## The Global Crisis and Equity Market Contagion

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#### ABSTRACT

We analyze the transmission of the 2007 to 2009 financial crisis to 415 countryindustry equity portfolios. We use a factor model to predict crisis returns, defining unexplained increases in factor loadings and residual correlations as indicative of contagion. While we find evidence of contagion from the United States and the global financial sector, the effects are small. By contrast, there has been substantial contagion from domestic markets to individual domestic portfolios, with its severity inversely related to the quality of countries' economic fundamentals. This confirms the "wakeup call" hypothesis, with markets focusing more on country-specific characteristics during the crisis.

EVER SINCE THE SEMINAL work of King and Wadhwani (1990) following the October 1987 global 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 cannot be explained by fundamentals or comovements that are viewed as "excessive." Countless papers have been written proposing quantitative measures of contagion (see Karolyi (2003) and Dungey et al. (2004) for surveys) or developing theories to explain it (e.g., Allen and Gale (2000)).

The financial crisis of 2007 to 2009 is arguably the first truly major global crisis since the Great Depression of 1929 to 1932. While the crisis initially had its origin in the United States in a relatively small segment of the lending market, namely the subprime mortgage market, it rapidly spread across virtually

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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 paper studies how and why the crisis spread so violently across countries and economic sectors. We develop a three-factor model to set a benchmark for what global equity market comovements should be, based on existing fundamentals. This model distinguishes between a U.S.-specific factor, a global financial factor, and a domestic factor for the pricing of 415 country-sector equity portfolios across 55 countries. We define contagion as the comovement in excess of that implied by the factor model. This contrasts with many contagion articles simply comparing comovements before and during the crisis. Obviously, our benchmark factor model, which we refer to as the *interdependence model*, implies a transmission of shocks proportional to the factor exposures. as measured precrisis. Excess comovements relative to the model can arise in four different ways, leading to four distinct types of contagion.<sup>1</sup> The first three involve factor exposures increasing unexpectedly in the crisis. Contagion stemming from the United States or from the global financial sector, which we label "U.S. contagion" and "global contagion." implies an increase in the comovement of domestic sector portfolios with the U.S. or global factors, respectively. Alternatively, the exposures relative to the domestic factor may increase, increasing the comovement of portfolios within a country during the crisis relative to the factor model predictions. We call this phenomenon "domestic contagion." Finally, returns unrelated to the factors may still be correlated across stocks during the crisis, which we call residual contagion.

We find significant evidence of contagion during the 2007 to 2009 financial crisis. However, while the interdependence model is strongly rejected in a statistical sense, it nonetheless explains a substantial fraction of return variation during the crisis. In addition, we find statistically significant but economically small evidence of contagion from U.S. markets and the global financial sector, whereas we find strong evidence of domestic contagion, with factor loadings with respect to the domestic factor portfolio increasing on average by 50%. Interestingly, there is no evidence that domestic contagion played a role in past crises, such as the 1998 Long-Term Capital Management (LTCM) crisis or the bust of the Telecommunications, Media, and Technology (TMT) bubble in 2000 to 2002. Importantly, we observe a high degree of heterogeneity in contagion across country-sector equity portfolios, with the contagion parameters and precrisis U.S. and global banking sector factor exposures being *negatively* correlated.

We next use our framework to disentangle the *channels of contagion*, and to explain the heterogeneity in contagion across portfolios by testing whether and how the dependence of factor exposures on various instruments changed

<sup>1</sup> Pukthuanthong and Roll (2009) stress that decreases in idiosyncratic volatility can also induce excess comovements.

during the crisis. We examine six channels. First, as the crisis originated in the banking sector, we examine international banking sector links at the country level, and firm-specific characteristics measuring the degree of financing constraints and interest rate exposure. Second, we study the role of various financial policies introduced during the crisis to protect the domestic financial sector, and in particular domestic banks (through debt and deposit guarantees and capital injections), which ultimately transferred risk on a massive scale from individual financial institutions to governments.

Third, we examine the "globalization hypothesis," which holds that crises hit hardest those economies that are highly integrated globally through trade and financial linkages. The globalization process may have gradually increased the U.S. and global banking sector factor exposures over time (see Bekaert and Harvey (1997), Baele (2005)) but may have also led to decoupling during the crisis as globalization reversed.

Fourth, we examine the hypothesis that information asymmetries decrease during crises, as investors focus on easily available public information, which may in turn increase correlations. Fifth, we investigate the "wake-up call hypothesis," which holds 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 (Goldstein (1998), Masson (1999), Goldstein, Kaminsky, and Reinhart (2000)).<sup>2</sup> Under the wakeup call hypothesis, countries without trade or banking linkages to the country in which the crisis originates may experience contagion, but the incidence or extent of their exposure depends on the strength of their local fundamentals and institutional factors. Finally, contagion may occur without discrimination at all, driven by herding behavior or investors' risk appetite beyond the effect of fundamentals, prompting us to examine the role of global risk and liquidity indicators.

We fail to find strong evidence in favor of the globalization hypothesis. Among various measures of globalization, only an overall measure of financial integration explains an economically important part of the contagion evidence, but more financially integrated countries experienced less contagion, not more contagion, from the U.S. market. Banking sector links and information flow variables also do not explain the variation in contagion across portfolios. Instead, we find that countries with high political risk, large current account deficits, large unemployment, and a high government budget deficit, experienced a high degree of contagion. We also find that the introduction of debt 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, U.S., and domestic factors.

 $^2$  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 finally recognized 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.

Hence, wake-up call effects and domestic banking policies are the main sources of the domestic contagion phenomenon that we document.

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 is closely related to the factor model approach in Bekaert, Harvey, and Ng (2005), who also define contagion as excessive comovement over and above the predictions of a factor model. What we add is a detailed analysis of the sources of contagion, which allows us to differentiate several economic hypotheses regarding contagion.

Second, our work relates to the growing literature on the global financial crisis of 2007 to 2009. This includes articles focusing on drivers of the transmission of the crisis across firms and markets within the United States, such as Tong and Wei (2010). Almeida et al. (2012), and Diebold and Yilmaz (2010). or articles taking a more macroeconomic perspective such as Eichengreen et al. (2012), Frankel and Saravelos (2010), and Rose and Spiegel (2010, 2011). A few contemporaneous articles also focus on international equity market contagion. For instance, Tong and Wei (2011) find that the average decline in stock prices during the crisis for a sample of 4,000 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). Hau and Lai (2012) show that stocks with a high share of equity fund ownership performed relatively well during the crisis, whereas stocks with ownership links to funds that were heavily affected by portfolio losses in financial stocks severely underperformed. In a related vein, Beltratti and Stulz (2012) 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, countrylevel regulation, as well as bank balance sheet and profitability characteristics before the crisis. Finally, Calomiris, Love, and Martinez Peria (2012) show that credit supply shocks, global demand shocks, and selling pressures in the equity market had a significant negative effect on individual stock returns during the financial crisis of 2007 to 2009 but had no such effects during an earlier placebo period.

The paper is organized as follows. Section I presents the empirical framework, defining 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 channels 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 Factor Model

We formulate an international factor model with three factors—a U.S. factor, a global financial factor, and a domestic market factor,  $F'_t = [R^U_t, R^G_t, R^D_t]$ . The three factors are value-weighted market indexes, so that the model potentially embeds different CAPMs as special cases: when the  $\beta$ 's 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. As in any factor model, the correlation between portfolios is increasing in the factor exposures of the portfolios and the magnitude of the factor volatilities. The use of these three factors, including a domestic factor, ensures that the model satisfactorily fits comovements across our portfolios in normal times.<sup>3</sup> The model thus allows us to study whether the financial crisis of 2007 to 2009 mainly spread through a global financial shock, a shock specific to the U.S. economy, or through increased vulnerability at the country or firm level.

The full model is:

$$R_{i,t} = \alpha_{i,0} + \alpha_{i,1}R_{i,t-1} + \alpha_{i,2}dy_{i,t-1} + \beta'_{i,t}F_t + \eta_{i,t}CR_t + e_{i,t},$$
(1)

$$\beta_{i,t} = \beta_{i,0} + \beta'_1 Z_{i,t-k} + \gamma_{i,t} C R_t, \qquad (2)$$

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

$$\eta_{i,t} = \eta_{i,0} + \eta_1' Z_{i,t-k}, \tag{4}$$

where  $R_{i,t}$  is the excess return of portfolio *i* during week *t* (i.e., the return minus the three-month U.S. T-bill rate in weekly units), dy is the local dividend yield of the portfolio (so that the expected excess return is measured as a linear function of the lagged excess return and the local dividend yield),  $F_t$  is a vector of the three observable factors,  $CR_t$  is a crisis dummy, and  $Z_{i,t}$  is a vector of control variables designed to capture time and cross-sectional variation in factor exposures. These variables may be portfolio or country specific, and are typically lagged by two quarters. If the dimension of Z is K, the matrices  $\beta_1$ and  $\gamma_1$  are  $K \times 3$  and  $\eta_1$  is  $K \times 1$ . When the model includes control variables Z, the expected return also depends automatically on these lagged Z's. The sample period is January 1, 1995, to March 15, 2009, that is, 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. Further details on our data are provided in Appendix A. We define the financial crisis as beginning on August 7, 2007, but in a robustness test we also use the collapse of Lehman Brothers on September 15, 2008, as an alternative starting point.

<sup>3</sup> 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), Bodnar, Dumas, and Marston (2003), and Brooks and Del Negro (2006) motivates the use of both global/international and domestic factors from a statistical perspective, even for developed markets.

Each portfolio *i* reflects a country-sector portfolio, measured as the valueweighted returns of all stocks in a particular sector of a particular country at time t. 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  $R_t^{D\setminus i}$ , but we use the shorthand for notational ease. All returns are measured in U.S. dollars.<sup>4</sup> To obtain an intuitive interpretation of the estimates of the factor loadings, we orthogonalize the three factors. The global factor is orthogonalized by regressing global financial sector returns on U.S. returns over the full sample period (including the crisis period) and then using the residuals of this regression as the global factor. Similarly, following Bekaert, Hodrick, and Zhang (2009), we extract a domestic return component that is orthogonal to those of both the U.S. factor and the global factor by regressing the domestic market return on U.S. returns and global financial sector returns, and then using the residual of this regression as the domestic factor. The orthogonalized domestic factor is estimated for each country-sector portfolio i individually as portfolio i itself is excluded from the domestic market portfolio.

#### A.1. Interdependence versus Contagion

When  $CR_t$  is eliminated from the model for all t, we refer to it as the "interdependence model." Each portfolio's risk exposure is then captured by three (potentially time-varying) factor loadings. Under the null of this model, the comovement (interdependence) between the various portfolios is determined by the factor exposures (the  $\beta$ 's) and the variance-covariance matrix of the factors. With orthogonal factors, such a model can potentially fit the observed increase in correlations during the crisis through an increase in factor volatilities. This is true because the correlation between a portfolio and a factor is then the  $\beta$ with respect to that factor, times the ratio of factor to portfolio volatility, which can be shown to be increasing in the factor's volatility. As volatilities tend to dramatically increase during crises, increased correlations are thus not necessarily indicative of contagion, an intuition formalized by Forbes and Rigobon (2002). To explain the crisis incidence across portfolios, portfolios with high  $\beta$ 's according to the model should decrease the most during the crisis. If this model fails to explain the crisis incidence and underpredicts portfolio correlations, we uncover contagion. By focusing on deviations from a reduced-form factor model, we avoid the volatility bias described in Forbes and Rigobon (2002) and thus contagion only reflects "unexpected" comovements relative to a factor model, consistent with the contagion definition in Bekaert, Harvey, and Ng (2005). The introduction of the crisis dummy in equations (1) and (2) allows us 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. If  $\eta$  is substantially negative for a subset of stocks, these

<sup>4</sup> We also estimated the model in local currency excess returns with qualitatively similar results.

stocks show excess comovement during the crisis. Our  $\eta$  coefficients potentially capture nonfundamental contagion, such as herd behavior, where investors stop discriminating across firms and countries based on economic fundamentals. 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 can 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 macrorisk factors and the information asymmetry in each market. Kyle and Xiong (2001) focus on losses by arbitrageurs that may lead to liquidations in several markets, thus inducing contagion. While we do not provide a formal test of these models, we consider some instruments related to risk aversion that may be informative about these channels.

Second,  $\gamma$  in equation (2) measures contagion via the factors  $F_t$ , that is, changes in interdependence during the crisis. Positive  $\gamma$ 's imply increased correlations of portfolios with the factors and across portfolios in the crisis relative to tranquil periods. Such contagion may be induced by either 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 (U.S., global, or domestic) and the transmission channels, which we now discuss in detail. While the model is linear, its reduced-form nature means that it is consistent with highly nonlinear models, as long as the nonlinearities are restricted to the factors. For example, in Ang and Bekaert (2004), a set of international stock returns is modeled using a linear factor model with exposure to the world market return, which in turn follows a (nonlinear) regime-switching model, thereby causing correlations and volatilities to increase during crises for all markets. We maintain the assumption that the factor exposures are approximately linear in a set of instruments in normal times and essentially test for a structural break in the exposures during the crisis. The model setup is also consistent with the classic volatility spillover models, in which tests are conducted on how volatility in one market affects volatility in other markets. Our model implicitly links the conditional variance of any portfolio to the conditional variances of the three-factor portfolios, with coefficients that potentially change during the crisis. The reduced-form approach obviates the need to parameterize the conditional volatility dynamics.

#### A.2. Instruments to Model Time Variation in Exposures

Equations (2) to (4) contain a set of lagged instruments,  $Z_{i,t\cdot k}$ , 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).<sup>5</sup> We entertain

 $^{5}$  Note that we do not mean to suggest that these "instruments" are "exogenous" in the strict sense of econometric identification. In the asset pricing literature, as discussed in Ferson and Harvey (1991) for instance, this term is simply used for variables that are not returns, are prea large number of potential instruments, which are listed in Table I, and divide them into six different categories to distinguish between different channels and hypotheses. Along the way, we consider various sources of domestic contagion.

The first category uses various proxies to investigate the importance of the banking sector as a transmission channel across equity markets. For that purpose, we investigate consolidated foreign claims of the domestic banking sector, either vis-à-vis banks in the United States or in all other countries, the growth of credit to the private sector, and various measures of firms' dependence on external financing, particularly through banks (interest rate exposure, size, and financial constraints).

Allen and Gale (2000) construct a bank-run model where liquidity shocks cause the default of a leveraged lender, which in turn leads to losses for banks lending to this institution, causing a potential domino effect. In the contagion literature, a number of authors stress the "common creditor problem," where countries linked to banks (through claims or liabilities) that have claims on countries in crisis may suffer contagion that extends to their equity markets (see Kaminsky and Reinhart (2000), Van Rijckeghem and Weder (2001), Caramazza, Ricci, and Salgano (2004), and Tong and Wei (2010, 2011)). In the context of the global crisis, the liquidity and solvency problems of the U.S. banks were rapidly transmitted to other international financial institutions, because of money market links, direct exposure, or exposure to toxic assets.

The data of the Bank for International Settlements measure the extent of claims local banks have to U.S. banks or any international banks through deposits, loans, or other assets. Such exposure has a direct effect on the local banking sector and indirect effects on other stocks. It is conceivable that the extent of the exposure is also commensurate to the extent to which local banks have (over) extended credit to the private sector, as deleveraging during the crisis may adversely affect domestic borrowers' ability to obtain funding.

Finally, we would expect the effect of banking problems to be particularly severe for firms with financing constraints and for firms with more interest rate exposure, as they may have shorter maturity debt and thus face steeper refinancing costs. For instance, Almeida et al. (2012) 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. We use the financial constraints measure proposed in Whited and Wu (2006) and compute interest-rate exposure using a regression procedure. Appendix B provides more details on the computation of these variables.

Small firms tend to rely more on bank financing than large firms, prompting us to also use the log of total assets as an instrument. Banking sector links are a potential but perhaps unlikely source of domestic contagion. For example,

determined (in a temporal sense), and are used to model time variation in factor exposures or prices of risk. Also, the instruments are too slow-moving to reflect public information that may instantaneously change prices and potentially cause contagion (see Connolly and Wang (2003)). However, later we also consider a specification with contemporaneous instruments.

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Variables	Units	Frequency	Definition	Unit of Observation	Source	Mean	S.D.	Min.	Max.
Banking exposure Banking	% of GDP	Annual	Foreign claims	Country	BIS	1.71	1.11	0.01	11.81
exposures to the United States			(assets incl. deposits, loans, debt securities) of domestic banks vis-à-vis U.S. banks, scaled by GDP		consolidated statistics				
Banking exposures to the rest of the world	% of GDP	Annual	Foreign claims (assets incl. deposits, loans, debt securities) of domestic banks vis-à-vis rest-of-the-world banks, scaled by GDP	Country	BIS consolidated statistics	16.36	11.68	0.12	90.49
Credit growth	ln %	Constant	Annual growth rate of credit to private sector (av. 2003–2007)	Country	IMF, Haver, Bloomberg	15.41	15.82	-55.70	98.80
Interest rate exposure	% of GDP	Constant	Estimated exposure coefficient; see Appendix B	Country- sector	IMF, Bloomberg, authors' estimates	3.99	126.88	-833.5	577.24
Size	Log USD values	Quarterly	Total assets	Country- sector	Bloomberg	9.42	3.11	0.68	18.10
Financial constraints	Index from 0 to 100	Quarterly	Estimate based on Whited and Wu (2006); see Appendix B	Country- sector	Bloomberg, authors' estimates	60.83	43.22	0.0	99.57

**Factor Exposure Instruments Table I** 

The table reports summary statistics for the various factor exposure instruments. All statistics shown in the table are calculated across the 415

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Variables	Units	Frequency	Definition	Unit of Observation	Source	Mean	S.D.	Min.	Max.
Banking policy Debt guarantees	0 to 1 dumny	Weekly	Dummy = 1 after announcement of	Country	BIS, CGFS database,	0.32	0.47	0	1
Deposit guarantees	0 to 1 dummy	Weekly	policy measure Dummy = 1 after announcement of	Country	Diounoerg BIS, CGFS database,	0.44	0.50	0	1
Capital injections	0 to 1 dummy	Weekly	policy measure Dummy = 1 after announcement of policy measure	Country	Bloomberg BIS, CGFS database, Bloomberg	0.26	0.44	0	1
External exposure / Capital flows	segmentation % of GDP	Monthly	Net sales of long-term U.S. securities by domestic residents and of foreign securities to U.S. residents, scaled by country GDP; a positive number means a net inflow of capital into	Country	U.S. Treasury International Capital (TIC) data	-1.19	9.87	-24.42	64.41
Financial integration	% of GDP	Annual	country X from the United States Stock of portfolio assets & liabilities with the United States, scaled by	Country	IMF, CPIS data	36.75	67.61	0.07	778.01
Financial depth	% of GDP	Quarterly	GDP Equity market capitalization, scaled by GDP	Country	Bloomberg	71.86	90.59	4.60	593.90

**Table I**—Continued

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Variables	Units	Frequency	Definition	Unit of Observation	Source	Mean	S.D.	Min.	Max.
Trade integration	% of GDP	Annual	Sum of exports and imports with the United States,	Country	IMF, Haver, Bloomberg	108.39	76.43	28.17	455.40
Exchange rate exposure	% of GDP	Constant	scaled by GDF Estimated exposure coefficient; see Appendix B	Country- sector	IMF, Bloomberg, authors'	-8.42	93.56	-690.8	808.82
Differences of opinion	Correlation between – 1 and +1		Correlation of (a) bilateral capital flows from the United States to destination country (as defined above) and (b) destination country's local equity returns before the	Country	esumates U.S. Treasury International Capital (TIC) data, Bloomberg	0.20	0.17	-0.17	0.76
Information asymn Distance	<i>tetries</i> In km, logs	Constant	crisis (in 2006) Log distance between country X's capital city and the United States	Country	Andrew Rose's website, Daude and Fratzscher	8.56	0.39	6.98	9.15
Telephone traffic	In 1000	Constant	Volume of telephone call traffic with the United States (av. 2003 to 2007)	Country	(2008) ITU Directions of Trade	555	1178	0.00	7068

**Table I**—Continued

			Table I—C	ontinued					
Variables	Units	Frequency	Definition	Unit of Observation	Source	Mean	S.D.	Min.	Max.
Newspaper imports	In USD million	Constant	Net imports of newspapers and periodicals from the United States (av. 2003 to 2007)	Country	UN Comtrade database, exports, of item 8922 SITC Rev.2	13.15	4.08	-2.16	20.15
Domestic macroect Political stabil- ity/institutions	<i>nomic fundamen</i> Index from 0 to 50	<i>utals</i> Constant	Political risk index; higher number = less risk/better institutions (av. 2003 to 2007)	Country	International Country Risk Guide (ICRG)	12.89	4.39	1	28
Sovereign rating	Continuous variable, 6 to 22	Weekly	Rating of sovereign debt, linear transformation	Country	Bloomberg	16.29	4.75	9	22
FX reserves	% of GDP	Annual	Foreign exchange reserves, scaled by GDP	Country	IMF World Economic Outlook	18.35	4.69	4.80	100.70
Current account	% of GDP	Annual	Current account balance, scaled by GDP	Country	IMF World Economic Outlook	0.68	7.59	-17.11	27.98
Unemployment rate	% ul	Annual	Unemployment rate	Country	IMF World Economic Outlook	7.81	6.18	2.10	38.71
Government budget	% of GDP	Annual	Fiscal balance, scaled by GDP	Country	IMF World Economic Outlook	-0.18	4.24	-7.80	19.61
Global / common r Risk: VIX	isk and liquidity In %	Weekly	VIX index based on S&P500 call options	Global	Bloomberg	22.00	8.92	9.89	80.86
Credit risk: TED spread	In %	Weekly	U.S. TED spread	Global	Bloomberg	52.18	44.97	0.11	463.08

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it is possible that exposures to the domestic factor return are increasing in international bank linkages if most firms in the economy are indeed dependent on bank financing and banks in the economy have international links. If we control for such linkages, we should not find contagion in the crisis. It is possible, however, that, for countries with banks that are disproportionally affected by the crisis, and where local bank dependence is large, we may pick up some domestic contagion through a banking sector effect.

As a second category of instruments, we collect data on three country-specific policy responses to the crises (listed under "banking policy"), namely, capital injections in both financial and nonfinancial firms (though these are primarily banks), as well as new or extended deposit guarantees and debt guarantees for banks.<sup>6</sup> A key feature that we exploit in this analysis is that not all countries implemented such policies; there are differences in the precise measures that were implemented, and there are differences in the timing of their announcement. We define dummy variables that take the value of one for the period after announcements of the various policies, and for the full period of their existence.<sup>7</sup>

Three caveats are in order. First, official announcements of such financial policies may have been preceded by rumors or concrete indications that a government was considering such policy measures, thus having a market effect even before an announcement is made. A second issue is that such policies may be endogenous to the crisis itself, that is, 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 find in the data that such policies are associated with a smaller decline in equity markets. Third, it could be the case that the introduction of these policies might have had longer lasting (and potentially adverse) effects on stock market performance beyond the time span analyzed in this paper, in particular during the European sovereign debt crisis. Such an analysis is beyond the scope of the current paper. The hypothesis we test is whether these policy responses help insulate countries and individual firms within a country, thereby reducing the magnitude of contagion, both from foreign markets and across sectors within a country.

The third set of variables measures external exposure through 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), Brière, Chapelle, and Szafarz (2012), Fratzscher

 $^{6}$  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 nonfinancial institutions.

<sup>7</sup> In almost all cases such policies were still in existence at the end of our sample. We prefer to use the policy announcement, rather than the actual implementation—which in many cases came several weeks after the announcement—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 to obtain measures that are comparable across countries, as it is otherwise difficult to normalize and compare magnitudes of such measures in a meaningful way. (2012)). The trade channel in particular has often been associated with international spillovers and contagion (see Kaminsky and Reinhart (2000), Caramazza, Ricci, and Salgano (2004), Forbes (2004)). As discussed in Baele and Inghelbrecht (2009), trends in market integration make it necessary to let interdependence coefficients 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. We use exports plus imports to measure trade openness. Financial integration with the rest of the world is measured using the stock of international portfolio 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 Harvev (1995)). Broner, Gelos, and Reinhart (2006) and Boyer, Kumagai, and Yuan (2006) stress how portfolio holdings of international investors in various countries and their capital reallocations following negative returns can affect the transmission of shocks. In the recent global crisis, U.S. international funds may have retrenched from global markets, causing spillovers to be particularly severe for countries with substantial bilateral portfolio flows with the United States. We therefore also use bilateral portfolio investment flows, that is. net flows of bilateral portfolio assets and liabilities with the United States, as is common in the literature (e.g., Kaminsky, Lyons, and Schmukler (2004)). We scale all the above-mentioned measures by GDP. We also include exchange rate exposure, which may constitute an alternative, firm-specific source of equity market comovements (e.g., Dumas and Solnik (1995)). The methodology for measuring exchange rate exposure is outlined in Appendix B.

Trade and financial integration channels may also contribute indirectly to domestic contagion if they break down during the crisis. Suppose international factor exposures are increasing in external integration measures and domestic factor exposures are decreasing in such measures. This could arise in a partial segmentation model where international firms are priced differently from purely domestic firms, and the latter are still an important part of the domestic market portfolio. If trade and capital flows collapse in the crisis, this could cause a pattern whereby firms now are more correlated with the domestic factor and less with the international factors. If we do not control for this time variation in  $\beta$ 's, our contagion estimates may show a reduction in global and an increase in domestic  $\beta$ 's. With the factor exposure and contagion channels depending on trade and financial integration directly, we can examine this story explicitly.

A fourth category of instruments relates to information asymmetries that may reduce cross-border capital flows and induce home bias (e.g., Brennan and Cao (1997), Albuquerque, Bauer, and Schneider (2009)). Apart from measures of information flow, such as the amount of telephone traffic and the ratio of the value of net imports of newspapers from the U.S. (in U.S. dollars) to domestic GDP, we also include the most commonly used proxy of information asymmetry in the literature on capital flows, namely, the geographic distance of a country to the United States (Portes and Rey (2005), Daude and Fratzscher (2008)). Dumas, Lewis, and Osambela (2011) generate implications similar to those of information asymmetry models by positing that domestic and foreign investors may have differences of opinion on public signals. In particular, local investors are better equipped to interpret (local) public news than foreign investors are. As shown by Dumas, Lewis, and Osambela (2011), in such a model, returns and international capital flows comove positively (as foreign investors erroneously view increases in the stock market as a signal of future increases). Following this approach, we proxy for differences of opinion using the precrisis (2006) correlation coefficients between the bilateral capital flows from the United States to a particular destination country (as captured by the net sales of longterm U.S. securities by domestic residents and of foreign securities to U.S. residents), on the one hand, and the destination country's local equity returns, on the other hand, with a higher correlation indicating higher differences of opinion.

The fifth set of variables includes a broad set of domestic macroeconomic fundamentals. With these variables, we can test what Goldstein (1998) coins the wake-up call hypothesis, following the 1997 to 1998 Asian financial crisis. This hypothesis holds that a crisis in a particular country induces investors to reassess risk in other countries with similarly bad fundamentals. The key feature of this contagion channel relative to others is that the affected countries need not be interconnected through bank linkages or trade linkages; the channel is simply a revaluation of risk by investors. While the original Goldstein hypothesis was formulated outside a formal model, an active but surprisingly small theoretical literature formalizes the concept, focusing on either debt markets (Basu (1998)) or currency markets (Ahnert and Bertsch (2013)). While the Goldstein hypothesis does not take a stand on whether investors are rational or irrational, both models formalize the wake-up hypothesis in a learning framework with rational speculators who have imperfect information about country fundamentals. In Basu's (1998) model of contagious debt default, the ability to pay the debt depends on the interaction between an imperfectly known risk factor. common across a number of countries, and country-specific economic fundamentals and institutional factors. Investors have a prior about the common risk factor. Default in one country, the wake-up call, prompts investors to revise their priors, not only for the country in question, but for all countries sharing the unobserved common risk factor. However, while the updated beliefs lead to higher risk premiums for all countries within the risk group, some countries may escape contagion if they have strong enough local fundamentals. Ahnert and Bertsch (2013) study contagion in a global game of speculative currency attacks under incomplete information. Here a successful attack also acts as a wake-up call to investors, inducing them to acquire costly information about their exposure to the country attacked. This helps speculators improve their forecast of country-specific fundamentals and update their views of the beliefs of other speculators. This leads in turn to an increased incidence of speculative attacks, because of fundamentals updated to be weak and/or heightened uncertainty about the behavior (beliefs) of other speculators.

Both models suggest that there is increased risk perception or risk exposure following the wake-up call, in that the same weak fundamental values may now be associated with more risk than before. Translated to our model, this change in risk reflects a change in the interaction effect of our  $\beta$  exposures with domestic fundamentals during the crisis, that is, a significant  $\gamma_{i1}$  coefficient for macroeconomic indicator *i*. For example, imagine that the unemployment rate did not affect the  $\beta$  before the crisis, but that the crisis made it relevant. This should lead to a significantly positive  $\gamma_{i1}$  for this indicator. If the local factors were priced before, we should record  $\beta$  changes such that bad (good) fundamentals lead to relatively more (less) factor exposure during the crisis. The wake-up call hypothesis provides a natural explanation of domestic contagion. The set of variables we use includes a measure of political risk from International Country Risk Guide (ICRG, i.e., high ratings reflect less risk), 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, and the unemployment rate.

While often mentioned (see, e.g., the survey of Kaminsky, Reinhart, and Vegh (2003)), the wake-up call hypothesis is rarely tested formally. In a study of contagion from Hong Kong's currency crisis in 1997, Basu (2002) uses structural break tests in a model of credit spreads to argue that contagion, consistent with investor learning about fundamentals, happened selectively in some South-East Asian countrie but not in other countries. Van Rijckegem and Weder (2003) find important common bank lender effects during the Mexican and South-East Asian crises as a channel of contagion, but view the Russian crisis as the outcome of a wake-up call in emerging markets. Finally, in looking at various emerging market currency crises during the 1990s, Dasgupta, Leon-Gonzalez, and Shortland (2011) find that institutional similarity (in terms of governance quality) to the "ground zero" country systematically plays an important role in determining the direction of contagion (a finding that they interpret as supportive of the wake-up call hypothesis), while the importance of trade and financial linkages varies across crisis episodes.

The final set of variables consists of global measures of risk aversion and liquidity that may cause investor contagion. Mounting evidence suggests that international asset prices are quite sensitive to such measures (see, e.g., Bekaert et al. (2011) and Baker, Wurgler, and Yuan (2012)). 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 United States and other advanced economies. We proxy for risk aversion through the VIX index of the S&P500. Moreover, a central element of the crisis was a freezing of credit and interbank markets and a liquidity squeeze that made it difficult for financial and nonfinancial institutions to obtain capital. Indeed, a literature is emerging that stresses the role of (il)liquidity in causing or exacerbating crises (e.g., Brunnermeier and Pedersen (2009), Adrian and Shin (2010)). We use the TED spread as an indicator of illiquidity, but it also reflects the credit risk of banks. Note that all these risk and liquidity variables are common to all equity portfolios in the sample.

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

#### B.1. Model Estimation

We estimate our model for all portfolios jointly by means of pooled OLS. Standard errors account for heteroskedasticity. Note that the instruments  $Z_{i,t}$ —with the exception of the financial policies, as outlined earlier—are lagged by two quarters to prevent an unobserved factor from simultaneously influencing both returns and the fundamental Z in a given period and thereby generating a spurious relationship between both.

Because we have 25 instruments, an estimation of the full model will generate a large amount of insignificant regressors that needlessly inject noise into the estimated model. When estimating the full model equations (1) to (4)with instruments, we therefore estimate different model specifications. In a first step, we include each of the 25 instruments individually in the model. In a second step, we 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. We start out with the full model including all 25 instruments simultaneously, and then step-by-step reduce the model by excluding the variable with the least statistically significant contagion parameter. We then test whether the corresponding interdependence parameter  $\beta$  is statistically significant at the 10% level, in which case this variable stays in the model with a pure interdependence effect. Pure contagion effects are thus not possible. This procedure is continued until only those instruments are left in the model that have significant contagion parameters at the 10% significance level. The aim of this "encompassing" approach is to reduce the dimension of the model and arrive at a model that can be interpreted in an economically meaningful wav.

#### **B.2.** Specification Tests and Diagnostics

We now focus our attention on the fit of the model. 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 comovements of the residuals at the country level, the most important dimension for contagion tests.

To measure excess comovements within countries, we now add an indicator subscript c denoting country, to each portfolio. There are  $N_c$  portfolios within country c; recall that there are 55 countries in total, so c runs from 1 to 55. Excess comovement within a country can occur when the factor model systematically over- or underpredicts exposure to the factors for portfolios within a given country. More formally, consider:

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

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

$$EXCOV_t = \frac{1}{55} \sum_{c=1}^{55} EXCOV_{c,t}.$$
 (6)

To create a test statistic, we must divide EXCOV by its sample variance. We use 26 Newey and West (1987) lags in computing this variance. The excess comovement test then becomes

$$ECTEST = \frac{\left[ (1/T) \sum_{t=1}^{T} EXCOV_t \right]^2}{VAR(EXCOV_t)},$$
(7)

which is  $\chi^2(1)$  under the null.

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

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

Second, *ECTEST* averages the country-specific comovements 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 comovement diagnostic:

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

where the time-series variance is again computed with 26 Newey-West lags. If the country-specific test statistics are independent, *ECDIAG* would have a  $\chi^2(55)$  distribution. However, we use the statistic to compare alternative models and alternative periods.

To further analyze the performance of the model(s), we conduct three additional diagnostic exercises, which are described in more detail below. First, we compare actual returns with the predicted returns under various versions of the factor model during the crisis. Second, we compare the average actual increase in correlations with the factor returns during the crisis with the increase generated by the factor model. Recall that, in the factor model, such an increase occurs when the volatility of the factors increases or factor exposures increase. Third, we perform a variance decomposition of returns to contrast the relative economic importance of interdependence versus contagion during the crisis and their various components.

#### **II. Empirical Results**

Our modeling strategy is to first investigate the presence of interdependence versus contagion in Sections II.A and II.B before turning to the channels of interdependence and contagion in Section II.C. It turns out that allowing for time variation in the  $\beta$ 's 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 factor model (1) to (4) with crisis interactions and contagion may not be necessary to explain the transmission of the 2007 to 2009 financial crisis. If the original factor model without contagion parameters correctly anticipates the systematic risks of the various portfolios, portfolios with larger (smaller) exposures to the U.S. and global financial sector portfolios should witness the steepest (smallest) valuation declines during the crisis. To explore this possibility, we estimate the following simple variant of our three-factor model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta'_{i,0}F_t + e_{i,t},$$
(10)

where all variables are defined as before, and we include the same three factors—a U.S. factor, a global financial factor, and a domestic market factor. Table II reports the  $\beta$ 's 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  $\beta$ 's, which helps improve the 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.

The  $\beta$ 's reported are equally weighted averages across all 415 portfolios, with the standard error also reflecting the covariance between the individual estimates. Economically, the exposure to the three factors is not very 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 United States.

#### Table II Interdependence

The table reports the estimates of the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,0}'F_t + e_{i,t}.$$
(10)

In particular, the table reports the unweighted average degree of interdependence across all portfolios in the sample, where G denotes the global factor, U the U.S. 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. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Coef.	St .Err.
Interdependence		
$\beta^U$	0.437***	0.015
$\beta^{G}$	0.406***	0.012
$\beta^{D}$	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	322,216	
R <sup>2</sup>	0.274	

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 U.S. or global financial factors. Emerging markets generally have low exposures to the U.S. and global financial factors, with the exception of a relatively high Latin American exposure to the U.S. factor. 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 factor, and its large exposure to the U.S. factor. The highest exposure to the global factor obtains for the financial sector, with a  $\beta$  estimate of 0.58. In addition, the financial sector has a relatively high exposure vis-à-vis the U.S. 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. The first columns of Table IV and Figure 1 represent the ability 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 their predicted values from the interdependence model (10) on the horizontal

#### **Table III**

#### **Interdependence across Regions and Sectors**

The table reports the estimates of the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta'_{i,0}F_t + e_{i,t}.$$
(10)

In particular, the table provides estimates of the average degree of interdependence across portfolios within a particular region (Panel A), and that within a particular sector (Panel B), where G denotes the global factor, U the U.S. factor, and D the domestic factor. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Panel A: By re	gion	
		Interdependence	
Region	$\beta^U$	$\beta^G$	$\beta^D$
Latin America	0.594***	0.360***	0.604***
Western Europe	0.633***	0.539***	0.512***
Emerging Europe	0.273***	0.347***	0.473***
Middle East/Africa	0.084***	0.163***	0.467***
Developed Asia	0.494***	0.531***	0.655***
Emerging Asia	0.267***	0.350***	0.679***
	Panel B: By se	ector	
		Interdependence	

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

axis. The computation is straightforward. From estimating (10), we obtain  $\hat{R}_{i,t}$  for each portfolio *i* and 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 crisis period.<sup>8</sup>

If the model predicts the relative crisis severity perfectly, the regression line through the scatterplot should be identical to the  $45^{\circ}$  line. However, this is not the case. Running a regression of actual on predicted returns for all 415 portfolios, we find:

<sup>8</sup> 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.

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The table reports total actual equity market returns over the entire crisis period (August 2007 to March 2009) against the fitted total returns from the interdependence 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.

Interdependence

			Mod	el				Con	tagion Mc	del			1
	Actual r	eturns	Fitted re	turns	Fitted re	turns			Mod	el parame	ters		
Country	Returns	Rank	Returns	Rank	Returns	Rank	β <sup>U</sup>	$\beta^G$	β	$\gamma^{U}$	$\gamma^{G}$	$\lambda^{D}$	u
Serbia	-85.6	1	-59.8	5	-83.9	-	0.080	0.148	0.632	0.210	-0.097	0.005	-0.777
Ukraine	-77.9	2	-33.2	25	-73.8	e,	0.180	0.217	0.227	0.074	0.178	0.612	-0.496
Remania	-77.3	ę	-32.2	28	-74.4	7	0.231	0.287	0.302	0.119	0.032	0.410	-0.878
Bulgaria	-74.2	4	-44.9	10	-68.8	S	0.029	0.245	0.191	0.271	0.195	0.541	-0.075
Slovenia	-71.9	5	-47.0	7	-71.8	4	0.111	0.315	0.726	0.067	-0.051	0.102	-0.364
Poland	-69.5	9	-56.4	e	-62.5	10	0.598	0.555	0.587	0.215	0.159	0.258	-0.150
Iceland	-67.7	7	-46.5	80	-67.0	9	0.174	0.325	0.472	0.014	-0.126	0.014	-0.396
Russia	-66.2	œ	-40.6	11	-53.3	19	0.304	0.186	0.291	0.239	0.328	0.355	-0.076
Latvia	-64.3	6	-39.5	13	-60.7	13	0.098	0.233	0.344	0.099	0.044	0.125	-0.508
Estonia	-64.3	10	-54.1	5	-63.9	7	0.254	0.383	0.380	0.200	0.027	0.424	-0.199
Turkey	-64.1	11	-70.5	1	-58.8	15	0.721	0.662	0.824	0.039	0.372	0.017	0.083
Croatia	-63.9	12	-35.2	18	63.8	80	0.100	0.280	0.322	0.245	-0.003	0.502	-0.034
Lithuania	-61.4	13	-33.9	23	-61.2	11	0.129	0.266	0.407	-0.001	0.019	0.310	-0.356
Ireland	-61.3	14	-31.4	29	-60.6	14	0.439	0.559	0.357	0.122	-0.169	0.035	-0.659
New Zealand	-60.2	15	-50.6	9	-62.6	6	0.362	0.326	0.641	0.168	0.124	0.164	-0.345
Norway	-60.1	16	-30.6	31	-60.9	12	0.487	0.454	0.620	0.330	0.021	0.127	-0.311
Hungary	-59.6	17	-54.4	4	-58.3	16	0.584	0.560	0.638	0.106	-0.062	0.147	0.056
Italy	-55.5	18	-37.2	15	-56.4	17	0.760	0.485	0.626	0.086	0.083	0.156	-0.137
Eevot	-54.2	19	-15.1	47	-33.1	39	0.085	0.164	0.372	-0.168	0.258	0.484	0.257
Korea	-52.9	20	-40.0	12	-48.1	26	0.610	0.510	0.610	0.199	0.042	0.213	-0.007
Portugal	-52.1	21	-32.6	27	-49.8	22	0.388	0.459	0.610	0.132	0.013	0.182	-0.092
Czech Republic	-52.1	22	-45.7	6	-49.4	23	0.291	0.557	0.534	0.129	0.017	0.136	-0.094
Brazil	-51.2	23	-36.6	16	-45.1	30	0.948	0.463	0.686	0.297	0.032	0.092	-0.153
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			Interdepe Mod	ndence el				Con	tagion Me	odel			
	Actual re	turns	Fitted re	turns	Fitted re	turns			Mod	lel parame	eters		
Country	Returns	Rank	Returns	Rank	Returns	Rank	βυ	βG	β	γ <sup>U</sup>	γ <sup>G</sup>	$\gamma^D$	h
Sweden	-51.0	24	-35.6	17	-51.1	20	0.781	0.669	0.385	0.245	-0.122	0.437	-0.052
Finland	-49.7	25	-27.5	35	-54.0	18	0.593	0.534	0.380	0.260	-0.143	0.439	-0.161
Thailand	-48.8	26	20.3	42	-48.4	25	0.306	0.420	0.530	0.129	0.148	0.241	-0.400
France	-47.1	27	-34.2	22	-48.7	24	0.872	0.736	0.532	0.139	-0.152	0.331	-0.003
United Kingdom	-43.9	28	-28.1	34	-46.5	27	0.669	0.595	0.543	0.125	-0.022	0.342	0.010
Argentina	-42.2	29	-2.2	54	-46.0	28	0.394	0.245	0.436	0.133	0.189	0.208	-0.273
China	-42.2	30	-38.5	14	-21.4	48	-0.012	0.087	0.701	-0.279	0.002	0.125	0.050
Spain	-41.6	31	-18.7	43	-42.1	32	0.646	0.568	0.542	0.152	0.017	0.301	-0.060
Netherlands	-40.5	32	-30.6	30	-45.5	29	0.959	0.515	0.427	-0.030	0.047	0.231	0.124
Denmark	-40.5	33	-22.9	39	-50.9	<b>21</b>	0.511	0.673	0.307	0.181	-0.044	0.380	-0.119
India	-40.4	34	-15.5	46	-31.3	41	0.442	0.295	0.630	-0.031	0.192	0.262	-0.097
Colombia	-39.8	35	-34.8	19	-38.3	35	0.358	0.241	0.618	0.190	0.129	0.227	0.439
Singapore	-39.7	36	-23.5	38	-34.1	37	0.560	0.602	0.570	0.058	-0.153	0.313	0.008
Indonesia	-39.2	37	-28.7	33	-28.9	44	0.429	0.704	0.716	-0.082	-0.066	0.176	0.038
Germany	-37.8	38	-34.7	20	-40.3	34	1.006	0.733	0.601	-0.143	-0.177	0.115	0.042
Belgium	-35.7	39	-29.6	32	-42.6	31	0.495	0.581	0.512	0.149	-0.028	-0.033	0.000
UAE	-35.6	40	-14.4	48	-21.3	49	0.002	-0.027	0.143	-0.177	0.214	0.422	0.441
Chile	-35.1	41	-15.6	45	-35.1	36	0.501	0.282	0.680	0.130	0.035	0.256	-0.130
Taiwan	-34.9	42	-32.9	26	-19.8	50	0.334	0.388	0.686	0.143	-0.053	0.116	0.120
Hong Kong	-33.7	43	-12.3	49	-32.0	40	0.565	0.530	0.546	0.172	0.131	0.382	-0.233
Mexico	-33.2	44	-34.6	21	-29.4	43	0.785	0.361	0.591	0.058	-0.014	0.105	0.054
Austria	-33.1	45	-33.9	24	-40.4	33	0.478	0.596	0.638	0.119	0.001	0.077	0.244
Qatar	-32.1	46	-3.1	53	-23.5	46	-0.029	0.044	0.352	-0.030	0.012	0.362	0.145
Australia	-31.8	47	-25.1	36	-31.1	42	0.455	0.462	0.624	0.124	-0.058	-0.005	0.069
Switzerland	-30.8	48	-24.1	37	-34.1	38	0.775	0.682	0.532	0.016	-0.059	-0.087	0.146
Japan	-30.6	49	-20.7	41	-23.4	47	0.296	0.567	0.771	0.058	-0.004	0.036	0.041
Luxembourg	-27.4	50	-21.0	40	-27.4	45	0.276	0.509	0.152	0.199	0.002	0.324	0.268
Israel	-21.7	51	-17.1	44	5.3	54	0.363	0.217	0.584	0.052	-0.067	0.282	0.106
Canada	-19.1	52	-3.6	52	-19.6	51	0.221	0.127	0.206	-0.030	0.013	0.145	-0.140
Malta	-13.8	53	-9.0	51	-17.2	52	0.002	-0.141	0.324	-0.035	0.029	0.179	0.056
Tunisia	-9.7	54	-10.5	50	-6.4	53	0.069	0.314	0.554	0.006	-0.051	0.083	-0.111

The Global Crisis and Equity Market Contagion

**Table IV**—Continued



**Figure 1. Goodness of fit of the interdependence model**. The figures show the total actual equity market returns over the entire crisis period (August 2007 to March 2009) against the fitted total returns from the interdependence model (10), 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° line.

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

with the joint test that the intercept is zero and the slope coefficient is unity being rejected at the 99% significance level. This relationship between actual and predicted returns is depicted through the line in Panel A of Figure 1.

Panel B of Figure 1 shows the distribution aggregated across countries, where actual and predicted returns for countries are equally weighted averages across the portfolios of a particular country.<sup>9</sup> On average the model underpredicts 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, the first set of columns in Table IV lists the various countries, ranked from worst to best actual crisis performance, and the second set of columns contrasts these returns with the predicted returns based on the three-factor interdependence model (the table also shows the estimates for the contagion model, which we turn to 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 most strongly not only 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 much 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 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, such as Thailand and Indonesia in South-East Asia, or Mexico and Brazil in Latin America, which were at the heart of previous crises. However, from the perspective of our benchmark model, the performance in three of these countries was actually worse than expected (Mexico being an exception).

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, equity returns in the financial sector were among the most affected in the data and in the model.

The three-factor interdependence model fails to fully explain the crisis severity, but the fit shown in Figure 1 still suggests that the interdependence model explains a nonnegligible fraction of the cross-sectional variation in crisis returns. To benchmark this model, we compare the predictive power of this model

<sup>9</sup>We repeated the computations with value-weighted returns and found qualitatively similar results. In particular, for almost all countries, the model underpredicts the crisis severity.

the crisis. The model pa	rameters ar	re from th	ne contagior	n model s	pecification	a (see Tal	ole VI).		9				
			Interdepe Mod	ndence el				Cor	tagion N	fodel			
	Actual re	eturns	Fitted re	turns	Fitted re	eturns			Mc	odel param	leters		
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	-55.8	-	-31.0	3	-54.6	1	0.495	0.441	0.439	0.203	0.106	0.194	-0.217
<b>Basic materials</b>	-54.9	2	-31.4	7	-52.2	7	0.391	0.379	0.494	0.009	0.324	0.469	-0.103
Diversified	-52.6	ი	-31.4	1	-49.1	က	0.433	0.477	0.709	0.037	0.157	0.163	-0.045
Consumer, cyclical	-46.3	4	-28.8	4	-46.2	5	0.379	0.386	0.519	0.039	0.096	0.232	-0.068
Industrial	-45.2	5	-25.4	7	-47.4	4	0.379	0.383	0.498	0.033	0.196	0.335	-0.148
Technology	-43.5	9	-25.3	ø	-39.3	6	0.217	0.704	0.574	0.192	-0.157	0.083	-0.105
Energy	-42.2	7	-27.9	S	-42.2	9	0.336	0.320	0.433	0.103	0.286	0.401	0.172
Communications	-40.8	80	-27.7	9	-40.1	œ	0.305	0.455	0.539	0.015	-0.037	0.096	0.036
Utilities	-35.7	6	-20.8	10	-34.5	10	0.286	0.236	0.394	0.068	0.179	0.310	0.172
Consumer, noncyclical	34.9	10	-23.6	6	-40.5	7	0.366	0.341	0.462	-0.075	0.091	0.137	0.000

 Table V

 Predicting Crisis Returns: Distribution at the Sector Level

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 table reports at the sector level the total actual equity market returns over the entire crisis period (August 2007 to March 2009) against the

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with that of a more standard world CAPM model. We do so by reestimating (10) including only the two common world factors, the U.S. factor, and the global factor. Figure 2 shows the fit of the model, again at the country level and the portfolio level. A regression of actual on predicted returns for all 415 portfolios for this two-factor model yields:

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

The  $R^2$  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 to 2009 financial crisis, even without yet allowing for contagion in the model specification.

In summary, the exploratory analysis of this subsection shows that a simple constant  $\beta$  model fails to fully explain the transmission of the 2007 to 2009 financial crisis to equity markets globally.

#### B. Contagion

#### **B.1.** Estimation Results

Was there contagion in global equity markets during the 2007 to 2009 financial crisis? If so, what type of contagion—did contagion primarily emanate from the global financial sector, from the U.S., or from the domestic market? To address these questions, Table VI reports estimation results of model (1) to (4), but still restricting the coefficients on  $Z_{i,t}$  to be zero:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta'_{i,t}F_t + \eta_{i,0}CR_t + e_{i,t},$$
(11)

$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0} C R_t. \tag{12}$$

Compared to Table II, the  $R^2$  increases by four percentage points and all statistics improve, suggesting that the imposition of constant  $\beta$ 's across the two periods was a misspecification. Still the model remains rejected at the 1% level. The crisis-specific exposures suffice for the model to eliminate withincountry 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.

We report the average  $\gamma_{i,0}$ ,  $\beta_{i,0}$ , and  $\eta_{i,0}$  coefficients, which reveals several interesting patterns. First, the  $\eta$  coefficients are, at least on average, small and insignificant. If there is contagion, it must be captured by changing exposures to the factors. Second, the interdependence coefficients have decreased slightly, suggesting that "dummying out" the crisis period overall leads to decreased



Figure 2. Goodness of fit of the 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 U.S. factors). It shows the cumulated actual equity market returns over the entire crisis period (August 2007 to 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° line.

#### Table VI Contagion and Interdependence

The table reports the estimates of the following model:

$$\begin{aligned} R_{i,t} &= E_{t-1}[R_{i,t}] + \beta'_{i,t}F_t + \eta_{i,0}CR_t + e_{i,t}, \\ \beta_{i,t} &= \beta_{i,0} + \gamma_{i,0}CR_t. \end{aligned} \tag{11}$$

In particular, 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. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Coef.	St. Err.
Contagion		
$\gamma^U$	0.133***	0.015
$\gamma^{G}$	0.056***	0.013
$\gamma^{D}$	0.249***	0.016
Interdependence		
$\beta^U$	0.397***	0.016
$\beta^{G}$	0.368***	0.012
$\beta^{D}$	0.491***	0.014
Other		
η	-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	322,216	
$R^2$	0.310	

comovement between the portfolios before the crisis. Third, there is statistically strong evidence of contagion from all three sources: from the U.S. market, from the global financial sector, as well as from the domestic market. Finally, and most strikingly, contagion during the 2007 to 2009 financial crisis seems to have been primarily domestic in nature. The domestic contagion estimate of 0.249 is much larger than the analogous estimates for U.S. contagion of 0.133 and global contagion of 0.056, and constitutes an economically large 50% increase in domestic factor  $\beta$ 's. Note that these results change little when the Eastern European countries, the countries experiencing the steepest declines during the crisis, are removed from the sample.

#### **B.2.** Heterogeneity

The evidence on the average contagion and interdependence parameters of Table VI potentially masks a considerable degree of heterogeneity across

equity portfolios. Figure 3 documents that such heterogeneity is indeed substantial. Despite positive contagion on average, a number of portfolios managed to decouple at least to some extent from global, U.S., or domestic equity market movements. Given the parameter estimates reported before, it is no surprise that the positive mean is most apparent for domestic contagion.

To provide further insights into this heterogeneity, Table VII provides the parameter estimates of equations (11) and (12) averaged at the regional (Panel A) and sectoral (Panel B) levels. Panel A confirms that domestic contagion dominates U.S. or global contagion, as the estimates for the former are positive, significant, and sizeable for all regions. Only in Latin America is U.S. contagion slightly larger than domestic contagion. Domestic contagion is most important in Emerging Europe and in the Middle East/Africa, but Emerging Europe shows significant global and U.S. contagion parameters as well. Moreover, the  $\eta$  parameter—measuring equity movements during the crisis that are not accounted for by the three factors—is only negative in a statistically significant fashion for Emerging Europe.

As to the sector analysis in Panel B, only three sectors have significant contagion coefficients for the global factor, namely, the energy, financial, and technology portfolios. The noncyclical 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 U.S. 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 U.S. factor, and thus partially decoupled during the crisis. There is significantly positive and mostly sizeable domestic contagion for portfolios in 9 out of the 10 sectors (the technology sector is the exception), broadly confirming that domestic contagion is not driven simply 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, that is,  $\eta$  is negative and large at -0.217. Taken together with the regional results, these results suggest that the bulk of the contagion effects can be captured by increases in factor exposures with respect to the three factors.

A final perspective on the nature of the contagion we have uncovered is in Table VIII, which reports 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 U.S. 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



**Figure 3. Distribution of contagion coefficients.** The figures show the distribution of the contagion coefficients  $\gamma_{i,0}$  from the estimation of (11) to (12) across all 415 equity portfolios from the factor model.

#### Table VII

#### **Contagion and Interdependence across Regions and Sectors**

The table reports the estimates of the following model:

$$\begin{aligned} R_{i,t} &= E_{t-1}[R_{i,t}] + \beta'_{i,t}F_t + \eta_{i,0}CR_t + e_{i,t}, \\ \beta_{i,t} &= \beta_{i,0} + \gamma_{i,0}CR_t. \end{aligned} \tag{11}$$

In particular, 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). \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

		Pan	el A. By Re	egion			
		Contagion		Int	erdepende	nce	Other
Region	$\gamma^U$	γ <sup>G</sup>	γ <sup>D</sup>	$\beta^U$	$\beta^G$	$\beta^D$	η
Latin America	0.223***	0.090***	0.212***	0.537***	0.305***	0.575***	0.091
Western Europe	0.173***	0.015	0.241***	0.588***	0.509***	0.468***	-0.049
Emerging Europe	0.167***	0.109***	0.318***	0.209***	0.281***	0.405***	-0.160***
Middle East/Africa	-0.038	0.082*	0.337***	0.092***	$0.127^{***}$	0.406***	0.171*
Developed Asia	0.156***	0.016	0.194***	0.455***	0.507***	0.617***	0.005
Emerging Asia	-0.004	0.089**	0.197***	0.261***	0.324***	0.639***	-0.036

		Panel l	B. By Sect	or			
		Contagion		Int	erdepende	nce	Other
Sector	$\gamma^U$	γ <sup>G</sup>	$\gamma^D$	$eta^U$	$\beta^G$	$\beta^D$	η
Basic materials	0.324***	0.009	0.469***	0.379***	0.391***	0.494***	-0.103
Communications	-0.037	0.015	0.096***	0.455***	0.305***	0.539***	0.036
Consumer, cyclical	0.096***	0.039	0.232***	0.386***	0.379***	0.519***	-0.068
Consumer, noncyclical	0.091***	-0.075***	0.137***	0.341***	0.366***	0.462***	0.000
Diversified	0.157*	0.037	0.163***	0.477***	0.433***	0.709***	-0.045
Energy	0.286***	0.103**	0.401***	0.320***	0.336***	0.433***	0.172***
Financial	0.106***	0.203***	0.194***	0.441***	0.495***	0.439***	-0.217***
Industrial	0.196***	0.033	0.335***	0.383***	0.379***	0.498***	-0.148*
Technology	-0.157**	0.192***	0.083	0.704***	0.217***	0.574***	-0.105
Utilities	0.179***	0.068	0.310***	0.236***	0.286***	0.394***	0.172***

contagion during the crisis. This is true both for international and domestic exposure. This evidence casts doubt on the globalization hypothesis as a main determinant of the differential performance across portfolios during the crisis. Given the low means of the U.S. and global banking sector contagion parameter distributions, the negative correlation implies that portfolios with relatively high (low) global  $\beta$ 's saw their exposures to the U.S. and global banking sectors decrease (increase) during the crisis. Thus, highly globalized portfolios often experienced declines lower than anticipated from their precrisis exposures. Instead, the fate of equity portfolios during the crisis became substantially more linked to that of other domestic portfolios.

#### Table VIII Correlation Patterns across Contagion and Interdependence Parameters

The table reports 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:

$$\begin{aligned} R_{i,t} &= E_{t-1}[R_{i,t}] + \beta'_{i,t}F_t + \eta_{i,0}CR_t + e_{i,t}, \\ \beta_{i,t} &= \beta_{i,0} + \gamma_{i,0}CR_t. \end{aligned} \tag{11}$$

p-values are shown below the correlation coefficients in italics. Standard errors are based on the cross-sectional distribution of the coefficients.

		Contagion		Iı	nterdepende	ence	Other
	γ <sup>U</sup>	γ <sup>G</sup>	γ <sup>D</sup>	$\beta^U$	$\beta^G$	$\beta^{D}$	η
Contagion							
$\gamma^{G}$	0.121	1					
	0.013						
$\gamma^D$	0.495	0.219	1				
	0.000	0.000					
Interdependence							
$\beta^U$	-0.203	-0.153	-0.306	1			
	0.000	0.002	0.000				
$\beta^{G}$	-0.027	-0.273	-0.213	0.620	1		
	0.590	0.000	0.000	0.000			
$\beta^D$	-0.276	-0.077	-0.515	0.389	0.319	1	
	0.000	0.119	0.000	0.000	0.000		
Other							
η	0.099	0.092	0.084	0.012	-0.018	-0.038	1
	0.045	0.061	0.063	0.813	0.713	0.438	

#### B.3. Diagnostics

Going back to Table IV, the contagion model naturally matches quite well the severity of the equity market collapse during the 2007 to 2009 financial 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; in fact, the Spearman rank correlation is 0.91 for the contagion model, substantially higher than the 0.68 rank correlation recorded for the interdependence model.

The goodness of fit of the contagion model is illustrated 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 of actual on predicted returns from the contagion model at the portfolio level yields:

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



**Figure 4. Goodness of fit of the contagion model**. The figures show the cumulated actual equity market returns over the entire crisis period (August 2007 to March 2009) against the fitted cumulated returns from the contagion model in (11) and (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° line.

#### Table IX Diagnostic Tests

Panel A of the table reports the average increase in correlation with the factor returns during the crisis period in the actual data, and compares it to that produced by the interdependence model and the contagion model. This is achieved by computing fitted returns from the interdependence model and from the contagion model, and then calculating correlations for each country-sector portfolio with the returns of a benchmark portfolio (the U.S. market, the global market, and the domestic market), for the precrisis period and the crisis period separately. Panel B reports results of a variance ratio analysis. For each factor k (U.S. factor, global factor, and domestic factor), we calculate the variance ratio for the fitted returns in the contagion model as  $VR_{\beta}^{k} = \frac{\operatorname{cov}(\hat{R}_{i,\ell})^{k}F_{i,\ell}^{k}]}{\operatorname{var}(\hat{R}_{i,\ell})}$  for the interdependence parameters and  $VR_{\gamma}^{k} = \frac{\operatorname{cov}(\hat{R}_{i,\ell})}{\operatorname{var}(\hat{R}_{i,\ell})}$  for the contagion parameters. Panel B of Table IX presents the averages of the variance ratios across portfolios, for each of the factors, during the crisis period.

Panel A: Increase	e in Correlations during t	the Crisis	
	United States	Global	Domestic
Actual	0.171	0.197	0.082
Predicted (interdependence model)	0.159	0.228	-0.001
Predicted (contagion model)	0.170	0.220	0.049
Panel B	: Variance Ratio Analysis	,	
United States	Globa	ıl	Domestic
γ 7.787	2.56	5	14.692
β 23.855	12.79	6	38.247

. The slope coefficient is close to unity, and the  $R^2$  is 84%, confirming the good fit. The joint hypothesis that the intercept is zero and the slope coefficient unity is not rejected.<sup>10</sup>

Table IX reports two final diagnostics. Panel A shows the average increase in correlation with the factor returns during the crisis period in the actual data, and compares it to that produced by the interdependence model and the contagion model. To implement these computations, we compute fitted returns from the interdependence model and the contagion model, and then calculate correlations for each country-sector portfolio with the returns of a benchmark portfolio (the U.S. market, the global market, and the domestic market—reflecting the three factors in the model), separately for the precrisis period and the crisis period. These correlations essentially reflect the product of the portfolio's  $\beta$  with respect to a volatility ratio (factor over portfolio) and thus increases in correlations are produced by increases in this volatility ratio or increases in the  $\beta$ 's. We find that correlations with the domestic factor increase by about 0.1. The

<sup>10</sup> Note that the model fit would be perfect if every single regressor in the model were interacted with a crisis dummy and the test were carried out with average rather than the economically more interesting cumulative returns.

interdependence model does reasonably well in fitting the average increase in correlations with the U.S. and global factors (because volatility ratios increase), but does not generate any increase in correlation with the domestic factor. The contagion model produces realistic increases with respect to all three factors although it still underpredicts the average increase in the correlation with the domestic factor.

Implicitly, these results show that the interdependence model may explain a nontrivial part of the predictable variation in returns during the crisis. This is confirmed more directly by the variance ratio analysis in Panel B of Table IX. For each factor k (U.S. factor, global factor, and domestic factor), we calculate the variance ratio for the fitted returns in the contagion model as

$$VR_{\beta}^{k} = \frac{\operatorname{cov}[\hat{R}_{i,t}, \beta^{k}F_{i,t}^{k}]}{\operatorname{var}[\hat{R}_{i,t}]}$$
(13)

for the interdependence parameters and

$$VR_{\gamma}^{k} = \frac{\operatorname{cov}[\hat{R}_{i,t}, \gamma^{k}F_{i,t}^{k}]}{\operatorname{var}[\hat{R}_{i,t}]}$$
(14)

for the contagion parameters.<sup>11</sup> By definition, these variance ratios will sum to one (except for the fact that expected returns also explain a minuscule part of return variation). Panel B of Table IX presents the averages of the variance ratios across portfolios, for each of the factors, during the crisis period. Two observations stand out. First, the interdependence model explains 75% of the movements in returns, and the shift in exposures accommodated in the contagion model 25%. Residual contagion, as captured by the  $\eta$ -coefficients, explains a negligible part of return variation and is not reported. In other words, once we control for the nonlinearities in factor returns, a linear model explains a relatively large portion of return variation in the crisis even when factor exposures are kept constant. Second, the main type of contagion that matters is domestic contagion. This again underscores our overall finding that global contagion and U.S. contagion were less important during the crisis, but that domestic contagion was economically important.

#### B.4. Robustness

The Internet Appendix contains a large number of tabulated robustness checks.<sup>12</sup> A first set of robustness checks focuses on alternative factor specifications. An alternative factor model with the world market return as the global factor, the U.S. financial sector as the U.S. factor, and the domestic market return as the domestic factor delivers qualitatively similar results. We also entertain two different orthogonalization schemes. In the first, we orthogonalize

<sup>&</sup>lt;sup>11</sup> We also compute a variance ratio for the  $\eta$ -part of the model, but find this to be unimportant, and hence do not report it in Table IX.

<sup>&</sup>lt;sup>12</sup> The Internet Appendix may be found in the online version of this article.

the U.S. factor vis-à-vis the global financial factor (rather than the reverse as in the benchmark). In the second, we use an orthogonalization derived separately from the precrisis versus crisis periods. The results are again robust and the mean domestic contagion parameter in both cases is 0.250 instead of 0.249. We also consider a factor specification where the domestic factor consists of the full set of securities, rather than representing the domestic market portfolio excluding the portfolio under consideration. The estimates do not change in a meaningful manner, but, not surprisingly, the independence and especially the contagion coefficients on the domestic factor increase slightly (the latter, on average, from 0.249 to 0.321).

Our reduced-form model may fail to appropriately account for certain nonlinear movements in the factor returns. Imagine that, in normal times, portfolios have different  $\beta$ 's with respect to "normal" and jump variation in the factor. Because of the higher concentration of jumps during the crisis, we measure a higher  $\beta$  with respect to this particular factor return, which is interpreted incorrectly as contagion. To verify this possibility, for each of the three factors we introduce a dummy for weeks when the respective returns are in their bottom decile, with the bottom decile based on the distribution over the entire sample period. The dummy is then interacted with all contagion and interdependence parameters. The table reported in the Internet Appendix reveals mild evidence of nonlinearities, but our main result that domestic contagion dominates during the 2007 to 2009 financial crisis remains valid, with the coefficients being very close to those of the benchmark model without interaction terms.

Table X reports a robustness test for the definition of the financial crisis, where the crisis starts 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 U.S. and global contagion. We now observe a significantly negative  $\eta$  coefficient.

#### **B.5.** Other Crises

An intriguing question is whether the 2007 to 2009 financial crisis differs 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 data availability (particularly 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 X shows the estimates for these two events, based on an estimation of the contagion model, but excluding the 2007 to 2009 financial crisis from the sample. The findings indicate that there was little if any contagion during those two episodes. For the LTCM crisis, the global and U.S. contagion parameters are significant and negative, suggesting a slight decoupling of equity markets from the U.S. market or the global financial sector during those episodes. There appears to be significant residual contagion: the  $\eta$ -coefficient

#### Table X

#### **Contagion and Interdependence: Robustness**

The table reports the estimates of the following model:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta'_{i,t}F_t + \eta_{i,0}CR_t + e_{i,t},$$
(11)

$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0} C R_t. \tag{12}$$

In particular, 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, that is, September 15, 2008, to March 15, 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 recent crisis observations are excluded. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Benchn	nark	Post-Lei	nman	LTCM (	Crisis	TMT E	Bust
	Coef.	St. err.	Coef.	St. err.	Coef.	St. err.	Coef.	St. err.
Contagion								
$\gamma^U$	0.133***	0.015	0.142***	0.018	-0.026***	0.002	-0.004*	0.002
$\gamma^{G}$	0.056***	0.013	0.047***	0.014	-0.089***	0.019	0.010	0.013
$\gamma^{D}$	0.249***	0.016	0.283***	0.021	-0.030	0.030	-0.013	0.026
Interdependence								
$\beta^U$	0.397***	0.016	0.405***	0.016	0.403***	0.016	0.398***	0.016
$\beta^{G}$	0.368***	0.012	0.375***	0.012	0.381***	0.012	0.365***	0.012
$\beta^{D}$	0.491***	0.014	0.517***	0.014	0.495***	0.014	0.498***	0.014
Other								
η	-0.038	0.025	-0.148***	0.048	-0.179***	0.042	-0.032*	0.018
Observations	322,216		322,216		185,223		185,223	
$R^2$	0.310		0.348		0.310		0.310	

indicates a statistically significant 18 basis points underperformance during that crisis that is not related to any of the factors. For the TMT bust, not a single contagion coefficient is significant at even the 5% level. This means that an interdependence model would have correctly described the incidence and transmission of the crisis.<sup>13</sup> Importantly, there is no evidence for domestic contagion during either of these earlier equity market crises. Hence, the importance and even dominance of domestic contagion appears to be a truly defining feature of the 2007 to 2009 financial crisis.

#### C. Channels of Contagion and Interdependence

#### C.1. Main Results

The analysis so far has revealed substantial heterogeneity in the contagion and interdependence coefficients across individual country-sector equity

<sup>13</sup> The Internet Appendix includes graphs similar to Figure 1, showing no systematic underprediction bias during both the TMT bust and the LTCM crisis. portfolios. What explains this heterogeneity? Is it related to the external exposure of portfolios (the globalization hypothesis), to country-specific factors and risks (the wake-up call hypothesis), or to other common factors? We now turn to formally examining the channels of contagion and interdependence.

Table XI reports estimates of the full contagion model (1) to (4) with each instrument  $Z_{i,t}$  individually included in the model. This table provides a general idea of potentially important relationships. Of course, many of these instruments, such as banking and external exposures, are highly temporally and cross-sectionally correlated, so it will be important to conduct a multivariate analysis to determine the instruments that really matter.

The banking channel results show that in normal times factor exposures are increasing in international banking links and credit growth. Portfolios with large interest rate exposure are less exposed to the international factors and more exposed to the domestic factor, perhaps because they comprise bankdependent smaller firms. In terms of contagion, large banking exposures to the U.S. and to the rest of the world, as well as high credit growth and financial constraints of domestic firms, raised the intensity of domestic contagion during the crisis. Moreover, higher banking sector exposure generally lowers contagion from the U.S. factor. This increased relative importance of the domestic factor as a function of banking exposure during the crisis appears inconsistent with the globalization hypothesis, but it does not mean that banking exposure did not transmit to local markets. It is conceivable that, in countries with more international banking exposure, bank financing became particularly difficult. increasing comovements of stocks within the country. Potential correlations with other fundamentals and global exposure must be taken into account, and we do so shortly.

We find that government policies to protect the domestic banking sector, such as through debt and deposit guarantees and through capital injections into domestic banks, reduced contagion during the crisis, and foremost domestic contagion. Thus, government policies have helped delink the domestic economy from problems in the domestic banking system.

Larger external exposure via trade and financial linkages increases the interdependence coefficients, in particular, interdependence with the U.S. and global factors. For instance, trade integration during noncrisis times has, not surprisingly, strong effects on the exposures of the portfolios with respect to global and U.S. factors, confirming results in the literature (see, e.g., Baele (2005)). During the crisis, the dependence of the factor loadings on external exposure (through trade integration, capital flows, and financial integration) decreased substantially. For example, the overall effect of trade integration on the U.S., global, and domestic factor  $\beta$ 's remains positive, as the sum of the (positive) interdependence and (negative) contagion coefficients remains positive, but it is statistically insignificant. In other words, the important message from these estimates is that the globalization hypothesis is not supported by the data as the behavior of portfolios decoupled from their precrisis external dependence. The effect is exacerbated by the temporary collapse in trade and capital flows observed during the crisis, which decreased the instrument

	Instruments	
Table XI	<b>Channels of Contagion: Individual</b>	

The table reports the estimates for the contagion parameters  $\gamma$  and the interdependence parameters  $\beta$  from the full model equations (1) to (4), with each variable included individually in each model estimation. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are not shown for brevity.

		Conta	agion			Interdep	endence	
	United States	Global	Domestic	Other	United States	Global	Domestic	Other
Banking exposure								
Bank exposure to United States	-0.058***	0.017	0.088***	0.016	$0.019^{***}$	0.010	0.007	0.004
Bank exposure to rest of the world	-0.009***	0.001	0.007***	0.004	0.004***	0.003***	0.003***	0.005***
Credit growth	-0.006***	-0.001	0.002*	0.022***	0.003***	$0.002^{***}$	0.002***	0.003***
Interest rate exposure (firm)	$-0.034^{**}$	0.017	-0.060*	0.043	$-0.081^{***}$	$-0.067^{***}$	$0.184^{***}$	$-0.041^{**}$
Size	-0.065	-0.125	0.118	0.279	0.039	0.008	-0.016	0.024
Financial constraint	$-0.014^{**}$	0.021**	0.014**	-0.006	0.002	0.000	-0.001	-0.009
Banking policy								
Debt guarantees	0.015	-0.014	-0.040*	-0.082				0.988***
Deposit guarantees	0.014	$-0.203^{*}$	-0.039*	-0.083				0.799***
Capital injections	0.024	0.013	$-0.130^{***}$	-0.066				0.713***
External exposure / segmentation								
Portfolio investment flows	$-0.001^{***}$	0.000	$-0.001^{***}$	0.0007**	0.001***	$0.001^{*}$	0.001***	0.000
Financial integration	$-0.019^{***}$	-0.009*	$-0.004^{**}$	0.022***	0.011***	$0.011^{***}$	0.001**	0.007***
Financial depth	$-0.001^{***}$	$-0.002^{***}$	$-0.001^{***}$	0.000	0.001***	0.002***	0.001***	0.001***
Trade integration	-0.004***	-0.003	$-0.001^{*}$	-0.006*	0.005***	0.005***	0.003***	0.003***
Exchange rate exposure (firm)	-0.060***	-0.048**	-0.139***	0.139***	-0.090***	-0.076***	-0.087***	$-0.062^{***}$
Information asymmetries								
Distance	0.014	-0.030	-0.0000	$-0.150^{***}$	0.024***	$0.051^{***}$	$0.113^{***}$	0.009
Telephone traffic	0.000	$0.0001^{**}$	-0.0000	$-0.0002^{*}$	0.000***	$-0.000^{**}$	0.000***	0.000
Newspaper imports	0.004	0.015	0.0000	-0.013	0.066***	0.035***	0.008	0.012
Difference in opinion	0.000	0.000	0.000	-0.002*	0.000	0.000	0.001**	0.096***
								(Continued)

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		Table	e XI—Continu	ed				
		Conta	agion			Interdep	endence	
	United States	Global	Domestic	Other	United States	Global	Domestic	Other
Domestic macroeconomic fundamentals								
Political stability/institutions	0.008***	-0.002	0.002	0.066***	$0.005^{***}$	$0.003^{**}$	$0.011^{***}$	0.003
Sovereign rating	0.033***	-0.010	-0.008	$0.113^{***}$	$0.013^{***}$	$0.013^{**}$	0.039***	0.007
FX reserves	$-0.006^{***}$	$-0.013^{***}$	$-0.013^{***}$	0.002	0.006***	$0.011^{***}$	$0.015^{***}$	$0.016^{***}$
Current account position	0.004	0.005	$-0.006^{***}$	0.000	$-0.003^{**}$	0.002	0.000	-0.002
Unemployment rate	$0.026^{*}$	-0.029	0.056***	0.098*	$-0.018^{***}$	$-0.017^{***}$	$-0.013^{***}$	$-0.023^{***}$
Government budget	-0.020***	-0.005	$-0.015^{***}$	0.021	$0.012^{***}$	0.006**	0.005***	0.009***
Global/common risk and liquidity								
Risk: VIX	0.008***	0.007***	0.009***	-0.005*	$-0.008^{***}$	0.007***	$-0.007^{***}$	-0.009***
Credit risk: TED spread	0.001***	0.002***	0.001***	$-0.002^{***}$	$-0.001^{***}$	$-0.002^{***}$	$-0.001^{***}$	$-0.002^{***}$

values as well. Exchange rate exposure decreases  $\beta$ 's in normal times, and even more so during the crisis. While the decoupling during the crisis is consistent with our early results, the negative  $\beta$  dependence on exchange rate exposure in normal times is somewhat puzzling.

The information asymmetry proxies yield weak results. It is intuitive that "distance" increases domestic factor  $\beta$ 's, but not that it increases the dependence on the U.S. and global financial sector factors in normal times. The U.S. and global financial sector  $\beta$ 's depend significantly and positively on newspaper imports in normal times, as expected. However, there are no real significant contagion effects, with the exception that countries further away from the United States performed worse overall (negative  $\eta$  coefficient). Differences of opinion are not related to contagion of the global, U.S., or domestic factors. Of course this does not mean that such differences of opinion may not be relevant; rather, they may just be hard to capture, particularly in a model such as ours, with data covering a very large and heterogeneous cross-section of countries.

For the fundamental variables, the  $\beta$  dependence is mostly positive (and negative for unemployment) in normal times. This indicates that well-performing countries tend to be more integrated with global capital markets but also show higher comovements within the country. During the crisis, we find evidence in favor of the wake-up call hypothesis as many domestic macroeconomic fundamentals are significant drivers of contagion. Compared to the precrisis period, countries with weak fundamentals now have relatively higher factor exposures than countries with good fundamentals. A higher current account deficit and lower foreign exchange reserves significantly increase the exposure to the domestic factor, whereas poor sovereign ratings substantially increase the exposure to the U.S. factor. Equally importantly, the budget position of a country mattered for contagion during the 2007 to 2009 financial crisis, with a weaker budget balance raising both U.S. and domestic contagion. For each variable, at least one of the contagion parameters is highly statistically significant.

Increases in the VIX and TED spread decrease comovements in normal times. This is potentially consistent with evidence in Bekaert et al. (2011) finding more "segmentation" in international portfolios in times of heightened risk aversion. It is surprising that the domestic exposures also decrease at such times, which could indicate that the extent of idiosyncratic risk increases. The contagion parameters are all significant as well and of very similar magnitude as the interdependent coefficients, suggesting the dependence on the VIX and TED spread was minimal during the crisis. It is quite likely that this result reflects an econometric problem given the highly unusual time-series behavior of the two series being highly collinear with the crisis dummy itself. Both the VIX and the TED spread show little variation and are at very low levels up until the crisis, at which time they increase rapidly and show more substantial variation. This makes them look like a stochastic version of the crisis dummy. We do not feel there is a substantive economic result here, and exclude these time series from our subsequent analysis. The significantly negative  $\eta$  coefficients do make economic sense, indicating that, at times of high VIX and TED spread levels, markets generally underperformed.

Of course, many of the instruments are highly collinear, such that it is impossible to understand from Table XI which of them are ultimately important. Table XII reports the results of the model selection procedure described earlier. Table XIII gauges the economic significance of the various instruments by reporting the change in the interdependence and contagion coefficients that would result when comparing a portfolio with the determinant at its 75<sup>th</sup> percentile to a portfolio with the determinant at its 25<sup>th</sup> percentile (i.e., varying the determinant by the interquartile range over the cross-section and time dimensions). For dummy variables (such as the banking policy variables), we report the difference that obtains when the variable changes from zero to one.

Table XII shows that simultaneous inclusion of instruments renders the coefficient estimates for many instruments statistically insignificant, with only 12 of 25 instruments surviving the selection procedure. None of the asymmetric information proxies survive. Perhaps surprisingly, most of the proxies for the banking and external exposure channels disappear as well. We find that the coefficients are in line with banking or external links increasing U.S. factor exposures in normal times and decoupling from the U.S. factor during the crisis. Again, we find that there is no evidence for the globalization hypothesis. Table XIII shows that these effects are mostly economically small, with the exception that financial integration explains a substantial part of the U.S. factor contagion during the crisis. Capital flows generate domestic contagion but the effect is economically insignificant. By contrast, the results of Table XII further strengthen the conclusion that banking policies and the strength of domestic fundamentals largely explain contagion during the 2007 to 2009 financial crisis. All six of the macrofundamental variables survive the model selection procedure, but the foreign exchange reserves variable does not generate a contagion effect. For several of these variables, the size of the coefficients increases substantially in the encompassing approach relative to the univariate approach. The economic importance of these channels for explaining contagion in the crisis is substantial. For instance, recall that the (unconditional) average estimate for domestic contagion in Table VI was 0.249. Looking at the interquartile ranges (during the crisis) in Table XIII indicates that, for example, the introduction of debt guarantees, a good government budget position, or strong political stability would itself have eliminated about half of the domestic contagion effect during the crisis. Comparing a "basket-case country" with its fundamentals each at the 25<sup>th</sup> percentile of the distribution to a country with strong fundamentals at the 75<sup>th</sup> percentile of the distribution, the U.S. factor exposure would be 0.31 larger, the global financial sector exposure 0.22 larger. and the domestic factor exposure 0.34 larger. This again highlights that the wake-up call hypothesis was the main driver of contagion in the recent crisis.

The wake-up call hypothesis should be contrasted with perhaps better known informational contagion models. In the well-known model of Calvo and Mendoza (2000), globalization decreases the incentives of costly information gathering about country-specific fundamentals in the presence of short-sell constraints, as different countries represent increasingly smaller proportions of the world portfolio. This may then induce contagious herd behavior. We do not

errors are not shown for brevity.		~		D			•	
		Contag	gion			Interdepen	dence	
	United States	Global	Domestic	Other	United States	Global	Domestic	Other
Banking exposure Bank exposure to rest of the world	-0.003***			-0.005**	0.006***		-0.001**	0.001*
<i>Banking policy</i> Deposit guarantees Debt guarantees Capital injections	-0.137***	-0.075*	-0.120** -0.171*** -0.086**	0.306**				
<i>External exposure / segmentation</i> Portfolio investment flows Financial integration	-0.008***		0.007***		0.028*** 0.003***		0.003	-0.005**
Domestic macroeconomic fundamentals Political stability/institutions Sovereign rating FX reserves		-0.014** -0.017*	-0.029***	-0.052**	0.003*	$\begin{array}{c} 0.002 \\ 0.010^{***} \\ -0.003^{***} \end{array}$	-0.012***	0.001
Current account position Unemployment rate Government budget	$-0.006^{**}$ $0.044^{***}$ $-0.002^{**}$		0.018** 0.017***	0.040***	$0.015^{***}$ -0.014^{***} $0.026^{***}$	-0.006***	0.001 0.038***	-0.003**

Table XII Channels of Contagion: Encompassing Model

the interdependence parameter  $\beta$  is statistically significant at the 10% level, in which case this interdependence stays in the model. We continue this procedure until those instrumental variables left in the model are those that have significant contagion and/or interdependence parameters for The table reports the estimates for the contagion parameters  $\gamma$  and the interdependence parameters  $\beta$  from the full model (1) to (4), following the encompassing approach of variable selection described in the text. The approach starts from the full model including all 25 instruments simultaneously, and then step-by-step reducing the model by excluding the variable with the least statistically significant contagion parameter. We then test whether a particular factor at the 10% significance level. \*\*\*, \*\*, and \*, indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard

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Channels of	of Contagio	n: Economi	c Sign	nificance	in Enc	ompa	ssing	g Model			
Based on the encompassing approach interdependence and contagion coeffici The columns labeled "interquartile in o while the columns labeled "interquartil	of the previou ents for a portfo risis" measure t e all" use the di	s table, this tak lio with the dete this range based stribution over t	ole shov erminan I on the the enti	vs the inter it at its 75 <sup>th</sup> distribution re (crisis ano	quartile r percentile across po precrisis	anges, e compa ortfolio () samp	that is ared wi s durin le peric	s, the different th a portfolio a g the 2007 to 2 od.	ce in th t its 25 <sup>1</sup> 2009 fin	te respe h perce ancial c	ective ntile. rrisis,
			Contag	ion				Interd	lepende	nce	
	Interqui	artile in Crisis		Inte	rquartile	IJ		Interg	luartile	All	
	United States	Global Dom. (	Other U	inited States	Global ]	Dom.	Other [	Jnited States	Global	Dom. (	Other
Banking exposure Bank exposure to rest of the world	0.00		-0.02	0.00			-0.02	0.00		-0.05	0.00
Banking policy Deposit guarantees		-0.12			I	-0.12					
Debt guarantees Capital injections	-0.14	-0.08 -0.17 -0.09	0.31	-0.14	-0.08	-0.17	0.31				
<i>External exposure   segmentation</i> Portfolio investment flows Financial integration	-0.03 -0.18	0.02		-0.02 -0.09		0.02		0.06 0.06		0.01 -	-0.01
Domestic macroeconomic fundamentals Political stability/institutions Sovereign rating		-0.05 -0.12 - -0.17	-0.21		- 0.07 -	- 0.14	-0.26	0.03	0.01	-0.06	0.00
FA reserves Current account position Unemployment rate Government budget	-0.12 0.17 -0.02	0.07 -0.15	0.42	-0.06 0.21 -0.02	1	0.09 -0.11	0.36	0.17 -0.07 0.17	-0.15 -0.03	0.01 0.25	0.00

**Table XIII** 

## The Global Crisis and Equity Market Contagion

find evidence of such a mechanism for the recent global crisis. The fact that the relatively illiquid and small Eastern European markets experienced substantial contagion is also inconsistent with this contagion channel. An intriguing thought is that the Calvo-Mendoza mechanism was at work *before* the crisis. In other words, because of globalization, investors ignored or failed to invest in local information signals, leading to a pricing model where risk exposures were not strongly differentiated on the basis of local fundamentals, but the crisis served as a wake-up call, leading local fundamentals to be more strongly reflected in factor exposures.

#### C.2. Robustness Checks

In the Internet Appendix we include a table reporting results when using instruments not lagged by two quarters but instead are contemporaneous; the empirical results are robust to this change.<sup>14</sup> We also try a few other instruments. We find that the contagion incidence does not depend significantly on the volatility of the country portfolio. It also does not depend significantly on "opaqueness" as measured by the market volatility divided by the average portfolio volatility within a country, differentiated across precrisis and crisis periods. This measure reflects an easy-to-compute proxy for the " $R^{2n}$ " (see Morck, Yeung, and Yu (2000)). If countries become more opaque during the crisis and firm-specific risk is less adequately priced in the equity market, opaqueness may be a channel for domestic contagion. While we find that the domestic factor's interdependence coefficient is positively and significantly related to opaqueness, none of the contagion coefficients is significantly linked to opaqueness.

#### **III.** Conclusions

The 2007 to 2009 financial crisis was 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 and 10 sectors. A first key result is that, from the perspective of a factor model with global and domestic factors, we find evidence of contagion. The comovements of our portfolios cannot be fully explained with the factor model without allowing for shifts in factor exposures.

<sup>&</sup>lt;sup>14</sup> We also extracted principal components for each of the six categories of instruments, but found the results difficult to interpret. First, the first principal components capture only around 60% of the variation of the underlying variables, making restricting attention to the first principal components ill-advised. Second, the use of six principal components does not resolve the correlation problem in the model estimation, with, for example, the banking and external exposure factors being highly correlated. Third, and most damning, some principal components themselves are hard to interpret economically, for instance both a higher unemployment rate and a better government budget load positively on the first principal component for domestic fundamentals. This undermines our interpretation of the role of macrofundamentals in contagion. We therefore do not report the results.

However, the interdependence model explains 75% of total predictable return variation. Second, despite its origination in the United States, we find weak evidence of contagion from U.S. markets to equity markets globally during the crisis. Instead, there was contagion from domestic equity markets to individual domestic equity portfolios. Third, the financial crisis did not spread indiscriminately across countries and sectors. Exposure to external factors through, for example, banking, trade, or financial linkages played no meaningful role for the global equity market transmission of the 2007 to 2009 financial crisis. However, portfolios in countries with weak economic fundamentals, poor sovereign ratings, and high fiscal and current account deficits experienced more contagion, both from the U.S. and from the domestic market, and were overall more severely affected by the global financial crisis. This result provides strong support for the validity of the wake-up call effect as a transmission device of the 2007 to 2009 financial crisis. Moreover, policies to protect domestic banks during the crisis, in the form of debt and deposit guarantees, were instrumental in shielding domestic equity portfolios in part from the 2007 to 2009 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 recent efforts by policymakers and international organizations to better understand macroprudential risks and perhaps institute closer scrutiny of such risks both at a country level and at a global level.

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#### **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 is 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 AI presents 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 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 AI. This comprises about 2,000 firms in total, for which we have daily equity returns in U.S. dollars.<sup>15</sup>

<sup>15</sup> The analysis is therefore from the perspective of a U.S. investor. Note that equity returns in U.S. dollar terms have been even more negative during the crisis given that almost all currencies

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## Table A.I

### **Country Sample and Equity Indices**

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

Country	Name of stock index	No. listed firms	Country	Name of stock index	No. listed firms
	Industrialized			Emerging Europe	
Australia	S&PASX	30	Bulgaria	SOFIX	20
Austria	ATX	20	Croatia	CROBEX	28
Belgium	BEL20	20	<b>Czech Republic</b>	PSE	14
Canada	<b>S&amp;P TSE 60</b>	60	Estonia	OMX	18
Denmark	OMX20	20	Hungary	BSE	14
Finland	OMX25	<b>25</b>	Latvia	OMX	35
France	CAC40	40	Malta	MSE	19
Germany	DAX	30	Lithuania	OMX	32
Iceland	OMX ICEX	11	Poland	WIG20	20
Ireland	ISEQ	60	Romania	BET	10
Italy	MIB30	30	Russia	MICEX	30
Japan	Topix 70	70	Serbia	Belex15	15
Luxembourg	LuxX	9	Slovenia	SBI	15
Netherlands	AEX	<b>25</b>	Turkey	ISE National30	30
Norway	OBX	24	Ukraine	PFTS	19
Portugal	PSI 20	20			
Slovenia	SBI	15		Middle-East and Africa	
Spain	IBEX35	35			
Sweden	OMX30	30	Egypt	CASE	30
Switzerland	SMI	20	Israel	TelAviv-25	25
UK	Footsie 100	100	Qatar	QE	20
			Tunisia	SEBVMT	32
	Asia-Pacific		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	NZX15	15	Chile	IPSA	40
Singapore	Strait Times	30	Colombia	IGBC General	28
Taiwan	TSEC Taiwan 50	50	Mexico	Bolsa	36
Thailand	SET 50	50			

From the firm-level data we construct country-sector portfolios, using the Bloomberg classification that allocates firms into 10 broad industry sectors.

(bar the Japanese yen, and a few pegged currencies) depreciated against the U.S. dollar; see Fratzscher (2009).

This yields 415 country-industry or country-sector portfolios. Not every country in the sample has 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 procedure restricts attention to relatively large firms in each country for which we have reliable data.

As to the recent 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 data set is March 15, 2009. An alternative crisis definition is to start with the bankruptcy of Lehman Brothers on September 15, 2008, which we investigate in a robustness check. Using our data to compute world market returns, the crisis was associated with 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. A large literature in monetary economics and finance focuses on how to measure the degree of financial constraints faced by firms (see, e.g., Almeida, Campello, and Weisbach (2004) and Whited and Wu (2006)). We follow the approach used by Whited and Wu (2006) and define financial constraints of a particular firm as follows:

$$FC_{i,t} = -0.09CF_{i,t} - 0.062DD_{i,t} + 0.02DA_{i,t} - 0.044 \ln A_{i,t} + 0.10IG_{i,t} - 0.035FG_{i,t},$$
(B1)

with CF 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 the firm's growth rate in net assets. A related exposure is a firm's exposure to changes in the cost of financing. Similar to the estimation proposed by Ammer, Vega, and Wongswan (2010), we measure this channel as the interest rate exposure of individual portfolios to changes in domestic three-month interest rates,  $\Delta r_{i,t}$ , as follows:

$$R_{i,t} = \eta_0 + \varphi_i \Delta r_{i,t} + \kappa_i R_t^{US} + e_{i,t}, \tag{B2}$$

where we use weekly data to obtain portfolio-specific interest rate exposures  $\phi_i$ . Unfortunately, short-term interest rates at a weekly frequency are not

available for all countries, so the sample size is more limited for this interest rate exposure variable, and a few portfolios drop out from the sample.

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

$$R_{i,t} = \delta_0 + \delta_i \Delta s_{i,t} + \kappa_i R_t^{US} + e_{i,t}, \tag{B3}$$

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

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Appendix S1: Internet Appendix.