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# GLOBAL CRISES AND EQUITY MARKET CONTAGION

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**ABSTRACT**

Using the 2007-2009 financial crisis as a laboratory, we analyze the transmission of crises to country-industry equity portfolios in 55 countries. We use an asset pricing framework with global and local factors to predict crisis returns, defining unexplained increases in factor loadings as indicative of contagion. We find evidence of systematic contagion from US markets and from the global financial sector, but the effects are very small. By contrast, there has been systematic and substantial contagion from domestic equity markets to individual domestic equity portfolios, with its severity inversely related to the quality of countries' economic fundamentals and policies. Consequently, we reject the globalization hypothesis that links the transmission of the crisis to the extent of global exposure. Instead, we confirm the old "wake-up call" hypothesis, with markets and investors focusing substantially more on idiosyncratic, country-specific characteristics during the crisis.

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Ever since the seminal work of King and Wadhwani (1990) following the global October 1987 stock market crash, the international finance literature has studied how shocks are transmitted across borders. Words with negative connotations such as "volatility spillovers" (e.g. Engle, Ito and Lin (1990); Masulis, Hamao and Ng (1990)) and "contagion" have been coined to indicate shock transmission that could not be explained by fundamentals or co-movements that were viewed as "excessive." Countless papers have been written proposing quantitative measures of contagion (see Dungey et al. (2004) for a survey) or developing theories to explain it (see Karolyi (2003) for a survey).

The financial crisis of 2007-09 has arguably been the first truly major global crisis since the Great Depression of 1929-32. While the crisis initially had its origin in the United States in a relatively small segment of the lending market, the sub-prime mortgage market, it rapidly spread across virtually all economies, both advanced and emerging, as well as across economic sectors. It also affected equity markets worldwide, with many countries experiencing even sharper equity market crashes than the United States, making it an ideal laboratory to revisit the debate about the presence and sources of "contagion" in equity markets.

This article studies how and why the crisis spread so violently across countries and economic sectors. We develop a three-factor asset-pricing model to set a benchmark for what global equity market co-movements should expected to be, based on existing fundamentals. This model distinguishes between a US-specific factor, a global financial factor and a domestic factor for the pricing of 415 country-sector equity portfolios across 55 countries worldwide, covering more than 85% of world equity market capitalization. In our most general specification, exposures to the factors may depend on firm-specific characteristics (the degree of financing constraints and interest rate exposure, for example), country-specific characteristics, measuring either the degree of financial and trade integration or macroeconomic and financial fundamentals (current account deficit, political risk, etc.), and global risk and liquidity indicators.

We define contagion as the co-movement in excess of that implied by the factor model, i.e. above and beyond what can be explained by fundamentals taking into account their natural evolution over time. This contrasts with many contagion articles simply comparing co-movements before and during the crisis. The inclusion of three different factors in our model enables us to distinguish between three distinct *types of contagion*. Contagion may stem from the US or from the global financial sector, implying a high co-movement of domestic sector portfolios with the US or global factors – and this may result if real and financial linkages to the US or the global economy are considered particularly important during a financial crisis or because domestic fundamentals are especially vulnerable to global or US shocks during a crisis. We will label these "US contagion" and "global contagion", respectively. Alternatively, while investors may continue to discriminate *across* countries in response to global or US-specific shocks during crises, they may discriminate less across stocks *within* countries in response to idiosyncratic, country-specific shocks, thus giving rise to what we call "domestic contagion".

Moreover, our framework allows us not only to test for the presence of different types of contagion but also to disentangle the channels of contagion by testing whether and how the factor exposures to the various instruments change during the crisis. In particular, we distinguish between two alternative hypotheses. The first hypothesis, or what we call the "globalization hypothesis", implies that contagion during crises hits hardest those economies that are highly integrated globally, such as through trade and financial linkages. The alternative hypothesis, or what we refer to as the "wake-up call hypothesis", states that a crisis initially restricted to one market segment or country provides new information that may prompt investors to reassess the vulnerability of other market segments or countries, which spreads the crisis across markets and borders (Goldstein, 1998; Masson, 1999; Goldstein, Kaminsky and Reinhart, 2000).[1] Under this hypothesis, domestic fundamentals are likely to play a dominant role in the transmission of the crisis. Another possibility is that contagion occurs without discrimination at all, driven by herding behavior or investors' risk appetite beyond the effect of fundamentals, or at least unrelated to observable fundamentals.

Overall we find statistically significant but economically small evidence of systematic contagion from US markets and the global financial sector to equity markets in the 55 countries of our sample during the 2007-09 financial crisis. By contrast, we find strong evidence of domestic contagion: the co-movement of portfolios within a country increased systematically during the crisis, above and beyond what can be accounted for by underlying fundamentals. Such contagion from domestic markets appears to have been present in all regions and for most sectors. Moreover, domestic contagion has been large, with betas with respect to the domestic factor portfolio increasing on average by 50%.

Taken together, the evidence thus suggests that contagion during the 2007-09 financial crisis was mostly domestic in nature and did not stem systematically from the United States or the global banking sector.

This finding of the importance of domestic contagion for the global transmission of the 2007-09 crisis is robust to several alternative model specifications and sensitivity tests. Interestingly, this feature seems quite specific to the 2007-09 crisis, as there is no evidence that domestic contagion played a role in past crises, such as the 1998 LTCM crisis or the 2000-02 bust of the TMT bubble.

A further striking feature of the crisis has been the high degree of heterogeneity in contagion across country-sector equity portfolios. While, *overall*, there is only limited contagion from US markets or the global financial sector, some of the individual equity portfolios have experienced substantial contagion from these markets during the financial crisis. For instance, Emerging Europe, which shows relatively limited interdependence with US markets, has seen strong contagion from US markets during the crisis. The same holds for some sectors that are relatively less integrated with US markets (energy, basic materials), while firms in sectors previously highly integrated with US markets, such as technology, experienced a decoupling, or "negative" contagion, from US markets during the crisis. A similar pattern, though much stronger, is also observed for the distribution of domestic contagion. Strikingly, overall contagion and pre-crisis external exposure are *negatively* correlated.

Studying the transmission channels during the financial crisis provides further insights. The globalization hypothesis is clearly rejected: differences in external exposure instruments – such as trade openness, or financial depth, do not explain contagion. Neither do firm-specific determinants, such as the degree of financial constraints, the exchange rate exposure or the interest rate exposure of firms. Risk indicators matter in normal times, but the extreme co-movements between various portfolios during the crisis are linked *negatively* to the evolution of risk indicators. Instead, we find that countries with poor macroeconomic fundamentals, high sovereign risk and poor institutions experienced by far the largest equity market declines and contagion. In particular the size of FX reserves, the current account position and the sovereign rating of countries are three of the factors that exerted a highly significant and economically sizeable effect on the overall equity market performance of countries in the crisis.

This evidence in support of the wake-up call hypothesis opens up the intriguing possibility that government policy can mitigate contagion. If macro-fundamentals matter so much during a crisis, cross-country differences in government policy may explain the relative exposure to the crisis. Therefore we study the role of various financial policies introduced during the crisis (debt and deposit guarantees and capital injections) which, in essence, transfer risk on a massive scale from individual firms (not just in the financial sector) to governments. We find that the introduction of debt guarantees and deposit guarantees during the crisis helped insulate domestic equity markets to an economically and statistically significant extent from the impact of the crisis, through reducing the exposures to global, US and domestic factors. For instance, the introduction or extension of debt or deposit guarantees during the crisis reduced the exposure of equity portfolios to the global factor by more than 30% compared to the global factor exposure in countries that did not introduce such policies.

Our work contributes mainly to two literatures. First, there is the vast literature on international market integration, shock transmission and contagion. Our approach does not suffer from the volatility bias described in the seminal work of Forbes and Rigobon (2002), and owes most to the factor model approach in Bekaert, Harvey and Ng (2005), who also define contagion as excessive co-movement over and above the predictions of a factor model. What we add is the idea of studying in detail the sources of contagion, allowing us to differentiate several economic hypotheses regarding contagion.

Second, our work relates to the growing literature on the 2007-2009 global financial crisis, more specifically, to the small, but rapidly growing literature that tries to uncover the drivers of transmission of the crisis across firms and markets *within the US*, including Tong and Wei (2009), Almeida et al. (2009) and Diebold and Yilmaz (2010).

Closer to our research, however, is the literature on the transmission of the crisis *globally* through macro and financial channels. Key contemporaneous papers include Tong and Wei (forthcoming) who find that the average decline in stock prices during the crisis in a sample of 4000 firms in 24 emerging countries was more severe for those firms intrinsically more dependent on external finance (in particular on bank lending and portfolio flows). In a related vein, Stulz and Beltratti (2009) investigate whether the variation in the cross-section of stock returns of large banks across the world during the crisis is related to bank-level governance, country-level governance, country-level regulation, as well as to bank balance sheet and profitability characteristics before the crisis. Eichengreen et al. (2009) find that the global crisis significantly increased the importance of common factors in the movements of banks' credit default swap spreads. From a more macro perspective, Rose and Spiegel (forthcoming) find limited evidence that international linkages were associated with the incidence of the crisis and in particular claim that countries heavily exposed to either U.S. assets or trade behaved similarly to other countries. Rose and Spiegel (2010) additionally find that countries with current account surpluses were better insulated from the crisis. Frankel and Saravelos (2010) find that international reserves and real exchange rate over-valuation are useful leading indicators in the 2008-2009 crisis, but their crisis definition involves real economic variables and exchange rates in addition to equity markets. Finally, Calomiris, Love and Martinez Peria (2010) focus on firm-specific "shock factors" which arise as a result of an unexpected crisis event and find that credit supply shocks, global demand shocks and selling pressures in the equity market had a negative effect on global stock returns during the crisis (August 2007 to December 2008) but a positive or insignificant effect during their placebo period (August 2005 to December 2006).

The paper is organized as follows. The first section presents the empirical framework, defining and distinguishing between market interdependence and contagion. Section II contains the empirical findings first contrasting how a pure "interdependence" model fares relative to a model accommodating "contagion" before analyzing the sources of contagion. Section III summarizes the findings and concludes.

## I. Empirical framework

This section outlines the model we estimate, contrasts the concepts of interdependence and contagion and discusses estimation issues.

### A. The asset-pricing model

We formulate an international factor model with three factors, a US factor, a global financial factor, and a domestic market factor, $F_t' = [R_t^U, R_t^G, R_t^D]$. The three factors are value-weighted market indices, so that the model potentially embeds different CAPMs as special cases: when the betas on the first two factors are zero, the model becomes a domestic CAPM; when the beta of the domestic factor is set to zero, the model can act as a World CAPM.[2] The choice of these three factors allows studying whether the global dimension of the 2007-09 crisis mainly reflected a global financial shock, a shock specific to the US economy that subsequently spread globally, or to what extent there was an element of increased vulnerability at the country or firm level that spread the crisis.

The full model looks as follows:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,t}' F_t + \eta_{i,t-1} CR_t + e_{i,t} \quad (1)$$

$$\beta_{i,t} = \beta_{i,0} + \beta_1' Z_{i,t-k} + \gamma_{i,t-1} CR_t \quad (2)$$

$$\gamma_{i,t-1} = \gamma_{i,0} + \gamma_1' Z_{i,t-k} \quad (3)$$

$$\eta_{i,t-1} = \eta_{i,0} + \eta_1' Z_{i,t-k} \quad (4)$$

where $R_{i,t}$ is the excess return of portfolio $i$ during week $t$ (the return less the three month US T-bill rate in weekly units), $E_{t-1}[R_{i,t}]$ is the expected excess return, measured as a linear function of the lagged excess return and the local dividend yield, $F_t$ is the vector of the three observable factors, $CR_t$ a crisis dummy, and $Z_{i,t}$ a vector of exogenous control variables, which are typically lagged by two quarters. The sample period is 1 January 1995 to 15 March 2009, i.e. it ends with the trough of the global equity market during the crisis. The sample contains about 725 weekly observations for our 415 country-sector equity portfolios. We define the financial crisis to begin on 7 August 2007, but later report a robustness analysis using the collapse of Lehman Brothers on 15 September 2008 as an alternative starting point.

Each portfolio $i$ reflects a country-sector portfolio, measured as the value-weighted returns of all stocks in a particular sector of a particular country at time $t$.[3] All returns are measured in dollars.[4] In order to obtain an intuitive interpretation of the estimates of the factor loadings, we orthogonalise the three factors. The global factor is orthogonalised by regressing global financial sector returns on US returns over the full sample period (including the crisis period) and then using the residuals of this regression as the global factor.[5] Similarly, following Bekaert, Hodrick and Zhang (2009), we extract a domestic return component which is orthogonal to those of both the US factor and the global factor by regressing each domestic market return on US returns and global financial sector returns, and then using the residual of this regression as the domestic factor.[6]

*Interdependence versus contagion*

A first step is to understand the evolution of equity market co-movements during tranquil times. In essence, this is a special case of the general model, or what one may refer to as an "interdependence model", which eliminates $CR_t$ from the model for all $t$. Each portfolio's risk exposure is then captured by three (potentially time-varying) factor loadings. Under the null of this model, these betas determine the co-movement ("interdependence") between the various portfolios.

By adding the crisis dummy to equations (1) and (2), we allow (inter alia) for a change in the beta coefficients during the crisis. If there is evidence for such a change, this suggests that the interdependence model is not sufficient to capture the crisis effects. Consistent with the definition in Bekaert, Harvey and Ng (2005), we call this phenomenon *contagion*. The model we specify then tries to uncover the sources of contagion through the various $\gamma$ or $\eta$ coefficients.

First, $\eta$ in equation (1) captures contagion unrelated to the observable factors $F_t$ of the model. Our analysis can therefore shed light on contagion theories involving investor behavior. At the simplest level, the crisis may induce herd behavior where investors stop discriminating across firms and countries based on economic fundamentals. This "herding contagion" should not depend on macro-economic fundamentals at all. It is also likely to induce global rather than domestic contagion, as the pricing effects likely happen through the asset holdings of international investors (see Boyer, Kumagai, and Yuan (2006)) for concrete evidence during the Asian crisis). Our $\eta$ coefficients potentially measure such "non-fundamental" contagion. However, there are also rational stories of "investor contagion." During a financial crisis, investors may face margin calls and/or may need to raise liquidity, which may transmit shocks from one country to another. Kodres and Pritsker (2002) develop a model where portfolio rebalancing creates "rational contagion," the severity of which depends on shared macro-risk factors and the information asymmetry in each market. Kyle and Xiong (2001) focus on losses by arbitragers which may lead to liquidations in several markets, thus inducing contagion. Whatever the story, it appears that investor contagion would lead to stronger transmission of international shocks and thus cause some form of global, not domestic contagion. While we do not provide a formal test of these models, we later consider some instruments related to risk aversion that may be informative about these channels.

Second, $\gamma$ in equation (2) measures contagion via the factors $F_t$, i.e. changes in interdependence during the crisis. Such contagion during the crisis may be induced either by an unconditional increase in the factor loadings ($\gamma_{i,0}$) or an increase in the factor loadings conditional on a number of possible determinants $Z_{i,t}$ ($\gamma_1$). The strength and novelty of this approach is that it allows us to identify the origin of contagion (global, US or domestic) and the transmission channels.

*Instruments to model time variation in exposures*

Equations (2) to (4) contain a set of lagged instruments, $Z_{i,t\text{-k}}$, which are used to model the time variation in the exposures ($\beta$, $\gamma$, $\eta$). This practice has a long tradition in finance; see, for example, Ferson and Harvey (1991). We entertain a large number of potential instruments, which are listed in Table I.

The first set of variables primarily measures trade and financial openness. A great many researchers have pointed out the increased vulnerability to crises that comes with financial and economic integration (see Mendoza and Quadrini (2010) for a theoretical analysis). The trade channel in particular has often been associated with international spillovers and contagion (see Forbes (2004), Kaminsky and Reinhart (2000)). Baele and Inghelbrecht (2009) show that it is important to account for trends in market integration before measuring contagion, which means that we must allow the interdependence coefficients to depend on openness indicators to properly test for contagion in a crisis, as average beta coefficients may underestimate the global exposures just before the crisis. Our proxies for the external exposure of our portfolios are mostly at the country level: exports plus imports (trade openness) and financial integration with the United States (via portfolio investment assets and liabilities); or financial depth (measured as the size of the domestic equity market capitalization), which has been shown to correlate with financial openness (see, e.g. Bekaert and Harvey, 1995). All measures are scaled by GDP. We also include exchange rate exposure, which may constitute an alternative, firm-specific source for equity market co-movements (e.g. Dumas and Solnik 1995). The methodology for measuring exchange rate exposure is outlined in Appendix B.

Because our model contains the global financial sector returns as a factor, we can also investigate a "banking channel" for global contagion during the recent crisis. A number of authors have stressed the importance of a banking channel, even for equity market contagion; see Van Rijckeghem and Weder (2001), Kaminsky and Reinhart (2000), Tong and Wei (forthcoming), and Tong and Wei (2009). We would expect the effect of banking problems to be particularly severe for firms with financing constraints and for firms with more interest rate exposures, as they may have shorter maturity debt and thus face steeper refinancing costs. For instance, Almeida et al. (2009) find that firms with large portions of long-term debt maturing at the time of the crisis reduced investment significantly more than similar firms that did not need to refinance their debt during the crisis. Both these possibilities are accounted for in our model through the second set of variables, covering instruments for financing costs (Rajan and Zingales, 1998; Whited and Whu, 2006) and interest rate exposure (see the appendix for more details on the computation of these variables).

Table I

The third set of variables consists of global measures of risk aversion and liquidity. Evidence is mounting that international asset prices are quite sensitive to such measures (see e.g. Bekaert, Harvey, Lundblad and Siegel, 2011; Baker, Wurgler and Yuan, 2009). The risk aversion of investors may substantially increase during the crisis, making them shun risky assets and flee into safer assets, in particular government bonds in the US and other advanced economies. We proxy for risk aversion through the VIX index of the S&P500. In addition, we include implied volatility in major foreign exchange markets as a proxy for uncertainty. Moreover, a central element of the crisis was a freezing of credit and inter-bank markets and a liquidity squeeze that made it difficult for financial and non-financial institutions to obtain capital. Indeed, a literature is emerging that stresses the role of (il)liquidity in causing or exacerbating crises (e.g. Adrian and Shin 2010, Brunnermeier and Pedersen 2009). We use the TED spread as an indicator of illiquidity, but it of course also reflects the credit risk of banks. Note that all these risk and liquidity variables are common to all equity portfolios in the sample. All these variables can also provide useful information about "investor contagion," when used to drive time-variation in $\gamma$ and or $\eta$.

The fourth set of variables intends to provide a broad view of domestic macroeconomic fundamentals. With these variables, we can test what Goldstein (1998) has coined the “wake-up call” hypothesis, following the 1997-98 Asian financial crisis. During that crisis, potential risk determinants at the country level –such as the quality of economic policies and institutions– became more important for investors’ decisions relative to determinants at the firm, sector or global levels. This hypothesis is easily testable in our framework, as it implies that macro-economic fundamentals that do not matter in normal times suddenly matter in crisis times, as reflected in the $\gamma_{it}$ coefficients for our set of macro-economic indicators (Aizenman and Lee 2007, Rose and Spiegel 2010, Fratzscher 2009). The wake-up call hypothesis provides a potential explanation of “domestic contagion,” as defined in the previous sub-section. The set of variables includes measures of political and financial risk (for which we use ICRG ratings) in addition to the sovereign rating and the level of foreign exchange reserves. It also contains several macroeconomic indicators, namely the current account balance, the government budget balance, GDP growth and the unemployment rate.

We also collected data on three country-specific policy responses to the crises (listed under “Financial policy variables”), namely capital injections in both financial and non-financial firms, as well as new or extended deposit guarantees and debt guarantees.[7] A key feature that we exploit for this analysis is that not all countries implemented such financial policies, that there are differences in the precise measures that were implemented, and in the timing of their announcement. We define dummy variables that take the value of one for the period after the announcements of the various policies, and for the full period of their existence.[8] This raises two caveats. First, official announcements of such financial policies may have been preceded by rumors or concrete indications that a government considers such policy measures, thus having a market effect even before an announcement is made. A second issue is that such policies may in part be endogenous to the crisis itself, i.e. they were implemented in response to the crisis hitting a particular country particularly hard. While we cannot resolve this potential endogeneity bias, we note that it should make it harder to prove in the data that such policies are associated with a smaller decline in equity markets. Our hypothesis is that these financial policy responses have helped countries and individual firms within a country to be more insulated and overall less affected by the crisis, which would show up as reducing the magnitude of domestic contagion in our model.

Finally, we add some firm-specific variables, as in the original Ferson and Harvey (1991) work. These variables include size and value factors, which constitute proxies for systematic risks (as in the Fama and French (1992) factor model), or capture style investing which may depend on market sentiment and drive co-movements between stocks (Barberis, Shleifer, Wurgler, 2005). Appendix B provides additional information for portfolio-specific variables.

**B. Estimation, Specification Tests and Diagnostics**

*Model Estimation*

We estimate our model for all portfolios jointly by means of pooled OLS, but account for cross-sectional dependence by clustering the standard errors across country portfolios. Note that the instruments $Z_{i,t}$ – with the exception of the financial policies, as outlined above – are lagged by 2 quarters in order to prevent that an unobserved factor may influence simultaneously both the degree of market integration and the fundamental $Z$ in a given period, thus generating a spurious relationship between both.

Because we have 24 instruments, an estimation of the full model will generate a large amount of insignificant regressors that needlessly inject noise into the estimated model. We therefore build on the work of David Hendry (see, for instance, Hendry and Krolzig (2005)) to pare down the regression to a more manageable number of independent variables. Concretely, we start by estimating model (1)-(4) with all instruments. We then eliminate the least statistically significant variable, using a significance threshold of 15%. We use relatively high significance levels, preferring to maintain a model with some useless regressors, rather than eliminate important ones. We proceed step-by-step by excluding individual variables, and simultaneously testing at each step whether an already excluded variable should be included again, until we arrive at a final encompassing model specification. Note that we keep a particular instrument, and all its interaction terms, if either its interdependence coefficient $\beta_1$ or its contagion parameter $\gamma_1$ is statistically significant.

*Specification Tests and Diagnostics*

We now focus our attention to model fit. A well-specified factor model should render all correlations between the residuals of the 415 portfolio regressions negligible. Given the dimensionality of our estimation, a formal test of such a hypothesis is rather meaningless. Instead, we test and/or diagnose excess co-movements of the residuals at the country level, the most important dimension for contagion tests.

To measure excess co-movements within countries, to each portfolio *i* we now add an indicator subscript *c*, denoting country. There are $N_c$ portfolios within country *c* and recall that there are 55 countries in total; so that *c* runs from 1 to 55. Excess co-movement within a country can occur when the factor model either systematically over or under predicts exposure to the factors for portfolios within a given country. Formally, consider:

$$EXCOV_{c,t} = \frac{2}{N_c(N_c - 1)} \sum_{i=1}^{N_c} \sum_{j>i}^{N_c} (e_{i,c,t} \times e_{j,c,t}) \tag{5}$$

This average covariance (across portfolios within a country) should be on average zero for all countries. To derive a formal test, we simply investigate the average across the countries:

$$EXCOV_{C,t} = \frac{1}{55} \sum_{c=1}^{55} EXCOV_{c,t} \tag{6}$$

The excess co-movement test becomes:

$$ECTEST_C = \frac{[(1/T)\sum_{t=1}^{T} EXCOV_{C,t}]^2}{VAR(EXCOV_{C,t})} \tag{7}$$

which is $\chi^2(1)$ under the null. We use 26 Newey-West (1987) lags in computing the variance of $EXCOV_{C,t}$.

We also compute two diagnostic statistics that are easily comparable across different models, or across different time periods (crisis versus non-crisis). First, let $\rho_{i,j,c}$ be the correlation between the residual of portfolios *i* and *j* within country *c*. Thus we compute:

$$EXCOR_C = \frac{1}{55} \sum_{c=1}^{55} \frac{2}{N_c(N_c - 1)} \sum_{i=1}^{N_c} \sum_{j>i}^{N_c} \rho_{i,j,c} \tag{8}$$

Second, the ECTEST averages the country-specific co-movements of residuals across all countries. It is conceivable that strong rejections in a few countries may not result in a rejection of the null. To better diagnose the performance of various models, we also compute the following country-level excess co-movement diagnostic:

$$ECDIAG_C = \sum_{c=1}^{55} \frac{[(1/T)\sum_{t=1}^{T} EXCOV_{c,t}]^2}{VAR(EXCOV_{c,t})} \tag{9}$$

where the time series variance is again computed with accommodating for 26 Newey-West lags.

If the country-specific test statistics would be independent, ECDIAG would have a $\chi^2(55)$ distribution. However, we use the statistics to compare alternative models and alternative periods.

## II. Empirical Results

Our modeling strategy is to first investigate the presence of interdependence versus contagion in sub-sections A and B, before turning to the channels of contagion, i.e. the determinants of time variation in interdependence and contagion in sub-section C. It turns out that allowing for time-variation in the betas does not affect our inference about contagion, but the cross-sectional variation in the instruments does help explain the cross-country incidence of the crisis.

### A. Interdependence

Our extended asset pricing model (1)-(4) with crisis interactions and contagion may not be necessary to explain the transmission of the financial crisis in 2007-09. If the original factor model without contagion parameters correctly anticipated the systematic risks of the various portfolios, portfolios with larger (smaller) exposures to the US and global financial sector portfolios should presumably witness the steepest (smallest) valuation declines during the crisis. To explore this possibility, we estimate the following simple variant of our three-factor model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,0}' F_t + e_{i,t} \tag{12}$$

with all variables defined as before, and including the same three factors – a US factor, a global financial factor, and a domestic market factor. Table II reports the betas and displays the specification tests. The specification test ECTEST should be $\chi^2(1)$ under the null, and rejects very strongly the null of no excess country-specific residual comovements, both across the full sample and in the crisis. Note that it is conceivable that the test has much less power during the shorter crisis period than over the full sample; yet the average within-country residual correlation is also similar across the two periods. Including the crisis period in the estimation tends to slightly increase the betas, which helps improve fit within the crisis period and worsens it outside the crisis period. The ECDIAG test statistic is a whopping 618 over the full sample period and 482 over the crisis period. The 1% critical value for a $\chi^2(55)$ is 94.42, but of course the various country statistics are not independent and are likely positively correlated.

Tables II – III

The betas reported are unweighted averages across all 415 portfolios, with the standard error also reflecting the covariance between the individual estimates. Economically, the average exposure to the three factors is not much different on average. It may be surprising that the exposure to the global banking sector is so large. However, if country factors dominate industry factors, this factor may proxy for the world market return, ex US.

In Table III, we explore the variation of the interdependence coefficients across portfolios, aggregating over regional groups and different industries. With the exception of Western Europe, the exposures to the domestic factor still dominate the exposures to the US or global financial factors. Perhaps also not surprising are the relatively high exposure of Latin America to the US factor, and the correspondingly very low US exposure in Emerging Europe, Middle East/Africa and Emerging Asia. The variation of the different exposures across different industries is much smaller than across regions. Striking is the low exposure of the technology sector to the global, and its large exposure to the US factor. The highest exposure to the global factor is found for the financial sector, with a beta estimate of 0.58. In addition, the financial sector also has a relatively high exposure vis-à-vis the US factor.

What would the model predict for the crisis? If the model is correctly specified, the factor exposures are sufficient to predict the relative vulnerability across the different portfolios during the crisis. Table IV and Figure 1 represent the performance of the "interdependence model" to predict the relative stock return performances across countries. In Figure 1, we graph the actual cumulative returns across the crisis period on the vertical axis against its predicted value from the interdependence model (12) on the horizontal axis. The computation is straightforward. From estimating (12), we obtain $\hat{R}_{i,t}$ for each portfolio *i* and each period/week *t*, and then obtain from these the total predicted return $\hat{R}_i$ and compare this to the total actual return $R_i$ over the whole crisis period.[9]

Figure 1, Table IV

If the model predicted the relative crisis severity perfectly, the regression line through the scatter plot should be identical to the 45 degree line. Of course, it is pretty clear this is not the case. When we run a regression of actual on predicted returns for all 415 portfolios, we find:

$$R_i = \underset{(2.444)}{-7.037} + \underset{(0.046)}{0.489}\hat{R}_i + \varepsilon_i, \text{ adj. } R^2 = 0.301$$

with the joint test that the intercept is zero and the slope coefficient is unity being rejected. This relationship between actual and predicted returns is graphically shown through the line in Panel A of Figure 1.

To obtain more information at the more aggregated country level rather than portfolio level, Panel B shows the distribution across countries, where actual and predicted returns for countries are unweighted averages across the portfolios of a particular country. On average the model under-predicts the severity of the crisis for nearly all countries and the prediction errors for some countries are quite large. To make the performance of the model more concrete, Table IV lists the various countries, ranked from worst to best actual crisis performance, then contrasts these returns with the predicted returns based on the three-factor interdependence asset-pricing model in the second set of columns (the table also shows the estimates for the contagion model, to which we turn in the next section).

What is striking from the table is that most of the worst performing countries are in Eastern Europe. This makes sense intuitively as these countries were affected not only the strongest in terms of equity market performance, but also in terms of economic growth and activity. However, the interdependence model would predict some of the Eastern European countries to be only moderately affected. The Spearman rank correlation between actual and predicted returns is a relatively modest 0.68. It would be even smaller if the model did not include a domestic factor. The presence of a domestic factor allows Eastern European countries to be affected by the severe country-specific crises in their countries. Even so, the model still substantially fails to predict the absolute and relative severity of the crisis. Many commentators have expressed surprise about the relatively good performance of many emerging markets, which were at the heart of previous crises, like Thailand and Indonesia in South-East Asia, or Mexico and Brazil in Latin America. However, from the perspective of our benchmark model, the performance in three of these countries was actually worse than expected (Mexico is the exception).

Table V

Table V provides an analogous ranking for each of the 10 sectors, where all returns of portfolios within a particular sector are equally weighted averages across countries. Expected returns and realized returns are much more similar and highly correlated, especially in their ranking (with a Spearman rank correlation of 0.89), thus not exhibiting the same mismatch as across countries. For instance, equities in utilities, non-cyclical consumer goods or in the energy sector were indeed relatively less affected as predicted by the factor model, and the financial sector was most affected in the data and in the model.

Figure 2

The three-factor interdependence model obviously performs relatively poorly in explaining the crisis severity. To benchmark this model, we compare the predictive power of this model with that of a more standard World CAPM model. We do so by re-estimating (12) including only the two common world factors, the global factor and the US factor. Figure 2 shows the fit of the model, again at the country and at the portfolio levels. A regression of actual on predicted returns for all 415 portfolios for this two-factor model yields:

$$\hat{R}_i \ = \ \underset{(3.439)}{-13.036} \ + \ \underset{(0.058)}{0.256}\hat{R}_i \ + \ \varepsilon_i, \ \text{adj.}\ R^2 = 0.094$$

The *R*-squared decreases from 0.301 in the three-factor model with the domestic factor to only 0.094 for the two-factor model without the domestic factor. Moreover, the slope coefficient of the two-factor model is substantially smaller as it drops by about one half. Overall, this suggests that the domestic factor is indeed highly important in improving the predictive power of the model for the 2007-09 financial crisis, even without yet allowing for contagion in the model specification.

In summary, the exploratory analysis of this sub-section shows that a simple constant beta model fails to explain the transmission of the 2007-09 financial crisis to equity markets globally. Because of the nature of the interdependence model, it must be the case that the countries with the strongest equity market collapses during the crisis are those that have been traditionally less open and exposed to the global and US factors (hence, they have a low predicted equity market decline during the crisis), while the less severely affected ones generally had substantially higher loadings for the US and global factors before the crisis. We will make this intuition concrete in the next section.

**B. Contagion**

Was there contagion in global equity markets during the 2007-09 financial crisis? If so, what type of contagion – did contagion primarily emanate from the global financial sector, from the US or from the domestic market? To address these questions, we now turn to the estimation results of the asset pricing model (1)-(4), but still restricting the coefficients on $Z_{i,t}$ to be zero:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,t}' F_t + \eta_{i,0} CR_t + e_{i,t} \tag{13}$$

$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0}\, CR_t \tag{14}$$

Our primary interest is in the parameters of interdependence $\beta_{i,0}$ and of contagion $\gamma_{i,0}$. Table VI provides the aggregate results with the average coefficients across all portfolios. Before we discuss the parameter estimates, let's briefly discuss the fit. Compared to Table II, the $R^2$ increases by 4% and all statistics improve for the full model, suggesting that the imposition of constant betas across the two periods was a mis-specification. Still the model remains rejected at the 1% level. The crisis-specific exposures suffice for the model to eliminate within-country residual correlation and the model fails to reject at the 5% level for that period. The average residual correlation is also negligible and the diagnostic test is now 336 instead of 482.

Table VI

More importantly, the parameter estimates reveal several important patterns. First, the interdependence coefficients have decreased slightly, already suggesting that "dummying out" the crisis period overall leads to decreased co-movement between the portfolios. Second, there is statistically strong evidence for the presence of contagion from all three sources: from the global financial sector, from the US market, as well as from the domestic market. Finally, and most strikingly, contagion during the 2007-09 crisis seems to have been primarily domestic in nature. The domestic contagion estimate of 0.249 is much larger than the analogous estimates for US contagion of 0.133 and global contagion of 0.056.

The contagion parameters from global and US markets being small in magnitude relative to the interdependence exposures during "normal" times is inconsistent with the "globalization hypothesis". Equity markets worldwide connected only slightly more strongly with what happened in the US or the global financial sector. In contrast, the dominance of domestic contagion suggests that the fate of equity portfolios during the crisis became primarily linked to that of other domestic portfolios. The economic magnitude of this effect is large as the domestic factor betas on average increase by 50%. This is striking and one of the key findings of the paper. Note that all of the contagion seems to be captured by changing factor exposures, as the $\eta$ coefficients are, at least on average, small and insignificant.

The evidence on the average contagion and interdependence parameters of Table VI potentially masks a considerable degree of heterogeneity across equity portfolios. For instance, the fact that there is very little contagion on average from US markets during the crisis may be consistent with the fact that some equity portfolios indeed experienced significant contagion from the US while other portfolios experienced "negative contagion" or a de-coupling from US markets during the 2007-09 financial crisis.

Table VII, Figure 3

Table VII provides an alternative perspective on the nature of contagion we have uncovered by reporting the cross-sectional correlations between the various contagion and interdependence coefficients across the 415 portfolios. The interdependence coefficients are substantially positively correlated, suggesting a positive association between domestic and international systematic risk. There is also significant but mostly more moderate positive correlation across different types of contagion –

those portfolios experiencing more domestic contagion were also more exposed to global and US sources of risk during the crisis.

Most striking is the mostly substantial negative correlation between the interdependence and contagion coefficients, indicating that portfolios that were less exposed to the three factors before the crisis experienced the strongest contagion during the crisis. This is true both for international and domestic exposure. Such evidence is rather damning for the ability of standard factor models to differentiate systematic risks across portfolios during global crises.

Figure 3 shows that there is a significant degree of heterogeneity in the contagion parameters across portfolios. Importantly, while there are many portfolios that experienced positive contagion from global, US or domestic sources during the crisis, there are also a number of portfolios that had negative contagion, i.e. managed to some extent to decouple from equity market movements elsewhere. Given the parameter estimates reported before, it is no surprise that the positive mean is visually most apparent for domestic contagion.

Table VIII

Table VIII provides the parameter estimates of Equations (13)-(14) averaged at the regional (Panel A) and sectoral (Panel B) levels. Panel A confirms that domestic contagion dominates US or global contagion, as the estimates for the former are positive, significant and sizeable for all regions. Only in Latin America is US contagion slightly larger than domestic contagion. Domestic contagion is most important in Emerging Europe and the Middle East/Africa, but Emerging Europe shows significant global and US contagion parameters as well. Moreover, the $\eta$ parameter – measuring equity movements during the crisis which are not accounted for by the three factors – is only negative in a statistically significant fashion for Emerging Europe. This implies that the three factors in our model do a reasonably good job in explaining the dynamics of equity returns during the crisis.

As to the sector analysis in Panel B, there are only three sectors that have significant contagion coefficients for the global factor, namely energy, financial and technology portfolios. The non-cyclical consumer goods sector shows a negative coefficient, suggesting some form of decoupling during the crisis, but the economic effect is certainly not large. Most sectors show positive contagion from the US market, with the strongest effects mostly in the production/manufacturing sectors (industrial, energy, basic materials and utilities). Technology shows a negative coefficient, but this sector was ex-ante heavily exposed to the US factor, and thus partially decoupled during the crisis. There is positive and mostly sizeable domestic contagion for portfolios in 9 out of the 10 sectors, broadly confirming that domestic contagion is not simply driven by the large response of a few portfolios in a few sectors. Finally, the decline in financial sector equities cannot be fully accounted for by the three factors in the model, i.e. $\eta$ is negative and large at -0.217.

The contagion model matches quite well the severity of the equity market collapse during the 2007-09 crisis. First, the third set of columns of Table IV shows much less systematic downward bias than the interdependence model, almost perfectly matching the equity market collapse for a number of countries. Second, the contagion model also fits the cross-country differences in severity across countries; in fact, the Spearman rank correlation is 0.91 for the contagion model, which is high and also substantially higher than the 0.68 rank correlation recorded for the interdependence model.

Figure 4

The goodness of fit is illustrated graphically in Figure 4. Unlike the interdependence model (Figure 1), the predicted overall crisis returns from the contagion model are very similar to the actual overall returns, both at the portfolio level and at the country level. A regression from actual on predicted returns from the contagion model at the portfolio level yields:

$$\hat{R}_i \;=\; \underset{(2.322)}{1.910} \;+\; \underset{(0.033)}{0.971}\hat{R}_i \;+\; \varepsilon_i,\ \text{adj. } R^2 = 0.843$$

The slope coefficient is close to unity, and the R-squared is 84%, confirming the good fit. The joint hypothesis that the intercept is zero and the slope coefficient unity is not rejected.

Table IX

Finally, Table IX reports a robustness test for the definition of the financial crisis, where the crisis starts only with the collapse of Lehman Brothers in mid-September 2008 (rather than in early August 2007 as in the benchmark). As shown in the second set of columns, this makes no meaningful difference to the findings. In fact, the domestic contagion parameter becomes somewhat larger, while there is little change in the coefficients for US and global contagion.

An intriguing question is whether the 2007-09 crisis differs markedly with regard to the transmission mechanism and contagion from other past crises. Since our sample starts only in 1995, and going back further would substantially reduce the sample size (in particular with regard to emerging economies), the two equity market collapses we focus on are the 1998 LTCM crisis and the strong decline of equity markets between 2000 and 2002 (the TMT bust). Table IX shows the estimates for these two events, based on an estimation of the contagion model, but excluding the 2007-09 financial crisis from the sample. The findings indicate that there was little if any systematic contagion at the global level during those two episodes. In fact, the global and US contagion parameters are significant and negative, suggesting a slight de-coupling of equity markets with the US market or the global financial sector during those episodes. There is no evidence for domestic contagion during those early equity market crises. Hence the importance and even dominance of domestic contagion appears a truly defining feature of the 2007-09 crisis.

In summary, the evidence uncovered so far suggests that there has been equity contagion from the global financial sector, from the US market and from domestic markets during the 2007-09 financial crisis. The intriguing finding is that contagion during the crisis was mainly domestic in origin, implying that this genuine global crisis ironically primarily drove up within-country equity return co-movements. These findings are robust to various extensions and alternative model specifications and apply to various levels of aggregation. Moreover, we also find a significant degree of heterogeneity in contagion across portfolios. We now try to explain the sources of this heterogeneity.

### C. Channels of contagion and interdependence

Figure 3 reveals substantial heterogeneity in the contagion and interdependence coefficients across individual country-sector equity portfolios. What explains this heterogeneity? Is it related to the external exposure of portfolios –or what we referred to as the “globalization hypothesis”? Is it linked to country-specific factors and risks –what we call the “wake-up call hypothesis”? Or is it related to other common factors? We discussed these hypotheses in detail above, and now turn to formally testing the channels of contagion and interdependence.

Table X

To start, Table X reports estimates of the interdependence model with instruments (i.e. it includes $Z_{i,t}$, but excludes the crisis dummy, $CR_t$). We report only the coefficients on the instruments that survive the model reduction method described in Section I. The specification tests reveal that introducing the instruments improves the model fit about as much as the addition of the crisis dummy (and thereby the possibility of contagion) does. The $R$-squared increases by 4%, the test statistic comes down considerably but still rejects the model at the 1% level, and the diagnostic statistic is reduced to 385. During the crisis, the model cannot even be rejected at the 5% level, and within country residuals now show less than 4% correlation.

To gauge the economic relevance of the estimates, the last column shows interdecile differences in exposures. These reflect the difference between the predicted beta when evaluated at the 90$^{th}$ percentile of the instrument's distribution and the beta evaluated at the 10$^{th}$ percentile of the distribution. For example, the effect of financial depth on the beta with respect to the global factor is both statistically and economically small, as the interdecile range means that a large change in market capitalization relative to GDP only induces a 0.02 change in beta.

The key instruments causing time-variation in the factor exposures are the external exposure variables and the TED spread. Trade integration has, not surprisingly, very strong effects, both statistically and economically, on the exposures of the portfolios with respect to global and US factors, confirming results in the literature (see e.g. Baele (2005)). Domestic exposures are larger in countries with more developed stock markets, with the effect both statistically and economically important. This finding seems inconsistent with the literature suggesting that development goes hand-in-hand with an increase in idiosyncratic risk (see e.g. Morck, Yeung and Yu (2000)). Note that this article focuses on cross-sectional relationships, while our coefficients are identified from a rich panel data set, with plenty of time series variation in market capitalization to GDP in many countries. Finally, the TED spread invariably significantly increases factor exposures, with the effect economically the strongest for domestic factor betas. It is conceivable that this variable identifies the aggregate financing implications of the liquidity problems in the financing markets, but it may also proxy for more general risk aversion, causing excessive co-movement in periods of high risk aversion.

The only macroeconomic variable that enters the betas significantly is the current account balance. The dependence on the US factor significantly increases when it deteriorates, but the effect is economically small.

Table XI

In Table XI, we report the full model, now also introducing instruments for the contagion parameters. In terms of specification tests, the model has the best fit overall in terms of the actual specification tests ECTEST, with its value dropping to 15.90 for the full sample and becoming really small for the crisis period. Its residual correlations are also the smallest of all models in both periods. However, in terms of the diagnostic statistic, the interdependence model with instruments produces a lower value over the full sample and is about as good for the crisis period. This is true despite the fact that the contagion model has many more instruments. Because we impose that instruments survive jointly in the contagion and interdependence coefficients, the many new significant variables we observe are mostly identified through exposures during the crisis being very different from before the crisis.

Our first main result is that during the crisis, the US factor exposure to trade integration and financial integration decreased substantially. The effects of trade integration on the global and domestic factor betas merely reflect insignificant changes from the strong basic interdependence effect. In other words, the globalization hypothesis is strongly rejected by the data; in fact, we find that the behavior of portfolios entirely decoupled from their pre -crisis external dependence.

Second, perhaps surprisingly, we find that the effect of the TED spread (and in one case also the VIX) substantially and significantly decreased during the crisis. The coefficients are such that in periods outside the recent global crisis, small increases in risk would translate into much stronger co-movements, but that in the crisis these variables generate almost no effect on the co-movements. One plausible interpretation of this finding is that shocks to liquidity, as proxied by TED spreads, during the crisis were widely reported to have triggered capital flows into the US and out of emerging economies, thus inducing a decoupling and a drop of the US and global factor loadings, Moreover, a rise in the TED spread also reduces co-movement across domestic equity portfolios, which may be explained by differences in the dependence on liquidity across sectors (e.g. with the financial sector likely to be affected very strongly).

Importantly, we do find intriguing evidence in favor of the wake-up call hypothesis. Several macro-economic fundamental variables are significant drivers of the contagion exposures. A current account deficit very significantly increases the exposure to the global factor; whereas poor sovereign ratings substantially increase the exposure to the US factor.

Moreover, domestic contagion is much reduced for countries with significant foreign exchange reserves. This finding is related to the current debate about the appropriate level of foreign exchange reserves countries should hold. Many international finance experts have been surprised by the very large stockpiles of official reserves built up by emerging markets over the last decade. It appears that in the recent crisis, this was one factor that made them perform better than countries that had "insured less" and were viewed riskier by financial markets. It remains perhaps a bit surprising that the variable only affects domestic and not global contagion.

Overall, investors discriminated largely on the basis of domestic economic and political risk factors. Hence, governments that attempted to introduce policies to reduce the vulnerability of their economies may have well mitigated contagion. Our analysis of the capital injections, and deposit and debt guarantee dummies suggest that these policies indeed were successful in reducing contagion. The introduction of deposit guarantees significantly reduced domestic contagion, with the coefficient featuring the largest interdecile range among the instruments affecting domestic contagion. Its effect on global exposure is only statistically significant at the 10% level but still economically important. Debt guarantees have a similar effect on global exposures as deposit guarantees but also affect US exposure significantly (at the 5% level). For instance, the introduction or extension of debt or deposit guarantees during the crisis reduced the exposure of equity portfolios to the global factor by more than 0.30 compared to countries that did not introduce such policies.

Finally, none of the firm-specific instruments survived the model selection procedure, including various proxies for financial constraints at the firm level, as defined above. We have conducted several robustness checks. The findings overall prove highly robust to changes in the sample, e.g. by excluding particular countries or sectors. In particular, the benchmark estimates are robust to excluding all financial sector portfolios from the sample.

In summary, the findings of this section suggest that contagion during the 2007-09 crisis was to a significant extent systematically related to observable factors. In particular, strong domestic economic policies significantly reduced the exposure of portfolios to contagion. By contrast, the exposure to external factors, such as via trade or financial linkages, or financial constraints played no meaningful role for the global equity market transmission of the 2007-09 financial crisis.

## III. Conclusions

The 2007-09 financial crisis has been truly remarkable in its severity and global reach. This paper seeks to understand the global transmission channels of the crisis in equity markets, studying the cross-sectional heterogeneity of the crisis incidence across 55 equity markets. Despite its origination in the US, we find little evidence of systematic contagion from US markets to global equity markets during the crisis. Instead, there was systematic contagion from domestic equity markets to individual equity portfolios.

Yet, the financial crisis did not spread indiscriminately across countries and sectors. In particular portfolios in countries with weak economic fundamentals, poor policies and bad institutions experienced more contagion, both from US and domestic markets, and were overall more severely affected by the global financial crisis. Moreover, good macroeconomic policies and the presence of financial policies during the crisis, in the form of debt and deposit guarantees, were instrumental in shielding domestic equity portfolios to some extent from the 2007-09 financial crisis.

The irony of this perhaps most global crisis ever is that a market's external exposure played such a small role in determining its equity market performance. Instead, investors focused primarily on country-specific characteristics and punished markets with poor macroeconomic fundamentals, policies and institutions. Our findings support the recent efforts by policymakers and international organizations to better understand macroprudential risks and perhaps institute a closer surveillance of such risks both at a country level and at a global level.

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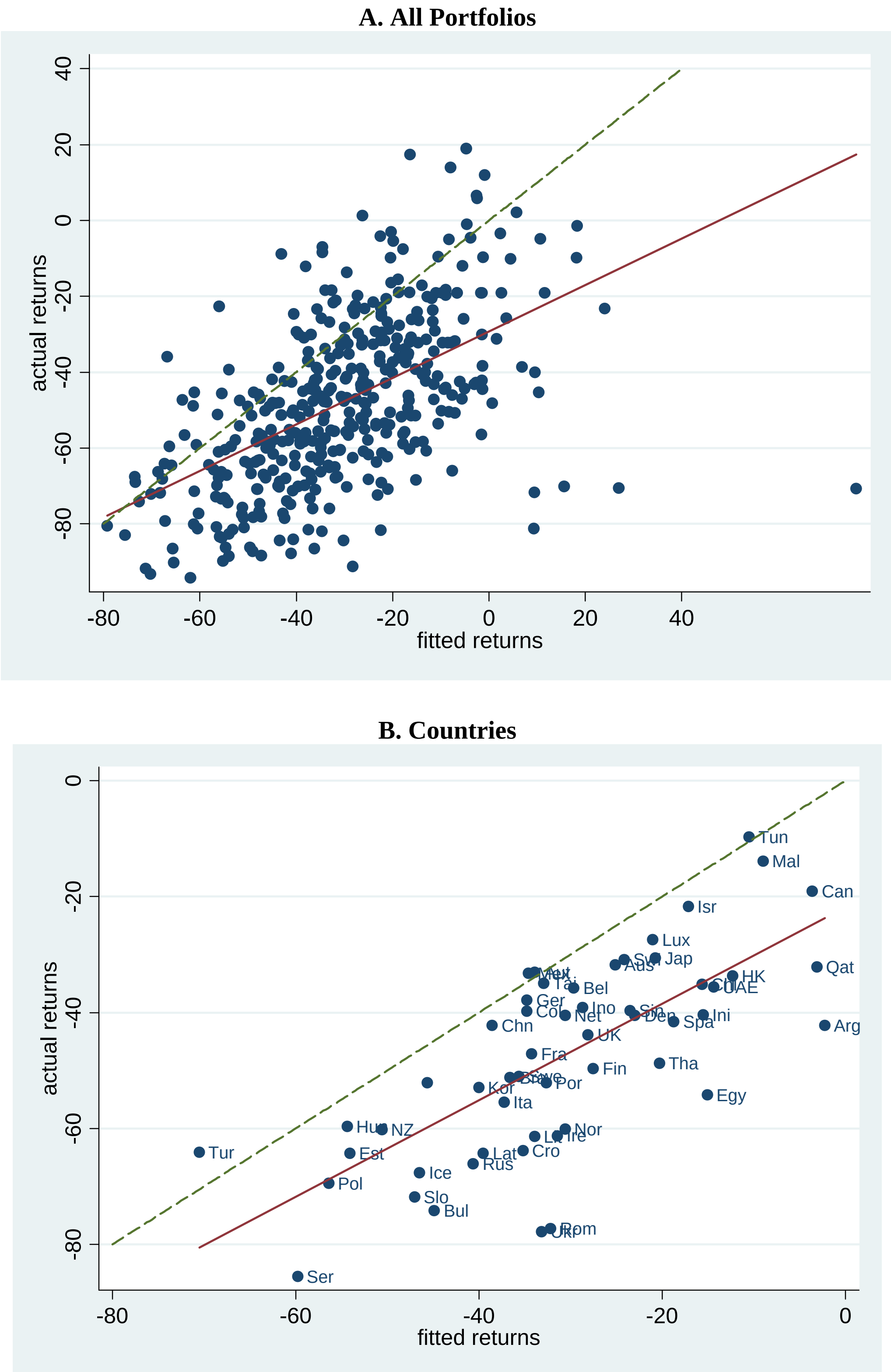



**Figure 1: Goodness of fit – Interdependence model**. The figures show the total actual equity market returns over the entire crisis period (August 2007 – March 2009) against the fitted total returns from the interdependence model (12), by portfolio (Panel A) and by country (Panel B). Country returns in Panel B are unweighted averages of portfolios within countries. The dashed line shows the 45 degree line.

**A. All Portfolios**


**B. Countries**

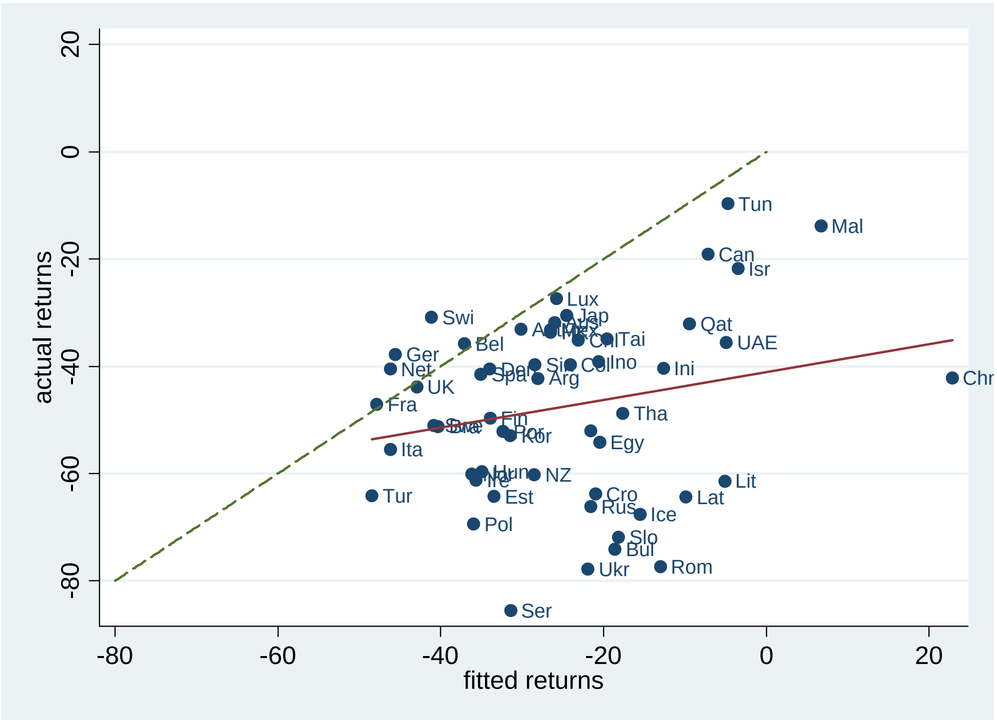
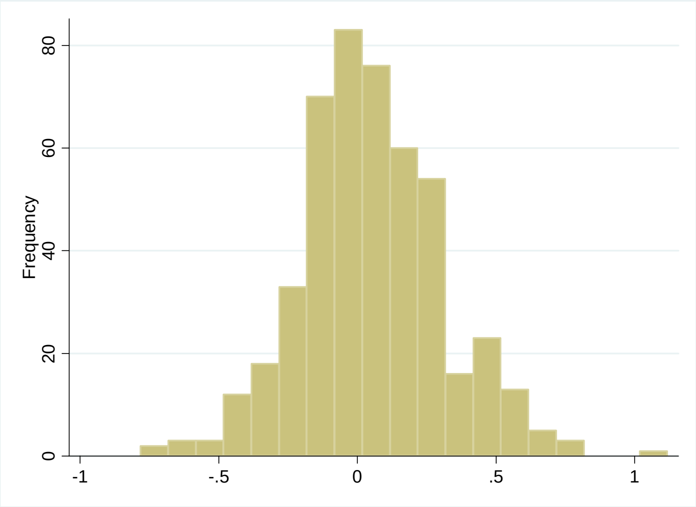
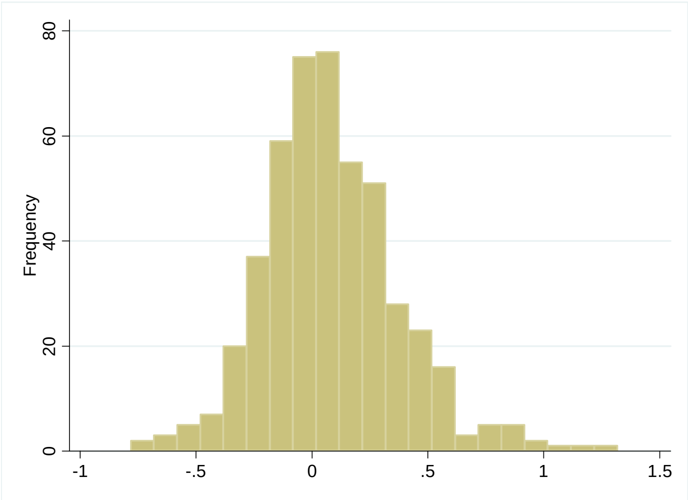



**Figure 2: Goodness of fit – Interdependence model – World CAPM (no domestic factor).** The figure is based on the two-factor model without the domestic factor (i.e. only the global and US factors). It shows the cumulated actual equity market returns over the entire crisis period (August 2007 – March 2009) against the fitted cumulated returns from the interdependence model, by portfolio (Panel A) and by country (Panel B). Country returns in Panel B are unweighted averages of portfolios within countries. The dashed line shows the 45 degree line.

**A. Contagion from the global financial sector**




**B. Contagion from US market**




**C. Contagion from domestic market**

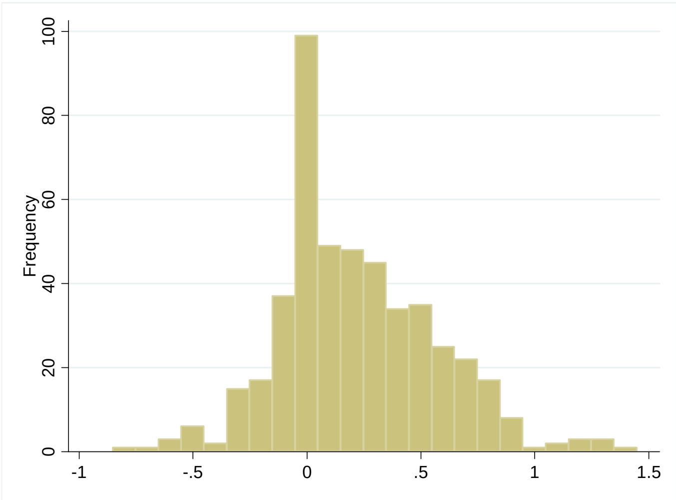
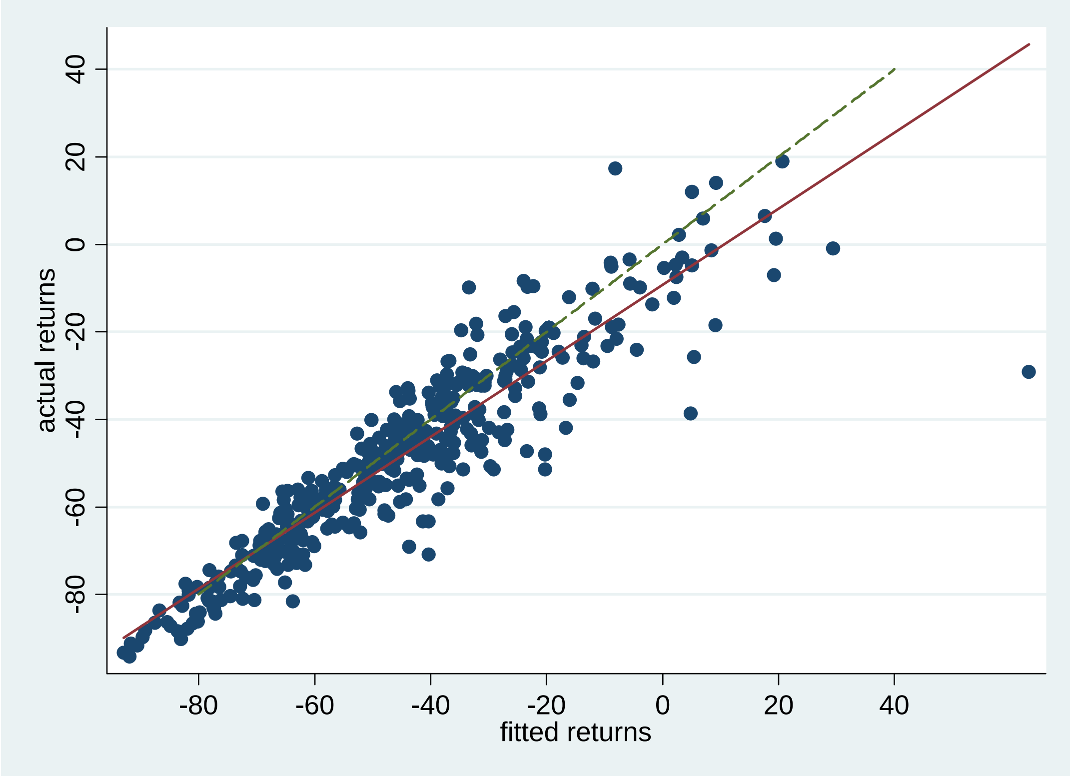



**Figure 3: Distribution of Contagion Coefficients.** The figures show the distribution of the contagion coefficients $\gamma_{\iota,0}$ from the estimation of (13)-(14) across all 415 equity portfolios from the factor model.

**A. All Portfolios**




**B. Countries**

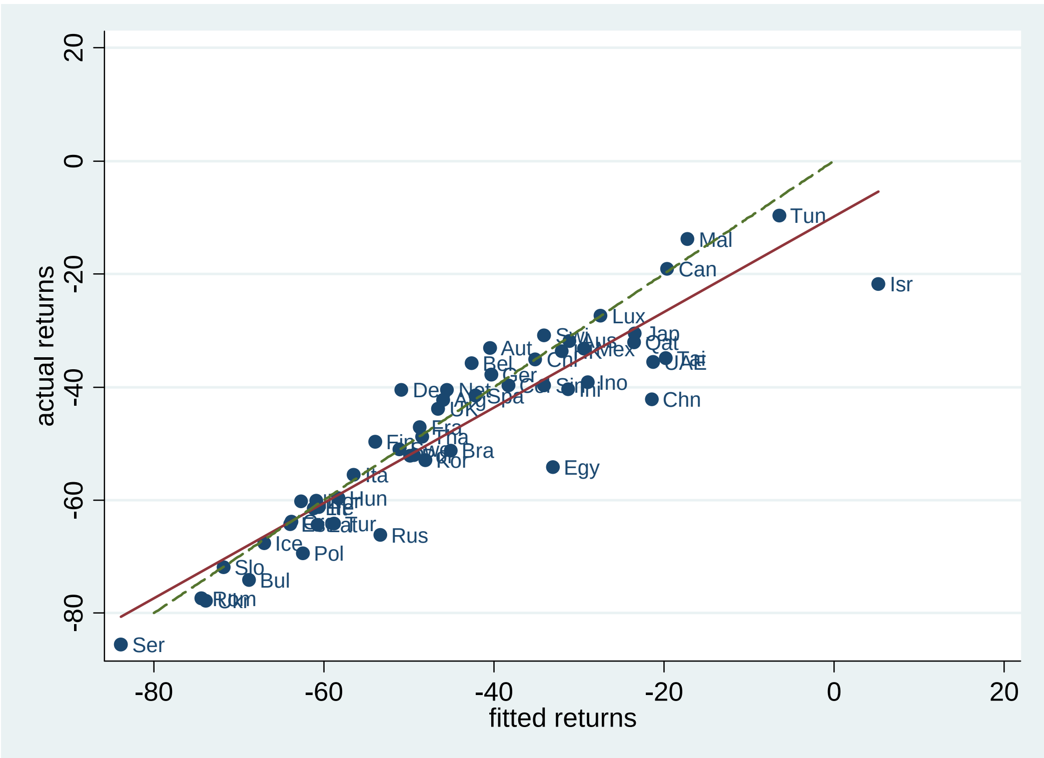



**Figure 4: Goodness of fit –Contagion model**. The figures show the cumulated actual equity market returns over the entire crisis period (August 2007 – March 2009) against the fitted cumulated returns from the contagion model (13) and (14), by portfolio (Panel A) and by country (Panel B). Country returns in Panel B are unweighted averages of portfolios within countries. The dashed line shows the 45 degree line.

# Table I: Risk Exposure Instruments

The summary statistics shown in the table are calculated across the 415 portfolios for the entire sample period, except for the financial policy variables, which are numbers for the crisis period since August 7, 2007.

| Variables | Units | Definition | Source | mean | std. dev. | min. | max. |
|---|---|---|---|---|---|---|---|
| ***External exposure:*** | | | | | | | |
| Financial depth | % of GDP | Ratio of equity market cap. to GDP | Bloomberg | 71.86 | 90.59 | 4.60 | 593.90 |
| Trade integration | % of GDP | Ratio of exports plus imports to GDP | IMF, Haver, Bloomberg | 108.39 | 76.43 | 28.17 | 455.40 |
| Financial integration | % of GDP | Ratio of external portfolio assets & liab. to GDP | IMF, CPIS | -1.19 | 9.87 | 4.42 | 64.41 |
| Exchange rate exposure (firm) | % of GDP | exposure coefficient at firm level, see Appendix | IMF, Bloomberg | -8.42 | 93.56 | -690.75 | 808.82 |
| ***Financing constraints and interest rate exposure*** | | | | | | | |
| Financial constraint | index from 0-100 | based on Whited and Wu (2006), see Appendix A | Bloomberg | 60.83 | 43.22 | 0.087 | 99.57 |
| Interest rate exposure (firm) | % of GDP | exposure coefficient at firm level, see Appendix | IMF, Bloomberg | 3.99 | 126.88 | -833.46 | 577.24 |
| ***Global risk aversion and liquidity:*** | | | | | | | |
| Risk aversion - VIX | in basis points | VIX index based on S&P500 options | Bloomberg | 22.00 | 8.92 | 9.89 | 80.86 |
| Credit risk - TED spread | in basis points | TED spread for US | Bloomberg | 52.18 | 44.97 | 0.11 | 463.08 |
| FX Implied volat. | in pricing units | from USD/EUR option prices | Bloomberg | 11.13 | 3.07 | 6.10 | 27.00 |
| ***Domestic macroeconomic fundamentals:*** | | | | | | | |
| Comp. political country risk | index from 0-100 | political risk index, higher number = better institutions | International Country Risk Guide (ICRG) | 38.89 | 4.39 | 28 | 49 |
| Comp. financial country risk | index from 0-100 | financial risk index, higher number = better institutions | International Country Risk Guide (ICRG) | 38.92 | 4.79 | 28 | 50 |
| FX reserves | % of GDP | Ratio of FX reserves to GDP | IMF, Haver, Bloomberg | 18.35 | 4.69 | 4.80 | 100.70 |
| Current account position | % of GDP | Ratio of current account position to GDP | IMF, Haver, Bloomberg | 0.68 | 7.59 | -17.11 | 27.98 |
| Sovereign rating | continuous variable, 6-22 | Rating of country's sovereign debt, linear transformation | IMF, Haver, Bloomberg | 16.29 | 4.75 | 6 | 22 |
| Unemployment rate | in % | Unemployment rate | IMF, Haver, Bloomberg | 7.81 | 6.18 | 2.10 | 38.71 |
| Government budget | % of GDP | Ratio of fiscal balance to GDP | IMF, Haver, Bloomberg | -0.18 | 4.24 | -7.80 | 19.61 |
| Growth | q-o-q growth rate, in % | GDP growth rate | IMF, Haver, Bloomberg | 0.82 | 2.30 | -13.03 | 13.39 |
| ***Financial policy variables:*** | | | | | | | |
| Deposit guarantees | 0-1 dummy | dummy=1 after announcement of policy measure | BIS, CGFS database (plus Bloomberg for missing countries) | 0.44 | 0.50 | 0 | 1 |
| Debt guarantees | 0-1 dummy | dummy=1 after announcement of policy measure | BIS, CGFS database (plus Bloomberg for missing countries) | 0.32 | 0.47 | 0 | 1 |
| Capital injections | 0-1 dummy | dummy=1 after announcement of policy measure | BIS, CGFS database (plus Bloomberg for missing countries) | 0.26 | 0.44 | 0 | 1 |
| ***Firm-specific financial constraints:*** | | | | | | | |
| Value factor | ratio | Price-to-Book ratio | Bloomberg | 4.46 | 19.64 | 0.04 | 359.26 |
| Size | log USD values | Total assets (log) | Bloomberg | 9.42 | 3.11 | 0.68 | 18.10 |

Source: IMF (IFS, WEO, DOTS, CPIS), ICRG, Bloomberg.

# Table II: Interdependence

The table shows the estimates of the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,0}' F_t + e_{i,t} \quad (12)$$

The table reports the unweighted average degree of interdependence across all portfolios in the sample, where *G* denotes the global factor, *U* the US factor, and *D* the domestic factor. The test statistics are described in section I.B. The critical value of a $\chi^2$ (1)-distributed variable is 3.84 (6.63) at the 5% (1%) level. The model is estimated allowing for errors to be clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

| | Benchmark | | |
|---|---|---|---|
| | coef | | *st.err.* |
| **Interdependence** | | | |
| $\beta_1^G$ | 0.406 | *** | *0.012* |
| $\beta_1^U$ | 0.437 | *** | *0.015* |
| $\beta_1^D$ | 0.540 | *** | *0.013* |
| **Test statistics** | | | |
| **Full Sample** | | | |
| ECTEST | 53.35 | | |
| EXCOR | 0.11 | | |
| ECDIAG | 618.31 | | |
| **Crisis Period** | | | |
| ECTEST | 12.09 | | |
| EXCOR | 0.11 | | |
| ECDIAG | 481.56 | | |
| Observations | 322216 | | |
| R-squared | 0.274 | | |

## Table III: Interdependence across Regions and Sectors

The table shows the estimates of the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,0}' F_t + e_{i,t} \quad (12)$$

The table provides estimates of the average degrees of interdependence across portfolios within a particular region (Panel A), and those within a particular sector (Panel B), where *G* denotes the global factor, *U* the US factor, and *D* the domestic factor. The standard errors are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

### A. By region

| | Interdependence | | |
|---|---|---|---|
| ***Region*** | $\beta_0^G$ | $\beta_0^U$ | $\beta_0^D$ |
| Latin America | 0.360 *** | 0.594 *** | 0.604 *** |
| Western Europe | 0.539 *** | 0.633 *** | 0.512 *** |
| Emerging Europe | 0.347 *** | 0.273 *** | 0.473 *** |
| Middle East/Africa | 0.163 *** | 0.084 *** | 0.467 *** |
| Developed Asia | 0.531 *** | 0.494 *** | 0.655 *** |
| Emerging Asia | 0.350 *** | 0.267 *** | 0.679 *** |

### B. By sector

| | Interdependence | | |
|---|---|---|---|
| ***Sector*** | $\beta_0^G$ | $\beta_0^U$ | $\beta_0^D$ |
| Basic Materials | 0.446 *** | 0.460 *** | 0.586 *** |
| Communications | 0.303 *** | 0.448 *** | 0.562 *** |
| Consumer, Cyclical | 0.410 *** | 0.416 *** | 0.568 *** |
| Consumer, Non-cycl | 0.358 *** | 0.360 *** | 0.492 *** |
| Diversified | 0.471 *** | 0.522 *** | 0.762 *** |
| Energy | 0.402 *** | 0.393 *** | 0.499 *** |
| Financial | 0.583 *** | 0.492 *** | 0.476 *** |
| Industrial | 0.421 *** | 0.440 *** | 0.561 *** |
| Technology | 0.249 *** | 0.679 *** | 0.575 *** |
| Utilities | 0.336 *** | 0.291 *** | 0.448 *** |

# Table IV: Predicting Crisis Returns

The table shows total actual equity market returns over the entire crisis period (Aug. 2007 – March 2009) against the fitted total returns from the interdependence model (see Table II for explanations) and against the fitted total returns from the contagion model (see Table VI). Portfolio returns in the table are averaged within countries. Countries are ranked according to actual equity market returns during the crisis. The model parameters shown are from the contagion model.

| | Actual returns | | Interdepend. Model Fitted returns | | Contagion Model Fitted returns | | *Model parameters (contagion model)* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Country*** | returns | *rank* | returns | *rank* | returns | *rank* | $\beta^G_{i,0}$ | $\beta^U_{i,0}$ | $\beta^D_{i,0}$ | $\gamma^G_{i,0}$ | $\gamma^U_{i,0}$ | $\gamma^D_{i,0}$ | $\eta_{i,0}$ |
| Serbia | -85.6 | *1* | -57.6 | *2* | -73.6 | *1* | 0.090 | 0.043 | 0.630 | -0.039 | 0.247 | 0.007 | -0.804 |
| Ukraine | -77.9 | *2* | -35.3 | *20* | -72.3 | *2* | 0.213 | 0.153 | 0.233 | 0.182 | 0.101 | 0.606 | -0.356 |
| Romania | -77.3 | *3* | -31.7 | *28* | -66.5 | *4* | 0.213 | 0.145 | 0.228 | 0.106 | 0.205 | 0.483 | -0.677 |
| Bulgaria | -74.2 | *4* | -50.3 | *6* | -65.9 | *5* | 0.158 | 0.047 | 0.199 | 0.283 | 0.253 | 0.534 | 0.190 |
| Slovenia | -71.9 | *5* | -30.8 | *30* | -58.3 | *11* | 0.287 | 0.059 | 0.385 | -0.024 | 0.119 | 0.444 | -0.400 |
| Poland | -69.5 | *6* | -52.3 | *4* | -65.2 | *6* | 0.436 | 0.493 | 0.416 | 0.278 | 0.320 | 0.428 | -0.031 |
| Iceland | -67.7 | *7* | -46.4 | *8* | -62.9 | *8* | 0.304 | 0.143 | 0.442 | -0.104 | 0.046 | 0.044 | -0.363 |
| Russia | -66.2 | *8* | -43.4 | *11* | -57.7 | *12* | 0.187 | 0.261 | 0.285 | 0.328 | 0.282 | 0.361 | 0.112 |
| Latvia | -64.3 | *9* | -39.9 | *13* | -61.5 | *10* | 0.188 | 0.063 | 0.343 | 0.088 | 0.134 | 0.126 | -0.432 |
| Estonia | -64.3 | *10* | -45.8 | *9* | -64.2 | *7* | 0.322 | 0.215 | 0.286 | 0.089 | 0.239 | 0.518 | -0.168 |
| Turkey | -64.1 | *11* | -70.6 | *1* | -69.8 | *3* | 0.671 | 0.644 | 0.823 | 0.363 | 0.116 | 0.018 | 0.168 |
| Croatia | -63.9 | *12* | -39.1 | *14* | -48.3 | *17* | 0.248 | 0.059 | 0.324 | 0.028 | 0.287 | 0.499 | 0.105 |
| Lithuania | -61.4 | *13* | -36.6 | *18* | -53.3 | *14* | 0.165 | 0.073 | 0.407 | 0.119 | 0.055 | 0.310 | -0.236 |
| Ireland | -61.3 | *14* | -30.4 | *33* | -48.0 | *18* | 0.498 | 0.421 | 0.343 | -0.108 | 0.141 | 0.049 | -0.643 |
| New Zealand | -60.2 | *15* | -52.2 | *5* | -62.2 | *9* | 0.388 | 0.356 | 0.641 | 0.061 | 0.175 | 0.164 | -0.267 |
| Norway | -60.1 | *16* | -30.6 | *31* | -49.0 | *16* | 0.453 | 0.453 | 0.569 | 0.021 | 0.364 | 0.177 | -0.244 |
| Hungary | -59.6 | *17* | -53.6 | *3* | -55.9 | *13* | 0.544 | 0.562 | 0.559 | -0.046 | 0.129 | 0.226 | 0.088 |
| Italy | -55.5 | *18* | -35.9 | *19* | -43.1 | *21* | 0.434 | 0.682 | 0.495 | 0.134 | 0.164 | 0.288 | -0.097 |
| Egypt | -54.2 | *19* | -13.0 | *48* | -11.2 | *49* | 0.153 | 0.060 | 0.326 | 0.268 | -0.143 | 0.529 | 0.270 |
| Korea | -52.9 | *20* | -44.8 | *10* | -45.4 | *19* | 0.491 | 0.558 | 0.613 | 0.062 | 0.251 | 0.210 | 0.178 |
| Portugal | -52.1 | *21* | -32.8 | *25* | -36.1 | *26* | 0.424 | 0.373 | 0.580 | 0.048 | 0.148 | 0.211 | -0.051 |
| Czech Republic | -52.1 | *22* | -47.8 | *7* | -50.4 | *15* | 0.569 | 0.295 | 0.563 | 0.005 | 0.125 | 0.107 | -0.003 |
| Brazil | -51.2 | *23* | -37.0 | *17* | -44.7 | *20* | 0.391 | 0.834 | 0.605 | 0.104 | 0.411 | 0.173 | -0.038 |
| Sweden | -51.0 | *24* | -33.9 | *23* | -37.8 | *23* | 0.561 | 0.700 | 0.404 | -0.014 | 0.325 | 0.419 | -0.018 |
| Finland | -49.7 | *25* | -25.4 | *37* | -38.8 | *22* | 0.451 | 0.572 | 0.366 | -0.059 | 0.280 | 0.453 | -0.162 |
| Thailand | -48.8 | *26* | -19.2 | *41* | -37.0 | *24* | 0.398 | 0.273 | 0.521 | 0.171 | 0.162 | 0.250 | -0.354 |
| France | -47.1 | *27* | -32.6 | *26* | -33.0 | *28* | 0.651 | 0.829 | 0.535 | -0.068 | 0.182 | 0.328 | -0.021 |
| UK | -43.9 | *28* | -26.9 | *35* | -27.5 | *32* | 0.525 | 0.612 | 0.508 | 0.048 | 0.182 | 0.378 | 0.009 |
| Argentina | -42.2 | *29* | -3.8 | *53* | -13.6 | *47* | 0.232 | 0.362 | 0.406 | 0.203 | 0.165 | 0.238 | -0.226 |
| China | -42.2 | *30* | -38.6 | *15* | -36.6 | *25* | 0.053 | -0.015 | 0.702 | 0.036 | -0.276 | 0.124 | 0.047 |
| Spain | -41.6 | *31* | -19.6 | *40* | -24.2 | *37* | 0.518 | 0.615 | 0.486 | 0.067 | 0.183 | 0.357 | -0.025 |
| Netherlands | -40.5 | *32* | -32.3 | *27* | -25.1 | *35* | 0.505 | 0.928 | 0.430 | 0.058 | 0.001 | 0.227 | 0.157 |
| Denmark | -40.5 | *33* | -21.2 | *39* | -31.1 | *29* | 0.537 | 0.424 | 0.310 | 0.092 | 0.269 | 0.377 | -0.088 |
| India | -40.4 | *34* | -14.2 | *47* | -24.3 | *36* | 0.252 | 0.417 | 0.627 | 0.234 | -0.006 | 0.265 | -0.058 |
| Colombia | -39.8 | *35* | -42.6 | *12* | -23.4 | *39* | 0.220 | 0.284 | 0.621 | 0.149 | 0.264 | 0.225 | 0.651 |
| Singapore | -39.7 | *36* | -35.0 | *22* | -24.2 | *38* | 0.735 | 0.591 | 0.568 | -0.286 | 0.026 | 0.316 | 0.181 |
| Indonesia | -39.2 | *37* | -28.4 | *34* | -26.6 | *33* | 0.587 | 0.358 | 0.662 | 0.051 | -0.011 | 0.230 | 0.091 |
| Germany | -37.8 | *38* | -35.1 | *21* | -29.1 | *30* | 0.646 | 0.962 | 0.553 | -0.090 | -0.099 | 0.163 | 0.047 |
| Belgium | -35.7 | *39* | -30.6 | *32* | -26.5 | *34* | 0.550 | 0.461 | 0.497 | 0.004 | 0.183 | -0.019 | 0.043 |
| UAE | -35.6 | *40* | -14.5 | *46* | -6.7 | *52* | -0.017 | 0.002 | 0.143 | 0.204 | -0.178 | 0.422 | 0.451 |
| Chile | -35.1 | *41* | -17.7 | *44* | -22.2 | *41* | 0.298 | 0.470 | 0.622 | 0.019 | 0.162 | 0.314 | -0.065 |
| Taiwan | -34.9 | *42* | -32.9 | *24* | -28.7 | *31* | 0.399 | 0.323 | 0.686 | -0.064 | 0.155 | 0.116 | 0.116 |
| Hong Kong | -33.7 | *43* | -12.9 | *49* | -22.3 | *40* | 0.442 | 0.489 | 0.487 | 0.219 | 0.249 | 0.442 | -0.160 |
| Mexico | -33.2 | *44* | -37.0 | *16* | -33.2 | *27* | 0.391 | 0.769 | 0.609 | -0.044 | 0.074 | 0.087 | 0.109 |
| Austria | -33.1 | *45* | -31.0 | *29* | -17.1 | *44* | 0.507 | 0.396 | 0.544 | 0.091 | 0.201 | 0.171 | 0.251 |
| Qatar | -32.1 | *46* | -3.4 | *54* | 2.4 | *54* | 0.046 | -0.018 | 0.341 | 0.010 | -0.041 | 0.373 | 0.148 |
| Australia | -31.8 | *47* | -26.2 | *36* | -21.3 | *42* | 0.479 | 0.457 | 0.631 | -0.075 | 0.122 | -0.013 | 0.078 |
| Switzerland | -30.8 | *48* | -25.4 | *38* | -15.8 | *45* | 0.580 | 0.644 | 0.461 | 0.043 | 0.146 | -0.016 | 0.201 |
| Japan | -30.6 | *49* | -19.1 | *42* | -17.4 | *43* | 0.553 | 0.293 | 0.753 | 0.010 | 0.062 | 0.054 | 0.010 |
| Luxembourg | -27.4 | *50* | -17.7 | *43* | -6.7 | *51* | 0.339 | 0.194 | 0.149 | 0.172 | 0.281 | 0.327 | 0.265 |
| Israel | -21.7 | *51* | -17.3 | *45* | -14.0 | *46* | 0.197 | 0.338 | 0.594 | -0.047 | 0.077 | 0.272 | 0.118 |
| Canada | -19.1 | *52* | -3.9 | *52* | -10.6 | *50* | 0.206 | 0.346 | 0.246 | -0.066 | -0.155 | 0.105 | -0.161 |
| Malta | -13.8 | *53* | -10.2 | *51* | -12.2 | *48* | -0.096 | 0.020 | 0.324 | -0.017 | -0.053 | 0.179 | 0.066 |
| Tunisia | -9.7 | *54* | -10.5 | *50* | -6.6 | *53* | 0.232 | 0.024 | 0.554 | 0.031 | 0.051 | 0.083 | -0.078 |

# Table V: Predicting Crisis Returns – Distribution at the Sector Level

The table shows at the sector level the total actual equity market returns over the entire crisis period (August 2007 – March 2009) against the fitted total returns from the interdependence model (see Table II for explanations) and against the fitted total returns from the contagion model (see Table VI). Portfolio returns in the table are unweighted averages within sectors. Sectors are ranked according to actual equity market returns during the crisis. The model parameters are from the contagion model specification (see Table VI).

| | | | Interdepend. Model | | Contagion Model | | *Model parameters (contagion model)* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Actual returns | | Fitted returns | | Fitted returns | | | | | | | | |
| ***Sector*** | returns | *rank* | returns | *rank* | returns | *rank* | $\beta^G_{i,0}$ | $\beta^U_{i,0}$ | $\beta^D_{i,0}$ | $\gamma^G_{i,0}$ | $\gamma^U_{i,0}$ | $\gamma^D_{i,0}$ | $\eta_{i,0}$ |
| Financial | -55.0 | *1* | -30.6 | *1* | -41.6 | *1* | 0.495 | 0.441 | 0.439 | 0.203 | 0.106 | 0.194 | -0.217 |
| Basic Materials | -53.5 | *2* | -29.1 | *3* | -39.6 | *2* | 0.391 | 0.379 | 0.494 | 0.009 | 0.324 | 0.469 | -0.103 |
| Diversified | -52.4 | *3* | -29.3 | *2* | -35.9 | *3* | 0.433 | 0.477 | 0.709 | 0.037 | 0.157 | 0.163 | -0.045 |
| Consumer, Cycli | -45.7 | *4* | -28.4 | *4* | -34.2 | *4* | 0.379 | 0.386 | 0.519 | 0.039 | 0.096 | 0.232 | -0.068 |
| Industrial | -44.6 | *5* | -24.4 | *8* | -32.5 | *5* | 0.379 | 0.383 | 0.498 | 0.033 | 0.196 | 0.335 | -0.148 |
| Technology | -43.0 | *6* | -27.8 | *5* | -29.2 | *6* | 0.217 | 0.704 | 0.574 | 0.192 | -0.157 | 0.083 | -0.105 |
| Energy | -40.6 | *7* | -27.0 | *7* | -26.8 | *7* | 0.336 | 0.320 | 0.433 | 0.103 | 0.286 | 0.401 | 0.172 |
| Communications | -39.7 | *8* | -27.7 | *6* | -25.6 | *8* | 0.305 | 0.455 | 0.539 | 0.015 | -0.037 | 0.096 | 0.036 |
| Utilities | -35.0 | *9* | -18.6 | *10* | -18.8 | *10* | 0.286 | 0.236 | 0.394 | 0.068 | 0.179 | 0.310 | 0.172 |
| Consumer, Non- | -34.0 | *10* | -22.4 | *9* | -22.2 | *9* | 0.366 | 0.341 | 0.462 | -0.075 | 0.091 | 0.137 | 0.000 |

## Table VI: Contagion and Interdependence

The table shows the estimates of the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,t}' F_t + \eta_{i,0} CR_t + e_{i,t} \quad (13)$$

$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0} \; CR_t \quad (14)$$

The table reports estimates of the unweighted average degree of contagion and interdependence across all portfolios in the sample. The critical value of a $\chi^2$ (1)-distributed variable is 3.84 (6.63) at the 5% (1%) level. The model is estimated allowing for errors to be clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

| | Benchmark | | |
|---|---|---|---|
| | coef | | *st.err.* |
| **Contagion** | | | |
| $\gamma_1^G$ | 0.056 | *** | *0.013* |
| $\gamma_1^U$ | 0.133 | *** | *0.015* |
| $\gamma_1^D$ | 0.249 | *** | *0.016* |
| **Interdependence** | | | |
| $\beta_1^G$ | 0.368 | *** | *0.012* |
| $\beta_1^U$ | 0.397 | *** | *0.016* |
| $\beta_1^D$ | 0.491 | *** | *0.014* |
| **Other** | | | |
| $\eta_1$ | -0.038 | | *0.025* |
| **Test statistics** | | | |
| **Full Sample** | | | |
| ECTEST | 27.78 | | |
| EXCOR | 0.06 | | |
| ECDIAG | 459.73 | | |
| **Crisis Period** | | | |
| ECTEST | 0.00 | | |
| EXCOR | 0.01 | | |
| ECDIAG | 335.94 | | |
| Observations | 322216 | | |
| R-squared | 0.310 | | |

## Table VII: Correlation Patterns across Contagion and Interdependence Parameters

The table shows the correlation coefficients across the estimates of the various contagion and interdependence coefficients for the 415 portfolios in the sample, based on the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,t}' F_t + \eta_{i,0} CR_t + e_{i,t} \quad (13)$$

$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0} \; CR_t \quad (14)$$

*P*-values are shown below the correlation coefficients in smaller figures and italics. Standard errors are based on the cross-sectional distribution of the coefficients.

| | Contagion | | | Interdependence | | | Other |
|---|---|---|---|---|---|---|---|
| | $\gamma_0^G$ | $\gamma_0^U$ | $\gamma_0^D$ | $\beta_0^G$ | $\beta_0^U$ | $\beta_0^D$ | $\eta_0$ |
| **Contagion** | | | | | | | |
| $\gamma_0^G$ | 1 | | | | | | |
| $\gamma_0^U$ | 0.121 | 1 | | | | | |
| | *0.013* | | | | | | |
| $\gamma_0^D$ | 0.212 | 0.493 | 1 | | | | |
| | *0.000* | *0.000* | | | | | |
| **Interdependence** | | | | | | | |
| $\beta_0^G$ | -0.273 | -0.027 | -0.210 | 1 | | | |
| | *0.000* | *0.590* | *0.000* | | | | |
| $\beta_0^U$ | -0.153 | -0.203 | -0.302 | 0.620 | 1 | | |
| | *0.002* | *0.000* | *0.000* | *0.000* | | | |
| $\beta_0^D$ | -0.077 | -0.276 | -0.524 | 0.319 | 0.389 | 1 | |
| | *0.119* | *0.000* | *0.000* | *0.000* | *0.000* | | |
| **Other** | | | | | | | |
| $\eta_0$ | 0.092 | 0.099 | 0.092 | -0.018 | 0.012 | -0.038 | 1 |
| | *0.061* | *0.045* | *0.063* | *0.713* | *0.813* | *0.438* | |

# Table VIII: Contagion and Interdependence across Regions and Sectors

The table shows the estimates of the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,t}' F_t + \eta_{i,0} CR_t + e_{i,t} \quad (13)$$

$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0}\ CR_t \quad (14)$$

The table reports the average contagion and interdependence coefficients across portfolios within a particular region (Panel A), and those within a particular sector (Panel B). The standard errors are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

## A. By region

| | Contagion | | | Interdependence | | | Other |
|---|---|---|---|---|---|---|---|
| ***Region*** | $\gamma_0^G$ | $\gamma_0^U$ | $\gamma_0^D$ | $\beta_0^G$ | $\beta_0^U$ | $\beta_0^D$ | $\eta_0$ |
| Latin America | 0.090 *** | 0.223 *** | 0.212 *** | 0.305 *** | 0.537 *** | 0.575 *** | 0.091 |
| Western Europe | 0.015 | 0.173 *** | 0.241 *** | 0.509 *** | 0.588 *** | 0.468 *** | -0.049 |
| Emerging Europe | 0.109 *** | 0.167 *** | 0.318 *** | 0.281 *** | 0.209 *** | 0.405 *** | -0.160 *** |
| Middle East/Africa | 0.082 * | -0.038 | 0.337 *** | 0.127 *** | 0.092 *** | 0.406 *** | 0.171 * |
| Developed Asia | 0.016 | 0.156 *** | 0.194 *** | 0.507 *** | 0.455 *** | 0.617 *** | 0.005 |
| Emerging Asia | 0.089 ** | -0.004 | 0.197 *** | 0.324 *** | 0.261 *** | 0.639 *** | -0.036 |

## B. By sector

| | Contagion | | | Interdependence | | | Other |
|---|---|---|---|---|---|---|---|
| ***Sector*** | $\gamma_0^G$ | $\gamma_0^U$ | $\gamma_0^D$ | $\beta_0^G$ | $\beta_0^U$ | $\beta_0^D$ | $\eta_0$ |
| Basic Materials | 0.009 | 0.324 *** | 0.469 *** | 0.391 *** | 0.379 *** | 0.494 *** | -0.103 |
| Communications | 0.015 | -0.037 | 0.096 *** | 0.305 *** | 0.455 *** | 0.539 *** | 0.036 |
| Consumer, Cyclical | 0.039 | 0.096 *** | 0.232 *** | 0.379 *** | 0.386 *** | 0.519 *** | -0.068 |
| Consumer, Non-cycl | -0.075 *** | 0.091 *** | 0.137 *** | 0.366 *** | 0.341 *** | 0.462 *** | 0.000 |
| Diversified | 0.037 | 0.157 * | 0.163 *** | 0.433 *** | 0.477 *** | 0.709 *** | -0.045 |
| Energy | 0.103 ** | 0.286 *** | 0.401 *** | 0.336 *** | 0.320 *** | 0.433 *** | 0.172 *** |
| Financial | 0.203 *** | 0.106 *** | 0.194 *** | 0.495 *** | 0.441 *** | 0.439 *** | -0.217 *** |
| Industrial | 0.033 | 0.196 *** | 0.335 *** | 0.379 *** | 0.383 *** | 0.498 *** | -0.148 * |
| Technology | 0.192 *** | -0.157 ** | 0.083 | 0.217 *** | 0.704 *** | 0.574 *** | -0.105 |
| Utilities | 0.068 | 0.179 *** | 0.310 *** | 0.286 *** | 0.236 *** | 0.394 *** | 0.172 *** |

## Table IX: Contagion and Interdependence – Robustness

The table reports the estimates of the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,t}' F_t + \eta_{i,0} CR_t + e_{i,t} \quad (13)$$

$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0}\ CR_t \quad (14)$$

The table reports the average contagion and interdependence coefficients across all portfolios in the sample. Results for "Post-Lehman" are based on a definition of the crisis ($CR_t = 1$) for the period after the Lehman Brothers collapse, i.e. 15 September 2008 – 15 March 2009. "LTCM" crisis takes the period after the collapse of LTCM, from October through December 1998 as the crisis definition, while "TMT bust" defines the decline of global equity markets from October 2000 through December 2002. For these last two estimations, the current crisis observations are excluded. The model is estimated allowing for errors to be clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

| | **Benchmark** | | | **Post-Lehman** | | | **LTCM crisis** | | | **TMT bust** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | coef | | *st.err.* | coef | | *st.err.* | coef | | *st.err.* | coef | | *st.err.* |
| **Contagion** | | | | | | | | | | | | |
| $\gamma_1^G$ | 0.056 | *** | *0.013* | 0.047 | *** | *0.014* | -0.089 | *** | *0.019* | 0.010 | | *0.013* |
| $\gamma_1^U$ | 0.133 | *** | *0.015* | 0.142 | *** | *0.018* | -0.026 | *** | *0.002* | -0.004 | * | *0.002* |
| $\gamma_1^D$ | 0.249 | *** | *0.016* | 0.283 | *** | *0.021* | -0.030 | | *0.030* | -0.013 | | *0.026* |
| **Interdependence** | | | | | | | | | | | | |
| $\beta_1^G$ | 0.368 | *** | *0.012* | 0.375 | *** | *0.012* | 0.381 | *** | *0.012* | 0.365 | *** | *0.012* |
| $\beta_1^U$ | 0.397 | *** | *0.016* | 0.405 | *** | *0.016* | 0.403 | *** | *0.016* | 0.398 | *** | *0.016* |
| $\beta_1^D$ | 0.491 | *** | *0.014* | 0.517 | *** | *0.014* | 0.495 | *** | *0.014* | 0.498 | *** | *0.014* |
| **Other** | | | | | | | | | | | | |
| $\eta_1$ | -0.038 | | *0.025* | -0.148 | *** | *0.048* | -0.179 | *** | *0.042* | -0.032 | * | *0.018* |
| Observations | 322216 | | | 322216 | | | 185223 | | | 185223 | | |
| R-squared | 0.310 | | | 0.348 | | | 0.310 | | | 0.310 | | |

# Table X: Channels of Interdependence

The table shows the estimates of the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,t}' F_t + e_{i,t} \quad (1')$$

$$\beta_{i,t} = \beta_{i,0} + \beta_1' Z_{i,t-k} \quad (2')$$

We report the $\beta_1$ coefficients, which are the coefficients on the $Z_{i,t}$ instruments that survive the encompassing approach of variable selection described in the text. This means that a variable is kept in the model only if its coefficient is statistically significant at the 15% level. The column labeled "interdecile" shows the difference in the respective interdependence coefficients for a portfolio with the determinant at its 90th percentile compared to a portfolio at its 10th percentile. The critical value of a $\chi^2$ (1)-distributed variable is 3.84 (6.63) at the 5% (1%) level. The standard errors are clustered by country. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

| | Interdependence | | | |
|---|---|---|---|---|
| | coef | | *std. err.* | Interdecile |
| **Global channel** | | | | |
| Financal depth | -0.020 | * | *0.011* | -0.021 |
| Trade integration | 0.181 | *** | *0.028* | 0.226 |
| Credit risk - TED spread | 0.073 | *** | *0.019* | 0.062 |
| **US channel** | | | | |
| Trade integration | 0.173 | *** | *0.021* | 0.216 |
| Current account | -0.381 | *** | *0.061* | -0.069 |
| Credit risk - TED spread | 0.220 | *** | *0.016* | 0.187 |
| **Domestic channel** | | | | |
| Trade integration | -0.003 | | *0.004* | -0.003 |
| Financial depth | 0.257 | *** | *0.016* | 0.320 |
| Financial integration | -0.071 | *** | *0.008* | -0.059 |
| Credit risk - TED spread | 0.359 | *** | *0.010* | 0.306 |
| **Test statistics** | | | | |
| **Full Sample** | | | | |
| ECTEST | 21.69 | | | |
| EXCOR | 0.06 | | | |
| ECDIAG | 385.36 | | | |
| **Crisis Period** | | | | |
| ECTEST | 2.19 | | | |
| EXCOR | 0.04 | | | |
| ECDIAG | 313.20 | | | |
| Observations | 281567 | | | |
| R-squared | 0.310 | | | |

# Table XI: Channels of Contagion and Interdependence

The table shows the estimates for the contagion parameters γ and the interdependence parameters β from the full model (1)-(4), following the encompassing approach of variable selection described in the text. This means that a variable is kept in the model if either the interdependence coefficient or the contagion parameter of a particular variable is statistically significant. The column labeled "Interdecile" shows the difference in the respective interdependence and contagion coefficients for a portfolio with the determinant at its 90th percentile compared a portfolio at its 10th percentile. The critical value of a $\chi^2$ (1)-distributed variable is 3.84 (6.63) at the 5% (1%) level. The standard errors are clustered by country. ***, **, and *, indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

| | **Contagion** | | | | **Interdependence** | | | |
|---|---|---|---|---|---|---|---|---|
| | coef | | *std. err.* | Interdec. | coef | | *std. err.* | Interdecile |
| **Global channel** | | | | | | | | |
| Trade integration global | 0.120 | | *0.284* | 0.150 | 0.167 | *** | *0.051* | 0.209 |
| Current account | -1.429 | ** | *0.686* | -0.239 | -0.193 | | *0.120* | -0.032 |
| Debt guarantees | -0.366 | * | *0.191* | -0.366 | | | | |
| Deposit guarantees | -0.327 | * | *0.196* | -0.327 | | | | |
| Risk aversion - VIX | -0.846 | *** | *0.222* | -0.159 | 0.515 | *** | *0.084* | 0.097 |
| Credit risk - TED spread | -0.878 | *** | *0.097* | -0.749 | 0.787 | *** | *0.092* | 0.671 |
| **US channel** | | | | | | | | |
| Trade integration global | -0.182 | | *0.181* | -0.227 | 0.274 | *** | *0.032* | 0.341 |
| Financial integration global | -0.711 | *** | *0.121* | -0.591 | -0.015 | | *0.017* | -0.013 |
| Sovereign rating | -0.596 | ** | *0.283* | -0.596 | -0.228 | | *0.512* | -0.228 |
| Debt guarantees | -0.251 | ** | *0.120* | -0.251 | | | | |
| Credit risk - TED spread | -0.515 | *** | *0.059* | -0.440 | 0.646 | *** | *0.051* | 0.551 |
| **Domestic channel** | | | | | | | | |
| Trade integration global | -0.045 | | *0.138* | -0.056 | 0.252 | *** | *0.021* | 0.315 |
| FX reserves | -0.391 | *** | *0.161* | -0.113 | 0.398 | *** | *0.058* | 0.115 |
| Current account | -1.021 | ** | *0.470* | -0.171 | -0.155 | *** | *0.060* | -0.026 |
| Deposit guarantees | -0.444 | *** | *0.169* | -0.444 | | | | |
| Credit risk - TED spread | -0.472 | *** | *0.034* | -0.403 | 0.485 | *** | *0.029* | 0.414 |
| **Test statistics** | | | | | | | | |
| **Full Sample** | | | | | | | | |
| ECTEST | 15.90 | | | | | | | |
| EXCOR | 0.05 | | | | | | | |
| ECDIAG | 420.47 | | | | | | | |
| **Crisis Period** | | | | | | | | |
| ECTEST | 0.01 | | | | | | | |
| EXCOR | 0.01 | | | | | | | |
| ECDIAG | 312.49 | | | | | | | |
| Observations | 281567 | | | | | | | |
| R-squared | 0.332 | | | | | | | |

# Appendices

### Appendix A. Equity market data and a few stylized facts

This Appendix outlines the equity market data coverage and definitions and presents a few stylized facts. As the objective is to test for the global transmission of the financial crisis, we use a broad set of 55 countries (other than the United States, which are not included in our analysis of cross-country transmission patterns) that includes not only most of the advanced economies, but also emerging market economies (EMEs) and a few developing countries. Table A.1 lists the country coverage by region. The objective of analyzing the global transmission of the crisis implies that we would like to include stocks of firms that are traded frequently and for which also data on firm-specific characteristics are available. Hence we include only those firms in the analysis that are part of the main equity market index in the respective country, as shown in Table A.1. This comprises about 2,000 firms in total, for which we have extracted daily equity returns in US dollars.[10]

Table A.1

From the firm-level data we construct country-sector portfolios, using the Bloomberg classification that allocates firms into 10 broad industry sectors. This yields in total 415 country-industry or country-sector portfolios. Not every of the 55 countries in the sample has therefore 10 country-sector portfolios as not all countries have firms in each of the 10 sectors in their main stock market index. These portfolios are value-weighted, so that each firm is weighted according to its relative market capitalization in its respective portfolio. While the number of firms included in a portfolio can be small (and indeed, for some of the smallest countries with a low number of listed firms, a single firm may represent an entire sector), our intention is to include only relatively large firms in each country that are traded frequently and for which we have reliable data.

As to the current financial crisis, we define the starting point of the crisis as August 7, 2007, when equity markets initially fell and central banks started intervening for the first time to provide liquidity to financial markets. The last observation in our dataset is 15 March 2009. An alternative crisis definition is to start with the bankruptcy of Lehman Brothers on September 15, 2008, which we investigate as a robustness check. Using our data to compute world market returns, the crisis meant an equity market decline of about 50% from peak to trough, occurring in about 18 months (from mid-2007 to early 2009).

**Appendix B. Portfolio-specific determinants**

In addition to the country-specific and common/global instruments outlined in section I, we control for a number of portfolio-specific determinants of crisis vulnerability. Specifically, we are interested in capturing two potential channels: financial constraints and external exposures at the firm level. There is a large literature in monetary economics and in finance on how to measure the degree of financial constraints faced by firms (Kaplan & Zingales 1997; Rajan and Zingales, 1998; Cleary 1999; Almeida et al. 2004; Whited & Wu 2006). We follow the approach used by Whited and Wu (2006) and define financial constraints of a particular firm in the following way:

$$FC_{i,t} = -0.09\ CF_{i,t} - 0.062\ DD_{i,t} + 0.02\ DA_{i,t} - 0.044 \ln A_{i,t} + 0.10 IG_{i,t} - 0.035 FG_{i,t} \quad \text{(A.1)}$$

with *CF* as the cash flow-net asset ratio, *DD* a firm's dividend payments, *DA* the debt-net assets ratio, *A* total net assets, *IG* industry growth rate, and *FG* as the firm's growth rate in net assets.

Turning to proxies of firm-level external exposure, the exchange rate exposure of firms has been stressed in the literature as an important reason for why firms' equity valuations are affected by foreign shocks (e.g. Adler and Dumas 1984, Dominguez and Tesar 2001 and 2006). The rationale is as follows: a firm is likely to be more strongly affected by a particular US shock and the resulting exchange rate change if it has a high external exposure, e.g. via trade or via external financial linkages. Following the methodology proposed by Dominguez and Tesar (2001), we proxy the exchange rate exposure of each portfolio to the United States by the sensitivity of its excess equity return at time $t$, $R_{i,t}$, to bilateral exchange rate changes vis-à-vis the US dollar, $\Delta s_{i,t}$, controlling in the estimation also for US equity returns $R_t^{US}$:

$$R_{i,t} = \delta_0 + \delta_i \Delta s_{i,t} + \kappa_i R_t^{US} + e_{i,t} \quad \text{(A.2)}$$

where the exchange rate exposure for each portfolio, estimated over the whole pre-crisis sample period 1 January 1995 to 6 August 2007, is measured as $\delta_i$. For the estimation we use weekly data.

Another type of exposure, and one related closely to the credit channel, is a firm's exposure to changes in the cost of financing. Similar to the estimation proposed by Ammer, Vega and Wongswan (2009), we measure this channel as the interest rate exposure of individual portfolios to changes in domestic three-month interest rates, $\Delta r_{i,t}$, in the following way:

$$R_{i,t} = \eta_0 + \varphi_i \Delta r_{i,t} + \kappa_i R_t^{US} + e_{i,t} \tag{A.3}$$

using weekly data, in order to obtain portfolio-specific interest rate exposures $\varphi_i$. Unfortunately, short-term interest rates at weekly frequencies are not available for all countries so that the sample size is more limited for this interest rate exposure variable.

## Table A.1: Country sample and equity indices

The 10 broad industry sectors taken from Bloomberg's classification used to create the market-weighted country-sector equity portfolios are: (i) basic materials, (ii) communications, (iii) consumer cyclical goods, (iv) consumer non-cyclical goods, (v) diversified, (vi) energy, (vii) financials, (viii) industrial, (ix) technology and (x) utilities. For the US, the stock index used is the S&P 500.

| Country | Name of stock index | No. listed firms | Country | Name of stock index | No. listed firms |
|---|---|---|---|---|---|
| | **Industrialised** | | | **Emerging Europe** | |
| Australia | S&P ASX | 30 | Bulgaria | SOFIX | 20 |
| Austria | ATX | 20 | Croatia | CROBEX | 28 |
| Belgium | BEL20 | 20 | Czech Republic | PSE | 14 |
| Canada | S&P TSE 60 | 60 | Estonia | OMX | 18 |
| Denmark | OMX20 | 20 | Hungary | BSE | 14 |
| Finland | OMX25 | 25 | Iceland | OMX ICEX | 11 |
| France | CAC 40 | 40 | Latvia | OMX | 35 |
| Germany | DAX | 30 | Lithuania | OMX | 32 |
| Ireland | ISEQ | 60 | Norway | OBX | 24 |
| Italy | MIB 30 | 30 | Poland | WIG 20 | 20 |
| Japan | Topix 70 | 70 | Romania | BET | 10 |
| Luxembourg | LuxX | 9 | Russia | MICEX | 30 |
| Netherlands | AEX | 25 | Serbia | Belex 15 | 15 |
| Portugal | PSI 20 | 20 | Turkey | ISE National 30 | 30 |
| Slovenia | SBI20 | 15 | Ukraine | PFTS | 19 |
| Spain | IBEX 35 | 35 | | | |
| Sweden | OMX 30 | 30 | | **Middle-East and Africa** | |
| Switzerland | SMI 30 | 20 | | | |
| UK | Footsie 100 | 100 | Egypt | CASE | 30 |
| | | | Israel | Tel Aviv-25 | 25 |
| | | | Lebanon | BLOM | 19 |
| | **Asia-Pacific** | | Tunisia | SE BVMT | 32 |
| | | | UAE | DFM | 29 |
| China | Shanghai SE 50 | 50 | | | |
| Hong Kong | Hang Seng | 42 | | **Latin America** | |
| India | BSE Sensex 30 | 30 | | | |
| Indonesia | Jakarta LQ-45 | 45 | Argentina | Merval | 22 |
| Korea | Kospi 50 | 50 | Brazil | Bovespa | 66 |
| New Zealand | NZX 15 | 15 | Chile | IPSA | 40 |
| Singapore | Strait Times | 30 | Colombia | IGBC General | 28 |
| Taiwan | TSEC Taiwan 50 | 50 | Mexico | Bolsa | 36 |
| Thailand | SET 50 | 50 | Venezuela | IBC | 17 |

Source: Bloomberg.

## Endnotes

[1] This term was coined by Goldstein (1998) in the wake of the Asian financial crisis, with the Thai currency crisis of 1997 acting as a "wake-up call" for international investors who eventually recognised that the so-called "Asian miracle" of the time was rather an "Asian mirage", which ultimately led to a reassessment of the creditworthiness of Hong Kong, Indonesia, Korea, Malaysia and Singapore.

[2] Whereas the imperfect integration of emerging markets into global capital markets is well-known (see for instance Bekaert and Harvey (1997), or Carrieri, Errunza and Hogan (2007)), the analysis in Bekaert, Hodrick and Zhang (2009) and Bodnar, Dumas and Marston (2003) motivates the use of both global/international and domestic factors from a statistical perspective, even for developed markets.

[3] To avoid adding-up constraints and spurious correlations, the $R_t^D$ factor is value-weighted across country-sector portfolios located in the same country as portfolio *i*, but excludes returns of portfolio *i* itself. Strictly speaking, we would therefore need to denote domestic returns by $R_t^{D\backslash i}$, but use the shortcut for notational ease. We choose domestic rather than regional market portfolios since country factors have been shown to capture most of the respective regional factor for a specific portfolio (e.g. Brooks and Del Negro 2006).

[4] We have also estimated the model in local currency excess returns with qualitatively similar results.

[5] Note that this orthogonalisation is quite independent relative to the precise time period over which it is done. For instance, orthogonalising separately for the crisis and non-crisis periods yields very similar factors as calculating it over the entire sample period.

[6] More specifically, the orthogonalised domestic factor is estimated for each country-sector portfolio *i* individually as portfolio *i* itself is excluded from the domestic market portfolio.

[7] King (2009) uses these data in an event study to investigate the effect of such policies on the pricing of bonds and equities of domestic financial and non-financial institutions.

[8] In almost all cases such policies were still in existence at the end of our sample. We prefer to take the policy announcement, rather than the actual implementation – which in many cases took several weeks after the announcement – in order to capture the expectations effect of such policies on financial markets. Moreover, we prefer to use dummies rather than measures of the magnitude of deposit and debt guarantees and capital injections, primarily in order to obtain measures that are comparable across countries, as it is otherwise difficult to normalise and compare magnitudes of such measures in a meaningful way.

[9] More specifically, the series of weekly predicted returns is used to create a fitted price index, from which in turn the total return over the entire sample period is calculated.

[10] The perspective of the analysis is therefore from the perspective of a US investor. Note that equity returns in US dollar terms have been even more negative during the crisis given that almost all currencies (bar the Japanese yen, and a few pegged currencies) depreciated against the US dollar; see Fratzscher (2009).