.029
PAK	0.116	0.025	0.062	0.040	0.789	0.138	0.475	0.077	0.150	0.088	0.598	0.062
SRI	0.017	0.006	0.077	0.025	0.825	0.118	0.532	0.041	0.000	0.000	1.121	0.491
THA	0.024	0.004	0.065	0.022	0.603	0.065	0.637	0.050	0.127	0.036	1.006	0.103
Asia	**0.028**	**0.009**	**0.053**	**0.003**	**0.625**	**0.043**	**0.540**	**0.052**	**0.148**	**0.032**	**0.826**	**0.076**
ARG	0.025	0.010	0.111	0.013	0.593	0.075	0.469	0.147	0.328	0.047	0.773	0.104
BRA	0.015	0.004	0.078	0.007	0.545	0.073	0.355	0.032	0.329	0.042	0.801	0.142
CHI	0.058	0.016	0.047	0.013	0.746	0.076	0.617	0.074	0.464	0.040	0.972	0.134
COL	0.033	0.013	0.201	0.046	0.571	0.085	0.576	0.131	0.263	0.029	0.840	0.106
MEX	0.039	0.023	0.087	0.024	0.648	0.133	0.629	0.083	0.467	0.066	0.815	0.133
PER	0.080	0.114	0.073	0.014	0.807	0.047	0.472	0.066	0.536	0.098	0.765	0.066
VEN	0.106	0.030	0.158	0.060	0.758	0.085	0.362	0.134	0.223	0.051	0.609	0.165
Latin America	**0.029**	**0.005**	**0.087**	**0.009**	**0.593**	**0.053**	**0.444**	**0.031**	**0.373**	**0.042**	**0.795**	**0.059**
United States	**0.028**	**0.007**	**0.070**	**0.004**	**0.146**	**0.010**	**0.508**	**0.031**	**0.199**	**0.038**	**0.777**	**0.032**
Europe	**0.018**	**0.002**	**0.047**	**0.002**	**0.093**	**0.009**	**0.500**	**0.024**	**0.335**	**0.038**	**0.811**	**0.112**

The table reports mean and standard deviation of banking system characteristics during the sample period for each country from July 01, 1994 to December 31, 2008. 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 the total assets of the biggest five banks to total assets of all banks (i.e. C5 measure) for each country in the region. Loan ratio is calculated as net loans to total earning assets for each country. Foreign banks is the ratio of total assets of foreign banks to the banking system of the country. Finally, wholesale funding is the ratio of net loans to the sum of demand deposits and other short-term funding. Regional variables for Asia and Latin America are obtained as a weighted-average of individual countries using total assets of banking system as weights.

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]	0.003			0.0913 [a]	0.003
Exchange Rate Changes				-0.3820 [b]	-0.014			0.2094 [b]	0.008
Interest Rate Level				0.0216	0.001			-0.0101	0.000
Log-Likelihood				-669.23				-651.01	
Pseudo-R^2				0.1118				0.1359	

The first column of each Panel shows the number of coexceedances and relative frequency for a specific region. We use the number of coexceedances of daily returns as dependent variable in a multinomial logistic 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 a binomial logistic model with a binary dependent variable equal to one when there is an exceedance on a given day, 0 otherwise. [a, b,] and [c] denotes significance level of 1%, 5% and 10% respectively.

Table 6: Banking System Characteristics and Regional Banking System Fragility

Negative		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Coexceedances		Coeff	Chg Prob	Coeff	Chg Prob	Coeff	Chg Prob	Coeff	Chg Prob	Coeff	Chg Prob	Coeff	Chg Prob
		Panel A: Asia											
Control for Macro													
Conditional Volatility		YES		YES		YES		YES		YES		YES	
Exchange Rate Changes		YES		YES		YES		YES		YES		YES	
Interest Rate Level		YES		YES		YES		YES		YES		YES	
Banking Characteristics													
Liquidity	1	-14.59 [c]	-2.01										
	2	-31.03 [b]	-1.31										
	3	-36.47 [c]	-0.50										
	>=4	-83.24 [a]	-0.52										
Capitalization	1			9.01	1.33								
	2			14.39	0.57								
	3			46.59	0.70								
	>=4			-17.29	-0.16								
Concentration	1					5.77 [a]	0.97						
	2					6.40 [a]	0.24						
	3					4.21	0.04						
	>=4					-1.85	-0.03						
Loan Ratio	1							5.99 [a]	1.11				
	2							1.58	0.01				
	3							1.57	0.00				
	>=4							-16.78	-0.13				
Foreign Banks	1									-7.03 [a]	-1.18		
	2									-10.45 [a]	-0.44		
	3									-0.78	0.02		
	>=4									12.13	0.10		
Wholesale Funding	1											-2.09 [a]	-0.37
	2											-1.64 [c]	-0.06
	3											0.23	0.01
	>=4											5.25 [b]	0.04
Constant		YES		YES		YES		YES		YES		YES	
Log-Likelihood		-3076.3		-3082.3		-3063.9		-3074.8		-2979.5		-3071.4	
Pseudo-R^2		0.08		0.07		0.08		0.08		0.08		0.08	
		Panel C: US											
Control for Macro													
Conditional Volatility		YES		YES		YES		YES		YES		YES	
Exchange Rate Changes		YES		YES		YES		YES		YES		YES	
Interest Rate Level		YES		YES		YES		YES		YES		YES	
Banking Characteristics													
Liquidity		-34.95 [b]	-1.32										
Capitalization				-46.51 [b]	-1.75								
Concentration						32.83 [a]	1.20						
Loan Ratio								-3.19	-0.12				
Foreign Banks										5.90 [b]	0.25		
Wholesale Funding												5.92 [b]	0.22
Constant		YES		YES		YES		YES		YES		YES	
Log-Likelihood		-666.6		-668.2		-657.6		-668.7		-656.0		-666.3	
Pseudo-R^2		0.12		0.11		0.13		0.11		0.10		0.12	

We use the number of coexceedances of daily returns as dependent variable in a multinomial logistic 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 a regional banking system characteristic, besides controlling for common macro factors. In case of the US and Europe, we use a binomial logistic model with a binary dependent variable equal to one when there is an exceedance on a given day, and zero otherwise. The 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 6 (cont'd): Banking System Characteristics and Regional Banking System Fragility

Negative		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Coexceedances		Coeff	Chg Prob	Coeff	Chg Prob	Coeff	Chg Prob	Coeff	Chg Prob	Coeff	Chg Pro	Coeff	Chg Prob
		Panel B: Latin America											
Control for Macro													
Conditional Volatility		YES		YES		YES		YES		YES		YES	
Exchange Rate Changes		YES		YES		YES		YES		YES		YES	
Interest Rate Level		YES		YES		YES		YES		YES		YES	
Banking Characteristics													
Liquidity	1	-51.98 [a]	-7.04										
	2	-100.50 [a]	-2.37										
	3	-99.98 [b]	-0.66										
	>=4	-212.60 [a]	-0.60										
Capitalization	1			-32.98 [a]	-4.59								
	2			-50.56 [a]	-1.19								
	3			-34.10	-0.21								
	>=4			-71.67 [b]	-0.24								
Concentration	1					5.82 [a]	0.82						
	2					7.75 [a]	0.18						
	3					3.35	0.02						
	>=4					11.15 [c]	0.04						
Loan Ratio	1							5.34 [a]	0.77				
	2							5.58	0.13				
	3							1.97	0.01				
	>=4							4.18	0.01				
Foreign Banks	1									-3.47 [a]	-0.45		
	2									-8.98 [a]	-0.22		
	3									-8.44 [b]	-0.06		
	>=4									-12.08 [b]	-0.04		
Wholesale Funding	1											-1.04	-0.11
	2											-5.78 [b]	-0.15
	3											-4.88	-0.04
	>=4											-10.57 [b]	-0.04
Constant		YES		YES		YES		YES		YES		YES	
Log-Likelihood		-2396.9		-2406.9		-2409.4		-2418.9		-2303.9		-2418.8	
Pseudo-R^2		0.07		0.06		0.06		0.06		0.06		0.06	
		Panel D: Europe											
Control for Macro													
Conditional Volatility		YES		YES		YES		YES		YES		YES	
Exchange Rate Changes		YES		YES		YES		YES		YES		YES	
Interest Rate Level		YES		YES		YES		YES		YES		YES	
Banking Characteristics													
Liquidity		-73.17 [a]	-2.65										
Capitalization				-2.64	-0.10								
Concentration						38.66 [a]	1.34						
Loan Ratio								-2.90	-0.11				
Foreign Banks										0.21	0.01		
Wholesale Funding												1.35	0.05
Constant		YES		YES		YES		YES		YES		YES	
Log-Likelihood		-650.2		-651.0		-644.6		-650.6		-633.5		-650.3	
Pseudo-R^2		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 a multinomial logistic 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 a regional banking system characteristic, besides controlling for common macro factors. In case of the US and Europe, we use a binomial logistic model with a binary dependent variable equal to one when there is an exceedance on a given day, and zero otherwise. The 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
Constant		YES		YES	
Control for Macro Factors		YES		YES	
Control for Banking Characteristics		YES		YES	
Control for Conditional Volatility in Triggering Regions		YES		YES	
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
Log-Likelihood		-2977.7		-2287.1	
Pseudo-R^2		0.1046		0.1088	
		Panel C: US		**Panel D: Europe**	
Constant		YES		YES	
Control for Macro Factors		YES		YES	
Control for Banking Characteristics		YES		YES	
Control for Conditional Volatility in Triggering Regions		YES		YES	
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		
Log-Likelihood		-557.6		-537.0	
Pseudo-R^2		0.2461		0.2711	

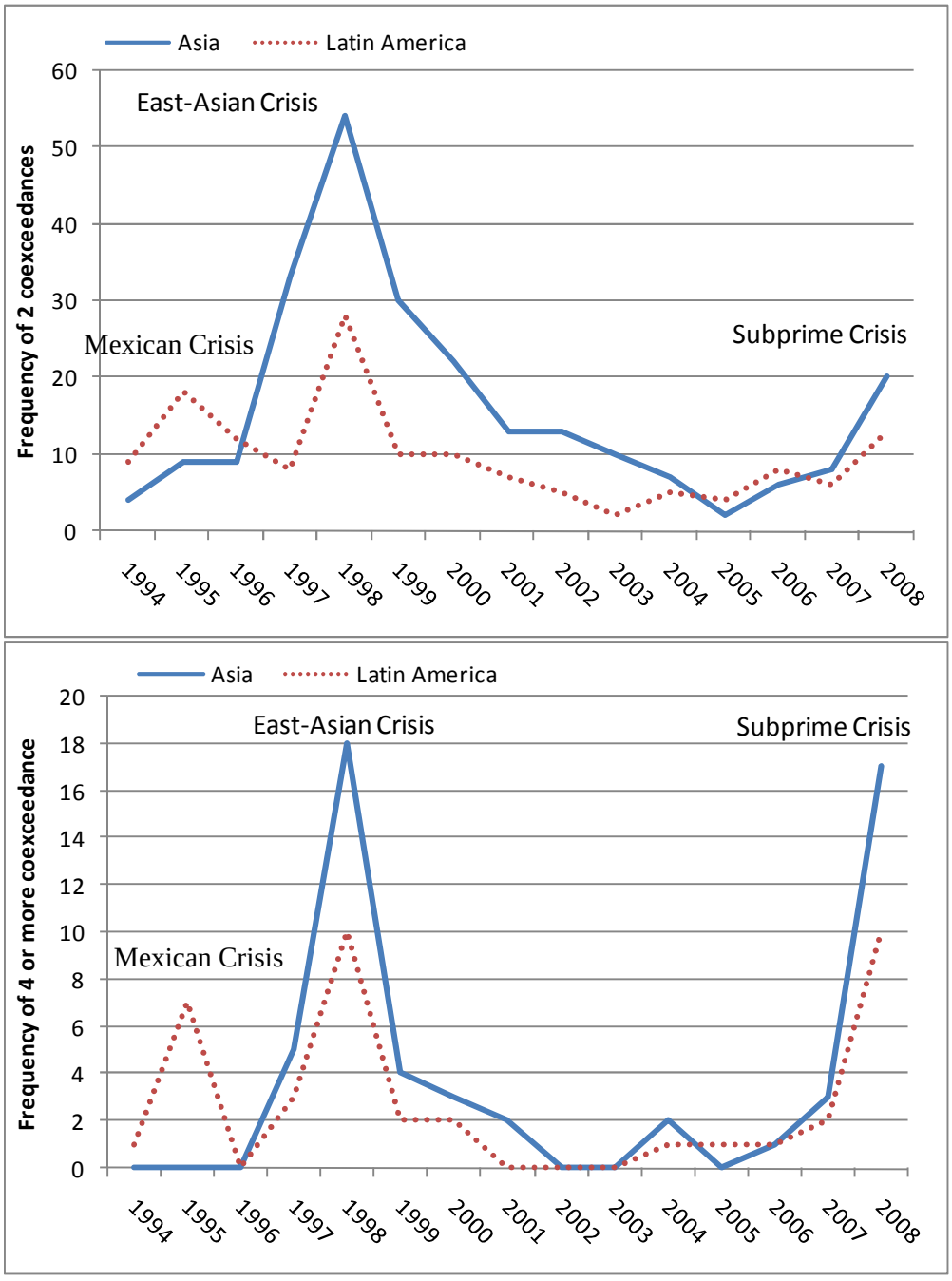
The four panels in Table 7 report the results for cross-regional contagion for Asia, Latin America, US and Europe, respectively. We use the number of coexceedances in the host region as dependent variable and include macro variables and banking characteristics of the host region as well as the conditional volatility in the triggering regions besides number of coexceedances in the triggering region as explanatory variables. For Asia and Latin America we use a multinomial logistics model whereas for the US and Europe we use a binomial model. [a, b, c] denotes significance levels at the 1%, 5% and 10% level respectively.

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

Interaction Effect	Liquidity	Capitalization	Concentration	Loan Ratio	Foreign bank	Wholes. Fund.
Constant	YES	YES	YES	YES	YES	YES
Control for Macro Factors	YES	YES	YES	YES	YES	YES
Control for Financial Fragility in All Triggering Regions	YES	YES	YES	YES	YES	YES
Control for Cond. Vol. in All Triggering Regions	YES	YES	YES	YES	YES	YES
	Panel A: Cross-Regional Contagion to Asia					
Neg. Coex. In Asia						
Neg. Coex. In Latin America	-5.452 [c]	3.895	0.145	0.315	-0.304	-0.083
Neg. Coex. In USA	-2.501	10.488	-0.767 [b]	-0.481	0.483 [c]	0.259
Neg. Coex. In Europe	-1.279	-0.674	-1.457 [a]	-1.790 [c]	0.837 [b]	0.679
	Panel B: Cross-Regional Contagion to Latin America					
Neg. Coex. In Asia	-2.771	-1.187	0.191	-0.547	-0.575	-0.470
Neg. Coex. In Latin America						
Neg. Coex. In USA	-17.526 [a]	-12.813 [a]	1.893 [b]	1.085	-2.346 [a]	-1.688 [c]
Neg. Coex. In Europe	-4.893	-1.988	0.474	-0.194	-1.693	-1.202
	Panel C: Cross-Regional Contagion to US					
Neg. Coex. In Asia	2.453	-0.540	-2.330 [a]	0.623 [b]	-0.417 [c]	-0.502 [c]
Neg. Coex. In Latin America	6.027	-17.723 [b]	-1.320 [a]	1.093	-0.924 [a]	0.464
Neg. Coex. In USA						
Neg. Coex. In Europe	-2.483	0.819	0.292 [a]	-0.288	0.428	-0.718
	Panel D: Cross-Regional Contagion to Europe					
Neg. Coex. In Asia	4.977	-14.461 [a]	1.108	-1.480 [a]	0.934 [b]	0.505 [b]
Neg. Coex. In Latin America	-8.352 [b]	-5.157	-3.032 [b]	-0.450	0.462	0.242
Neg. Coex. In USA	10.204	17.789	-6.988 [a]	0.427	0.735	0.064
Neg. Coex. In Europe						

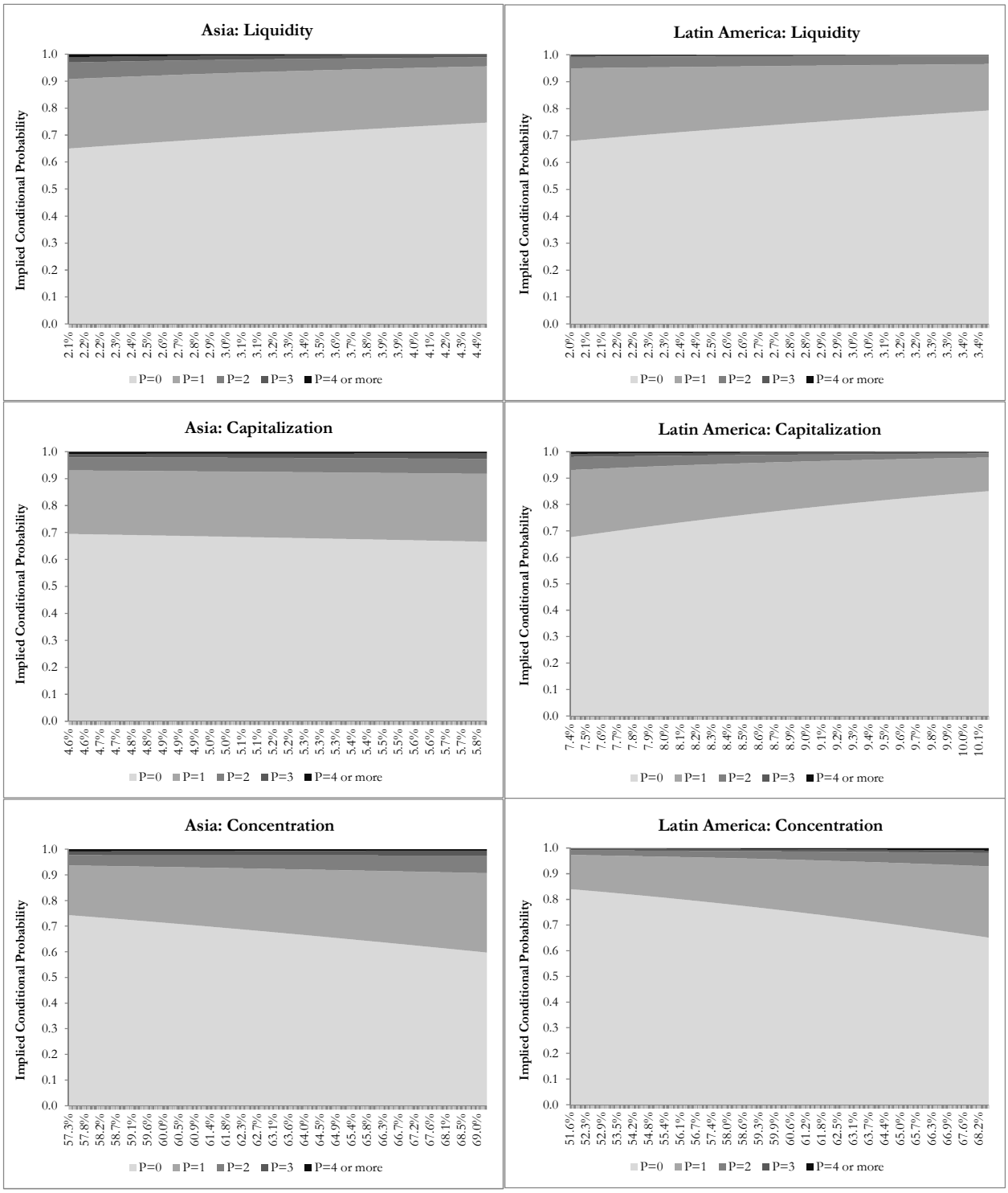
Table 8 reports the average interaction effect from the Ai and Norton methodology (2003) and its statistical significance for 72 different regressions (18 for each host region). For our analysis in this Table, we first converted the number of coexceedances into a binary model (i.e. for Asia and Latin America we give the value 1 capturing financial fragility when 2 or more coexceedances occur in the region and give a value of zero otherwise). Each logit regression has the financial fragility in the host region as dependent variable. The control variables in all regressions are the macro factors in the host region, the financial fragility measure of the three triggering regions, and the conditional volatility in the three triggering regions. In each regression we add to these controls a specific bank characteristic, and an interaction of the specific bank characteristic with the financial fragility measure of a specific triggering region. We therefore run 18 regressions for each host region, one for each banking characteristic and triggering region. [a, b, c] denotes significance levels at the 1%, 5% and 10% level respectively.

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



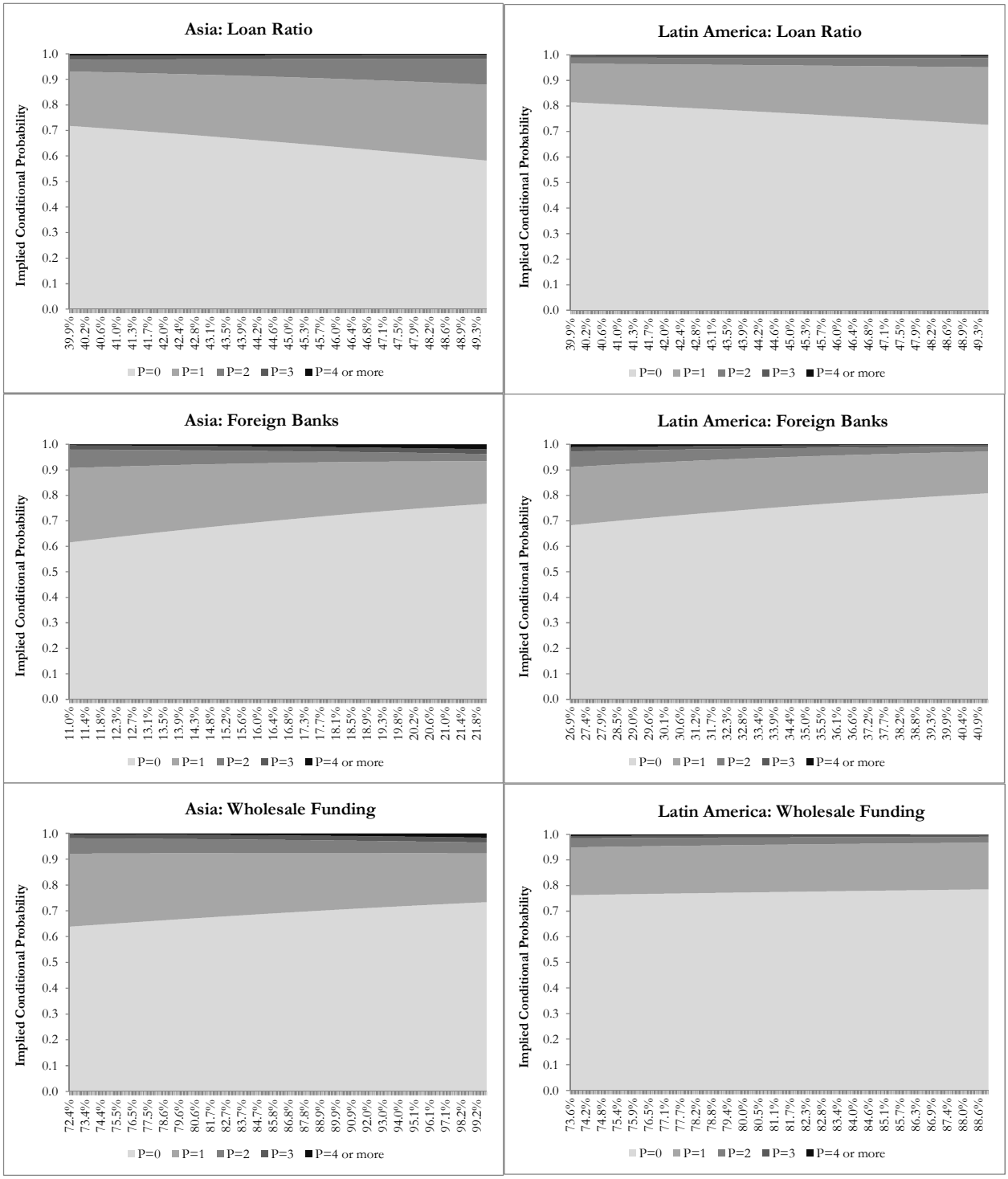
We measure the frequency of coexceedances in calendar year in our sample period. Upper graph reports the frequency of 2 coexceedances (i.e. how frequent are 2 countries have negative extreme returns on banking indices on the same day). Lower graph shows the joint occurrences more extreme shocks when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



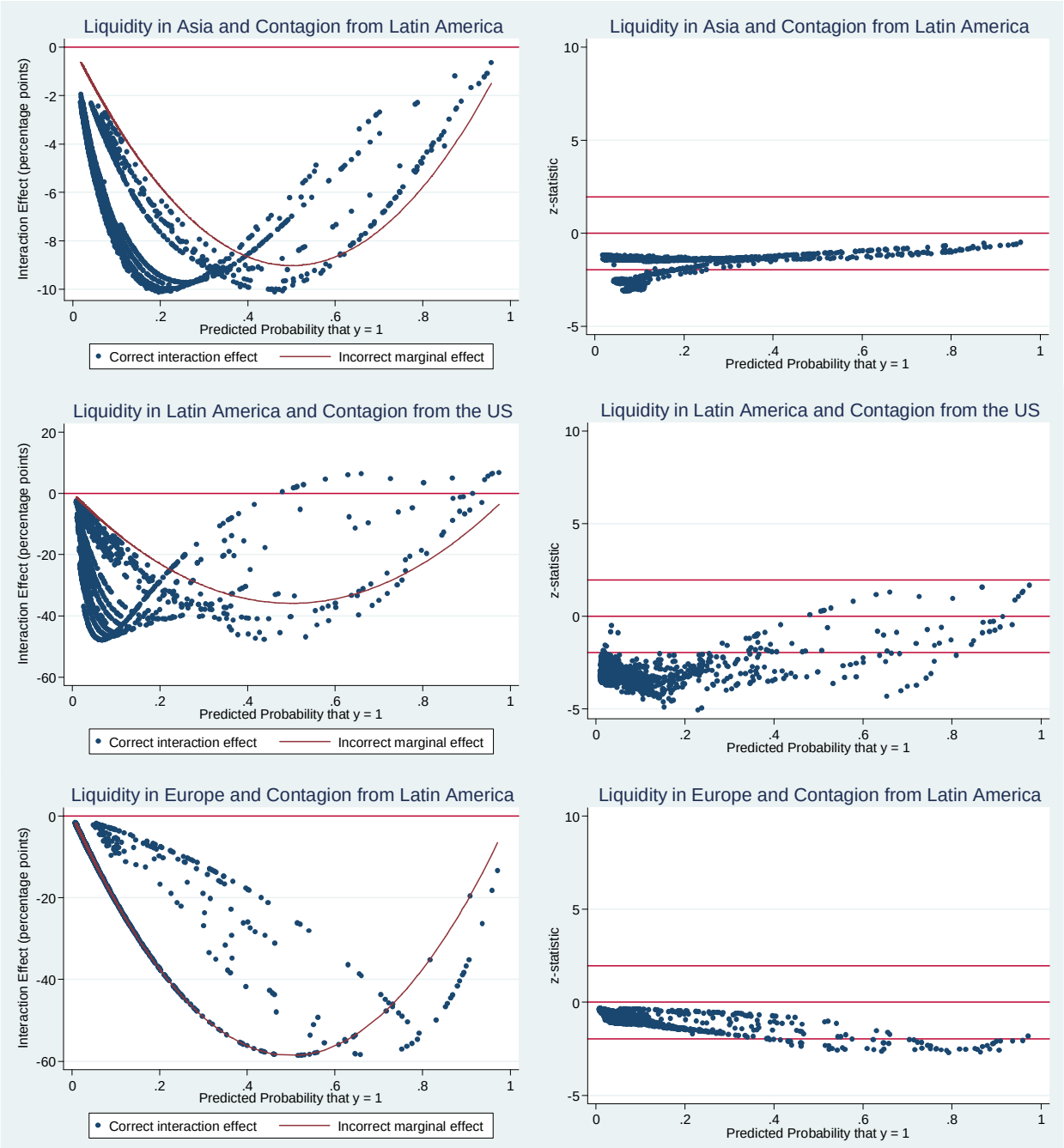
This shows the response of the probability measures for the *full range* of values of each banking characteristic, instead of focusing on the average value as is the case in the marginal probabilities reported in the Tables 5 and 6

Figure 2 (cont'd): Coexceedance Response Curve of Banking Characteristics in Asia and Latin America



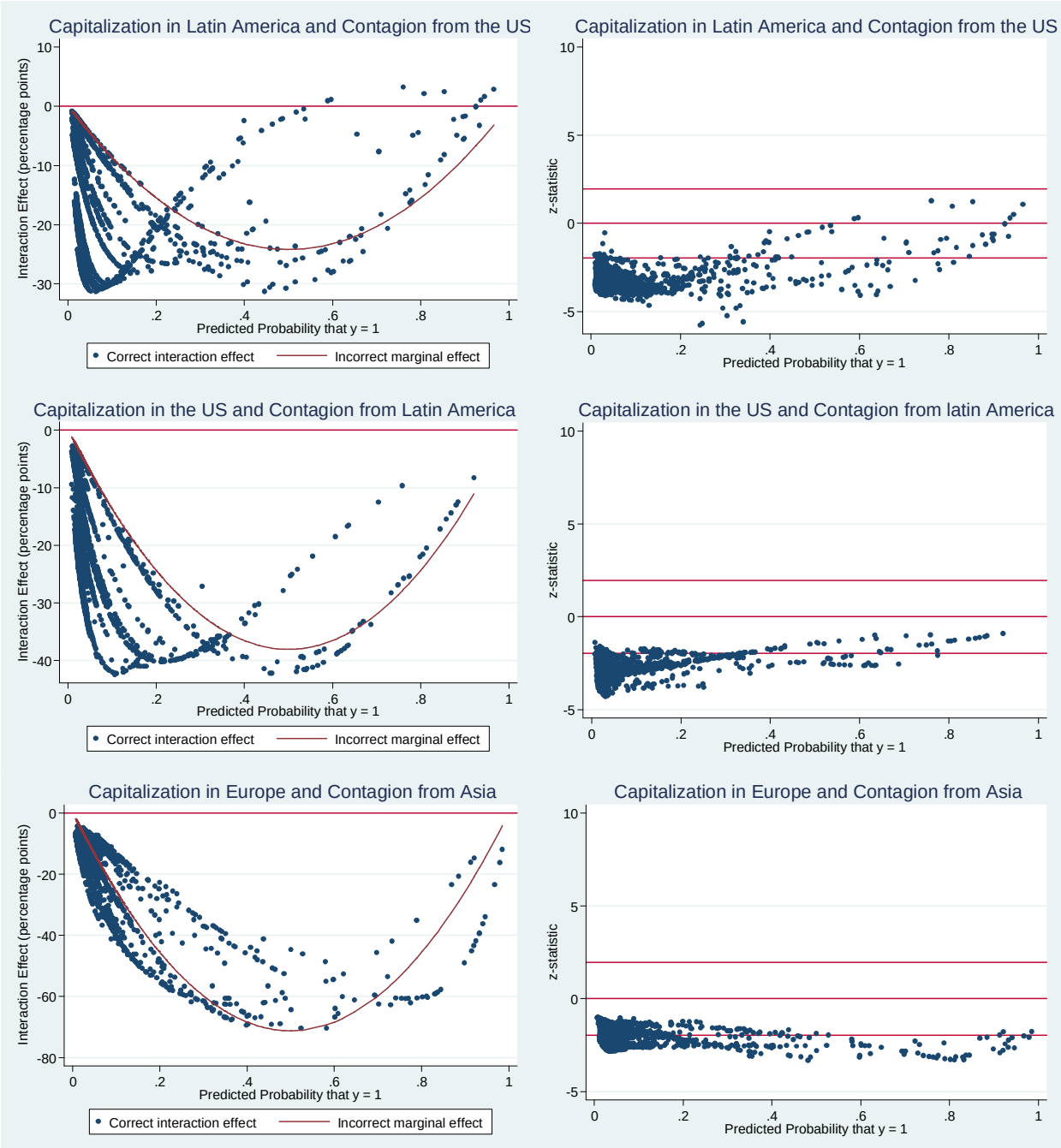
This shows the response of the probability measures for the *full range* of values of each banking characteristic, instead of focusing on the average value as is the case in the marginal probabilities reported in the Tables 5 and 6

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.