

Global crises and equity market contagion

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Views are those of the authors and not necessarily those of the ECB

Motivation

An ideal lab: the global financial crisis of 2007/09

- US origin, small market (subprime) segment
- All market segments/economic sectors/countries affected
- Global nature helpful to revisit debate on presence/sources of contagion

Why did the crisis spread so violently? 3 hypotheses

1. “Globalization/interdependence” (*Forbes & Rigobon, 2002, etc.*)
Highly integrated economies with US/global economy hit hardest
2. “Wake up call” (*Goldstein, 1998; Masson, 1999, etc.*)
A restricted crisis provides info to investor who reassess the vulnerability of other markets/economies leading to generalized crisis
3. Herd behavior (*Boyer, Kumagai & Yuan, 2006, etc.*)
Contagion without discrimination at all, unrelated to fundamentals

Related literature

Pre-2007/9 studies on equity market contagion

- Early post-1987 crash work (*King and Wadhvani, 1990; Engle, Ito and Lin, 1990; Masulis, Hamao and Ng, 1990*)
- Surveys (*Dungey et al. 2004; Karolyi, 2003*)
- Volatility bias and measurement controversy (*Forbes & Rigobon, 2002*)
- Factor approach (*Bekaert, Harvey and Ng, 2005*)

Drivers of 2007/09 crisis transmission across US firms

- *Tong & Wei, 2009; Almeida et al. 2009; Diebold and Yilmaz, 2010, etc.*

Drivers of 2007/09 crisis transmission globally

- *Tong & Wei, forthcoming; Stulz and Beltratti, 2009; Eichengreen et al. 2009; Rose & Spiegel, 2009 and 2010; Calomiris et al. 2010, etc.*

Methodology

- **“There is no consensus on exactly what constitutes contagion or how it should be measured.”**

Forbes and Rigobon, 2002; Journal of Finance

- **Contagion = excess correlation – that is, correlation over and above what one would expect from economic fundamentals**

Bekaert, Harvey and Ng, 2005; Journal of Business

- **Any statements on contagion will be contingent on specification of a model that implies “normal correlations”**

Methodology

- **Volatility bias in correlations:**

Let $R_{i,t}$ = excess equity return on portfolio i

Let R_t^G = excess equity return on the global market

Let $R_{i,t} = \beta_i R_t^G + e_{i,t}$ Then: $\rho_{i,G} = \beta_i \frac{\sigma_G}{\sigma_i}$

The diagram shows the equation $R_{i,t} = \beta_i R_t^G + e_{i,t}$ on the left and the correlation formula $\rho_{i,G} = \beta_i \frac{\sigma_G}{\sigma_i}$ on the right. Two blue arrows point from the text labels below to the terms in the equation: one from "global risk" to R_t^G and one from "country-specific risk" to $e_{i,t}$.

global risk country-specific risk

→ Increase in factor volatilities increases correlations \neq contagion

→ Unexpected increase in β = contagion

Methodology

3-factor CAPM (Bekaert, Harvey and Ng, 2005)

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

$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0} CR_t \quad (2)$$

- Estimate as one equation, proxy expectations with lagged returns and local dividend yield
- US, global financial and domestic factors
- Subsequent addition of possible determinants

Allows to assess

- Whether there is contagion or not
- Where it comes from
- What its key underlying determinants are

Main findings

- 1. Limited contagion from US/global sources**
- 2. Much stronger evidence of domestic contagion**
 - +50% beta increases; all economies/most sectors
- 3. Specific to 2007-09 crisis**
 - 1998 LTCM crisis, 2000/02 TMT bust: No domestic contagion
- 4. Little evidence for globalization/herd behavior**
 - External exposure (trade & financial integration) explain little; firm level characteristics and risk indicators do not either
- 5. Evidence for “wake-up” call hypothesis**
 - Poor macro fundamentals (FX reserves, CA position, country ratings, etc.) explain contagion, particularly domestic contagion

Data

- Stock prices from Bloomberg for 2000 firms, constituents of the major stock indices
- 55 countries, 10 sectors
- 415 value-weighted sector-country portfolios
- Excess returns (3-month US t-bill rate)
- Returns in US\$
- January 1, 1995 – March 15, 2009, weekly data
- Two crisis definitions, starting August 7, 2007 or September 15, 2008

Key results - *Interdependence*

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

- Three orthogonal factors: $F_t = [R_t^U, R_t^G, R_t^D]$
- Interdependence: β
- Pooled OLS, standard errors clustered across countries

Key results - *Interdependence*

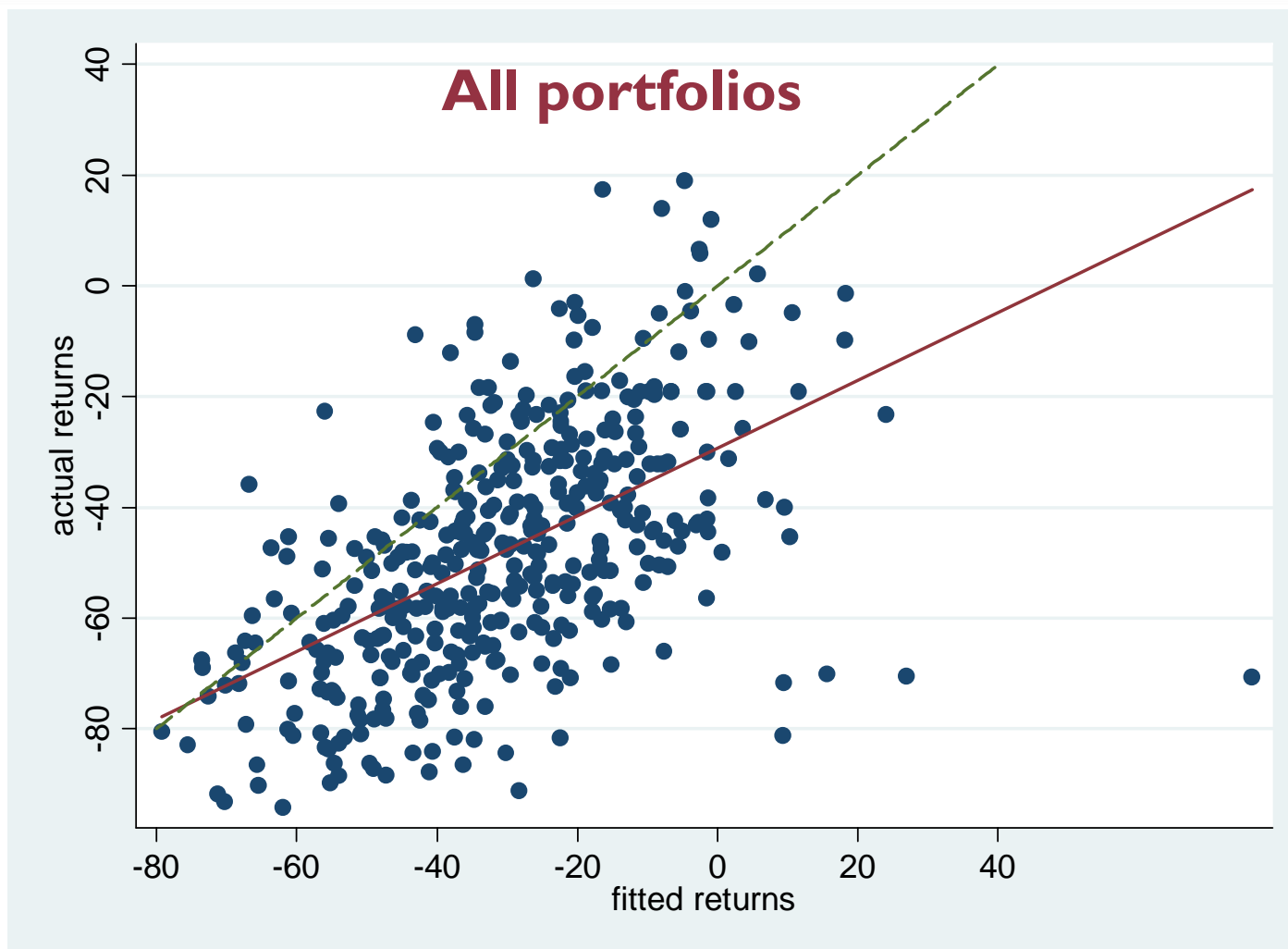
	Benchmark	
	coef	st.err.
Interdependence		
β_1^G	0.406 ***	0.012
β_1^U	0.437 ***	0.015
β_1^D	0.540 ***	0.013

- Unweighted average of β_i
- Clearly misspecified (excess comovement of residuals at country level)

Key results - *Interdependence*

<i>Region</i>	Interdependence					
	β_0^G		β_0^U		β_0^D	
Latin America	0.360	***	0.594	***	0.604	***
Western Europe	0.539	***	0.633	***	0.512	***
Emerging Europe	0.347	***	0.273	***	0.473	***
Middle East/Africa	0.163	***	0.084	***	0.467	***
Developed Asia	0.531	***	0.494	***	0.655	***
Emerging Asia	0.350	***	0.267	***	0.679	***

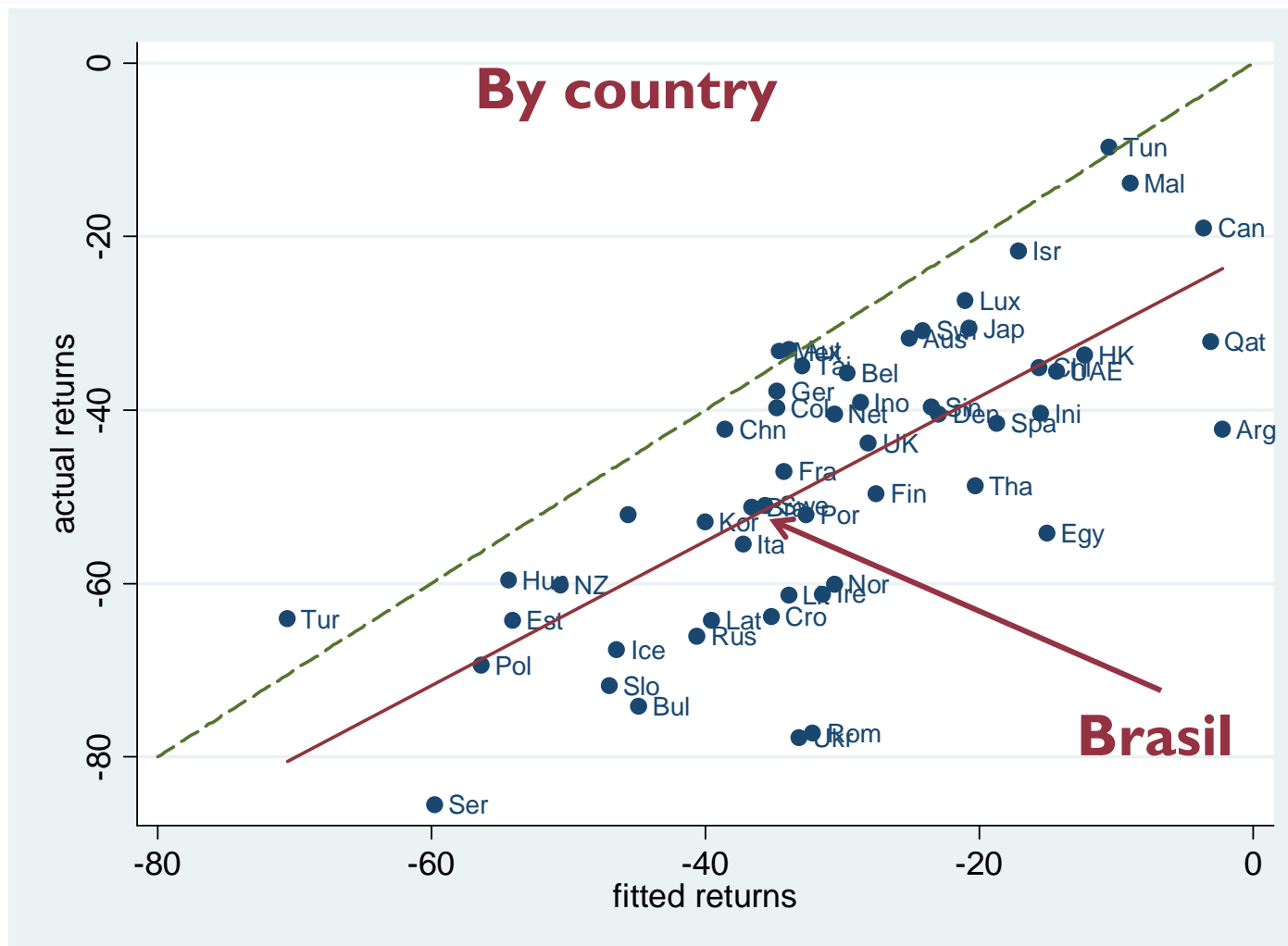
Goodness of fit – *Interdependence model*



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

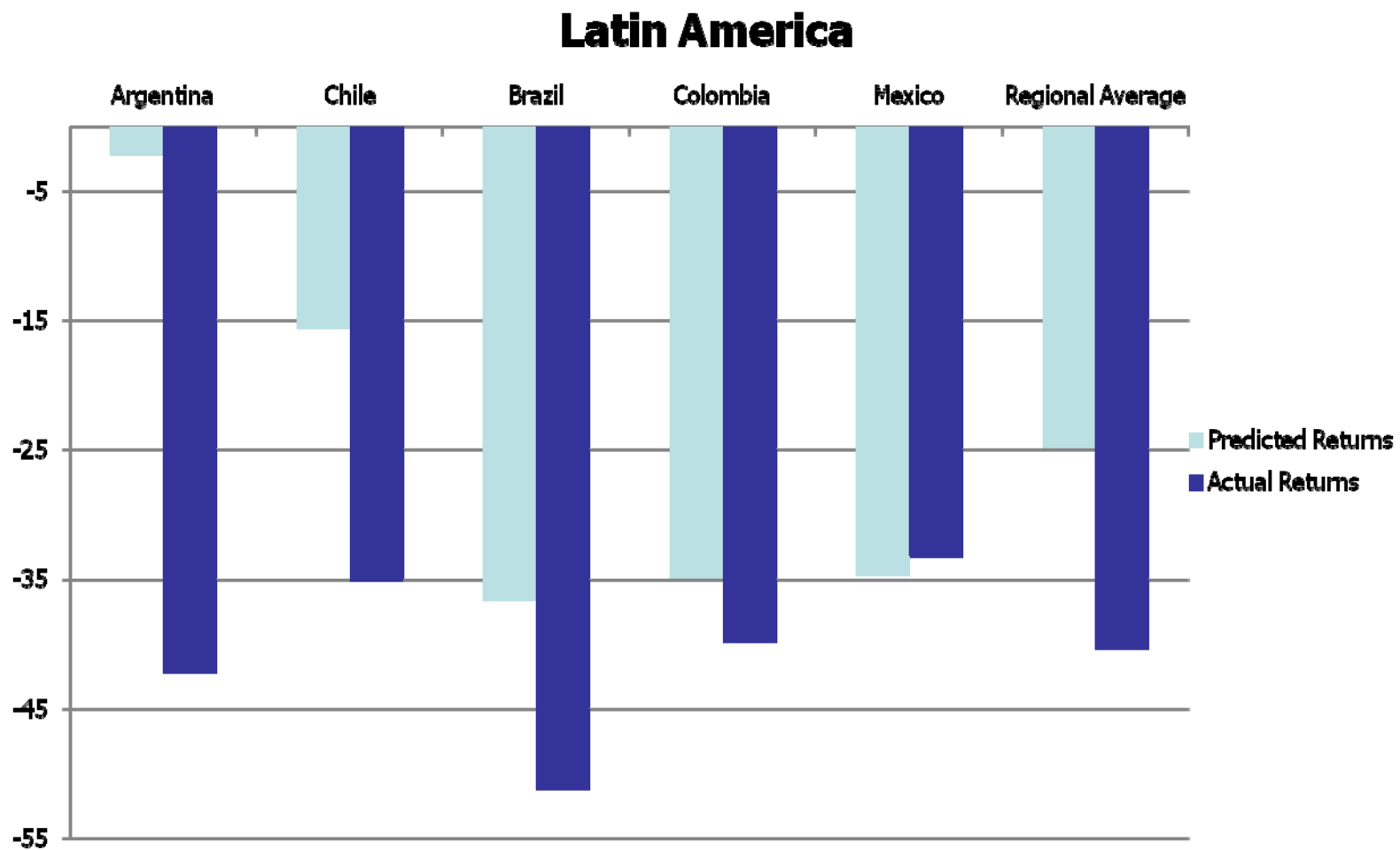
(2.444) (0.046)

Goodness of fit – *Interdependence model*



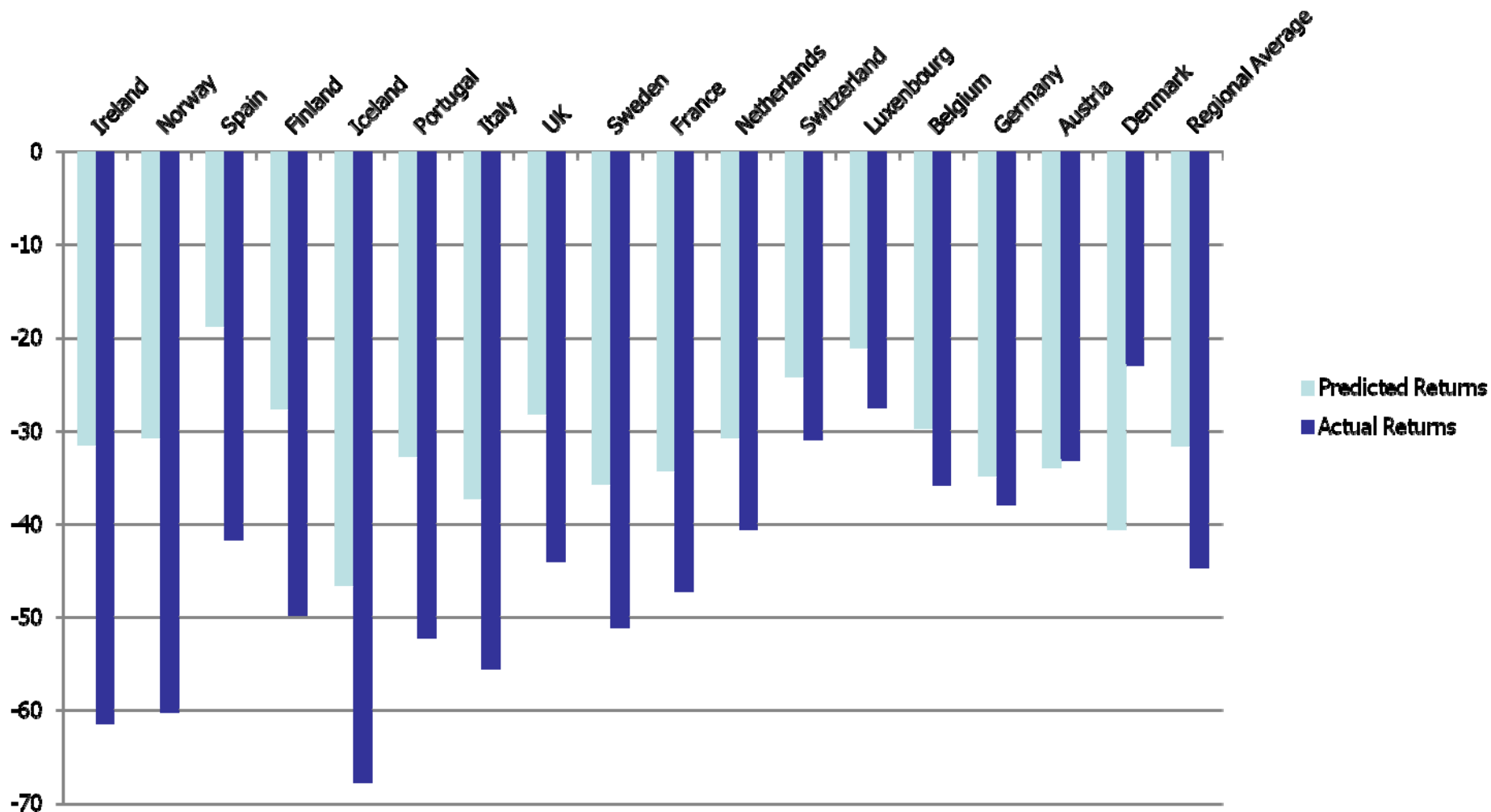
Overprediction of crisis returns

Goodness of fit – *Interdependence model*



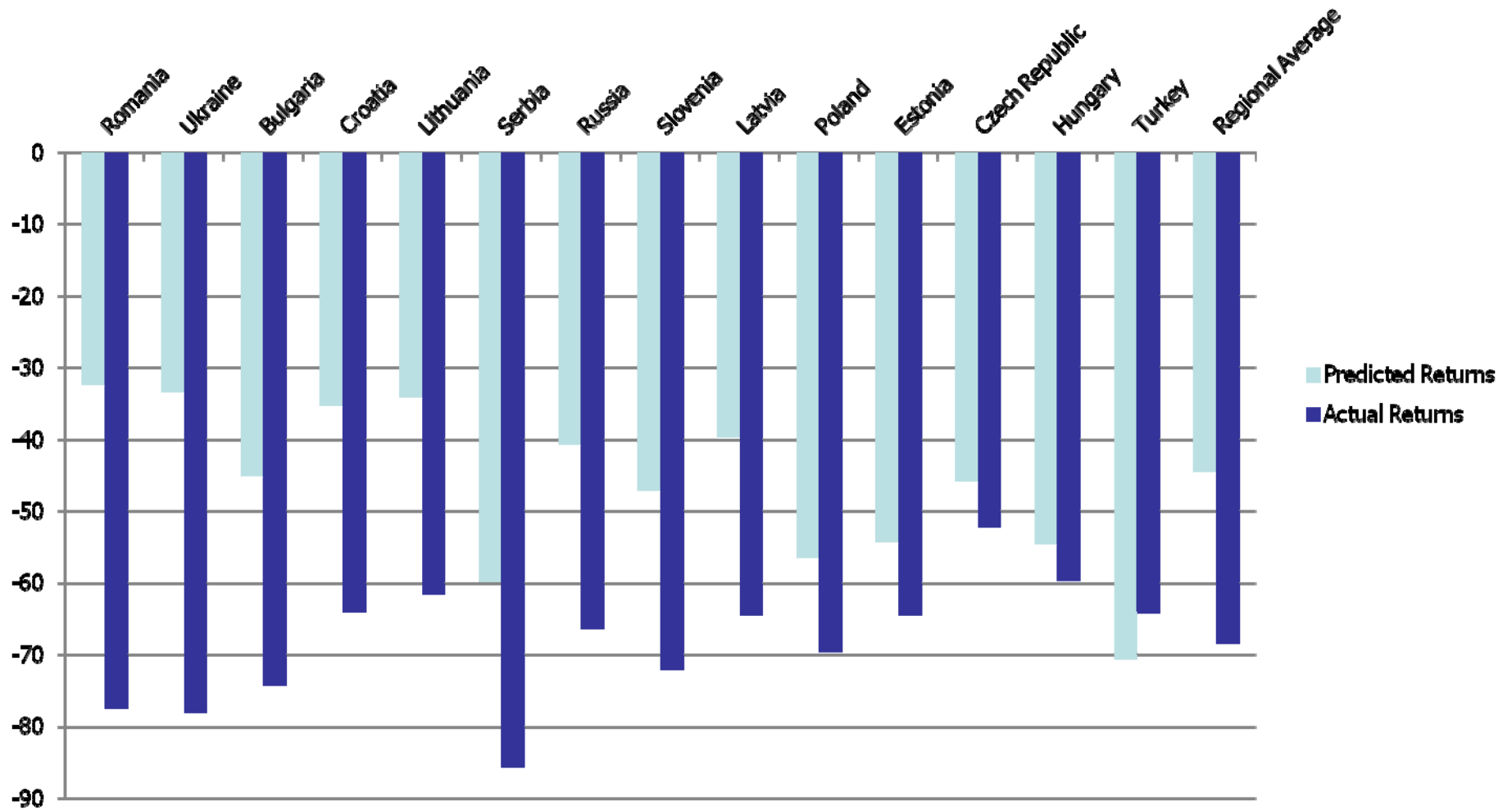
Goodness of fit – *Interdependence model*

Developed Europe

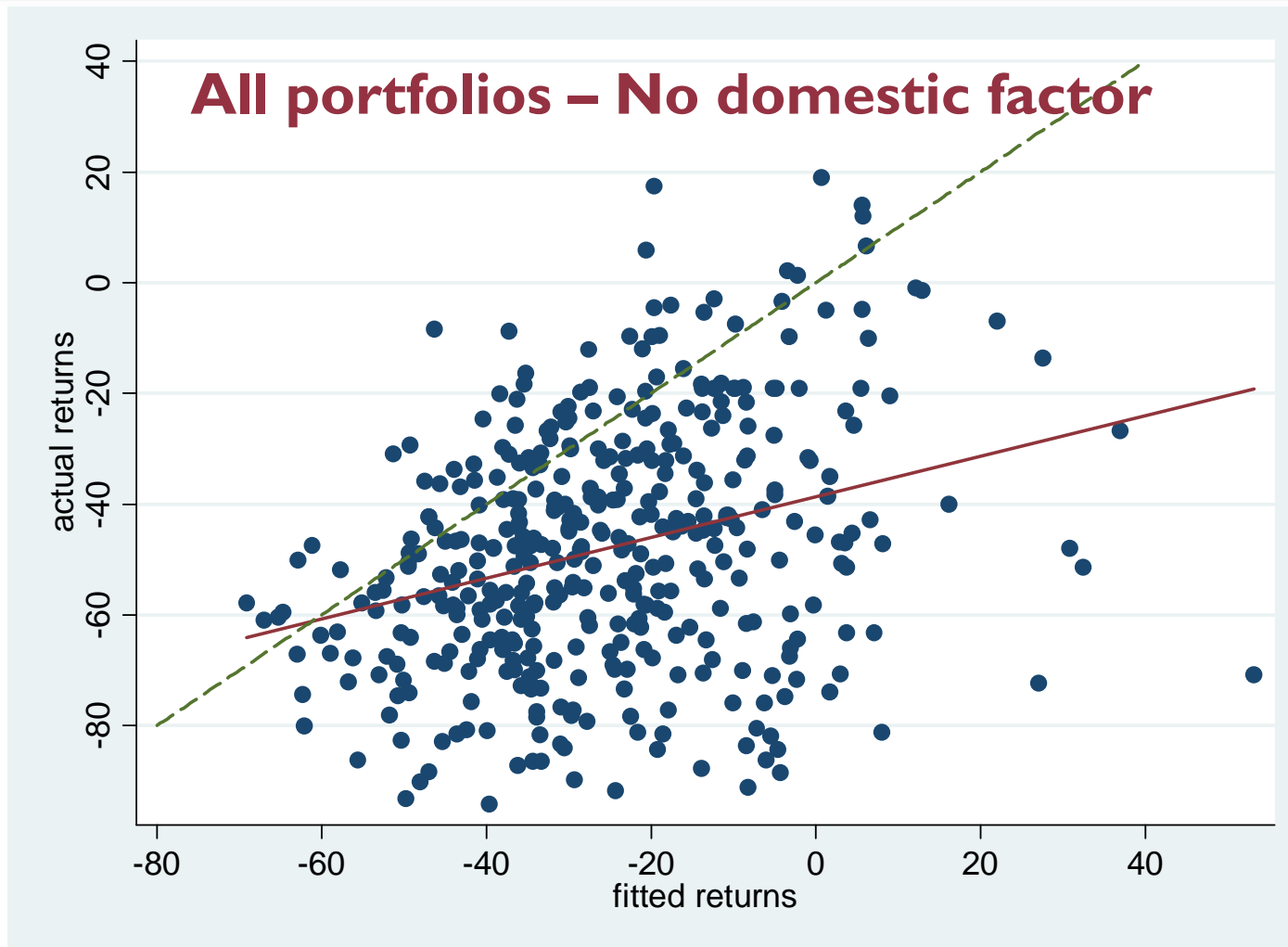


Goodness of fit – *Interdependence model*

Emerging Europe



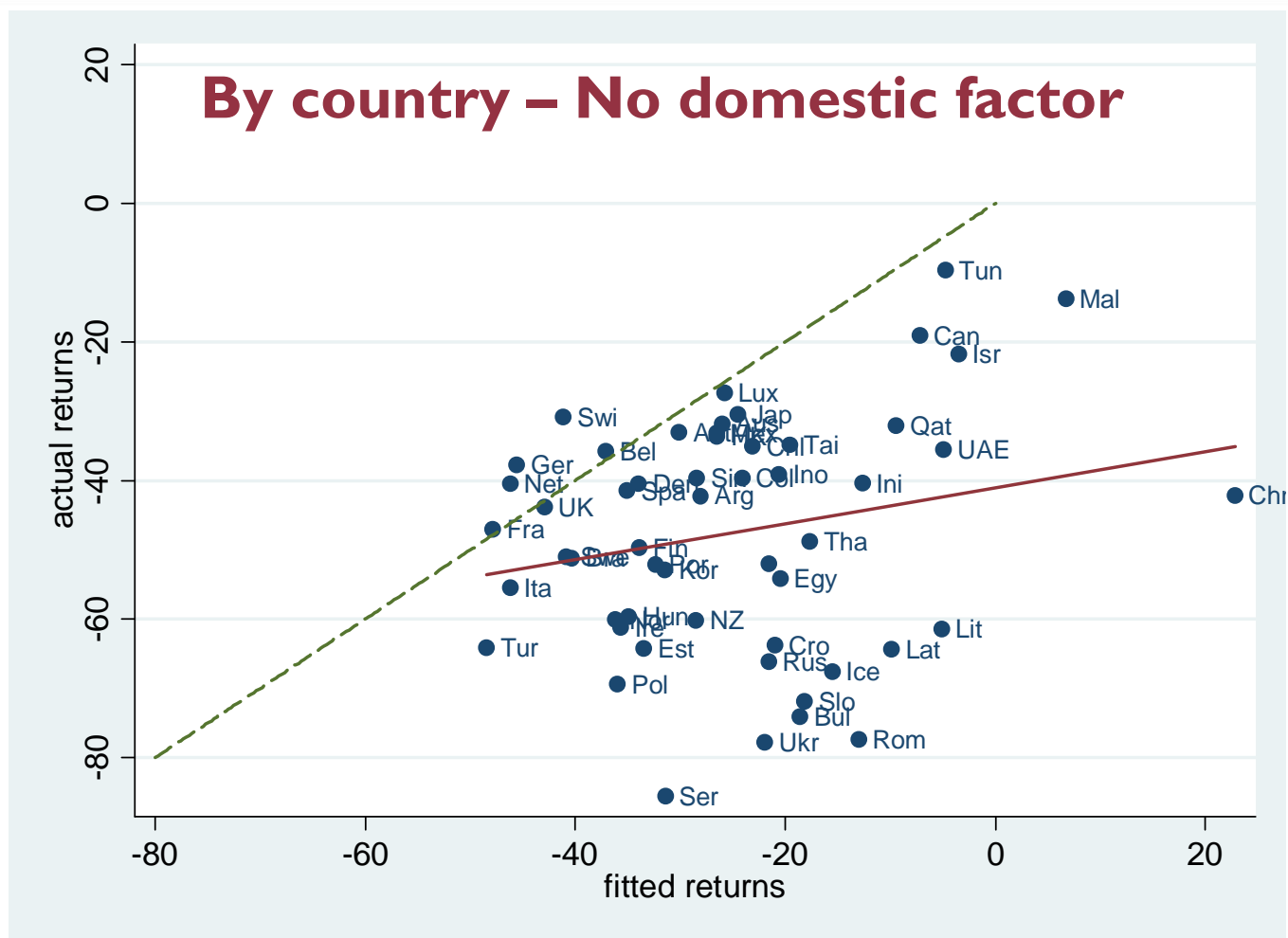
How much did the domestic factor add?



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

(3.439) (0.058)

How much did the domestic factor add?



Key results - Contagion

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

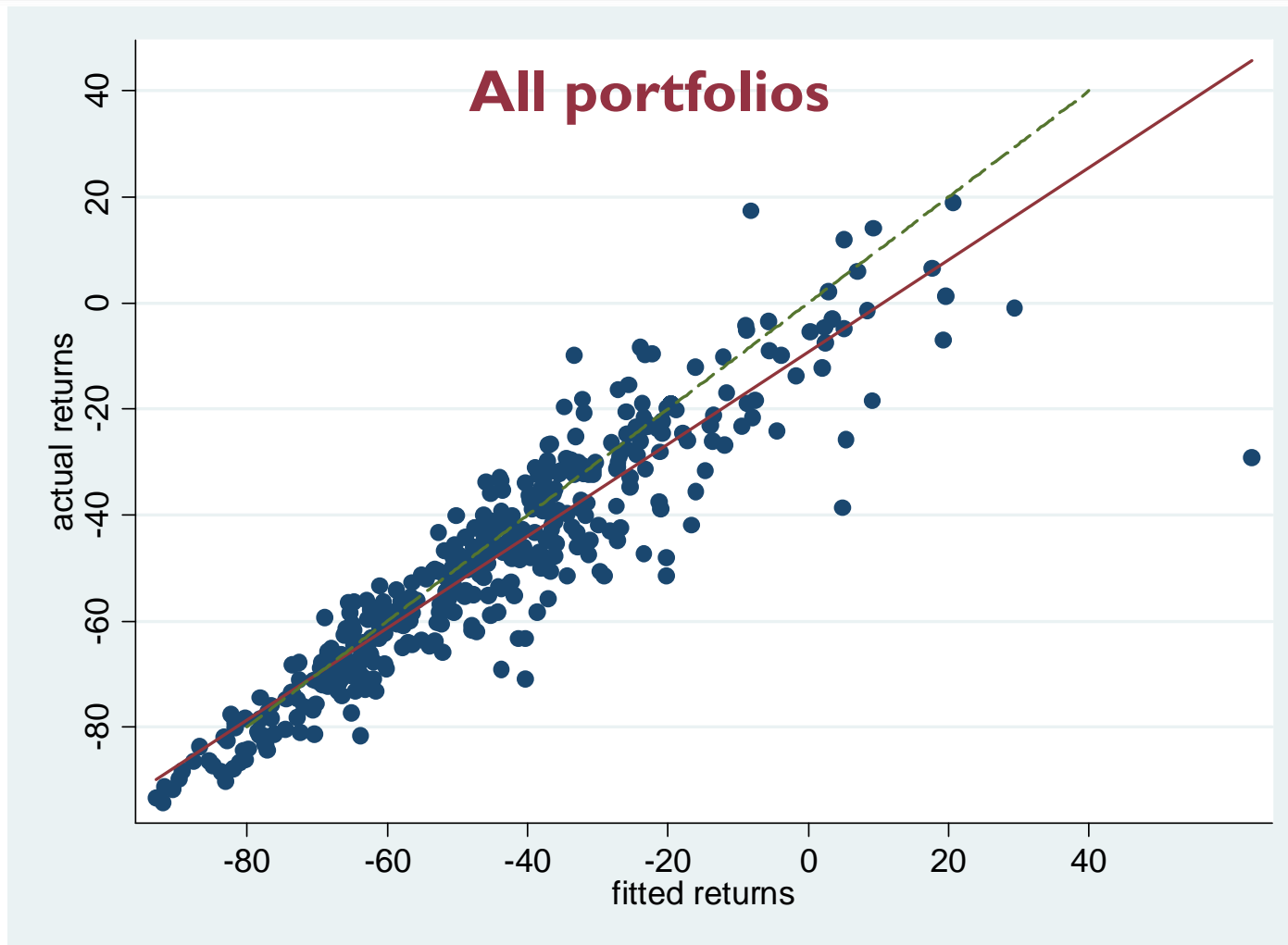
$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0} CR_t \quad (2)$$

- Contagion: γ ; non-fundamental: η
- CR_t crisis dummy (start: 7 August 2007)

Key results – Contagion

	Benchmark	
	coef	st.err.
Contagion		
γ_1^G	0.056 ***	0.013
γ_1^U	0.133 ***	0.015
γ_1^D	0.249 ***	0.016
Interdependence		
β_1^G	0.368 ***	0.012
β_1^U	0.397 ***	0.016
β_1^D	0.491 ***	0.014
Other		
η_1	-0.038	0.025

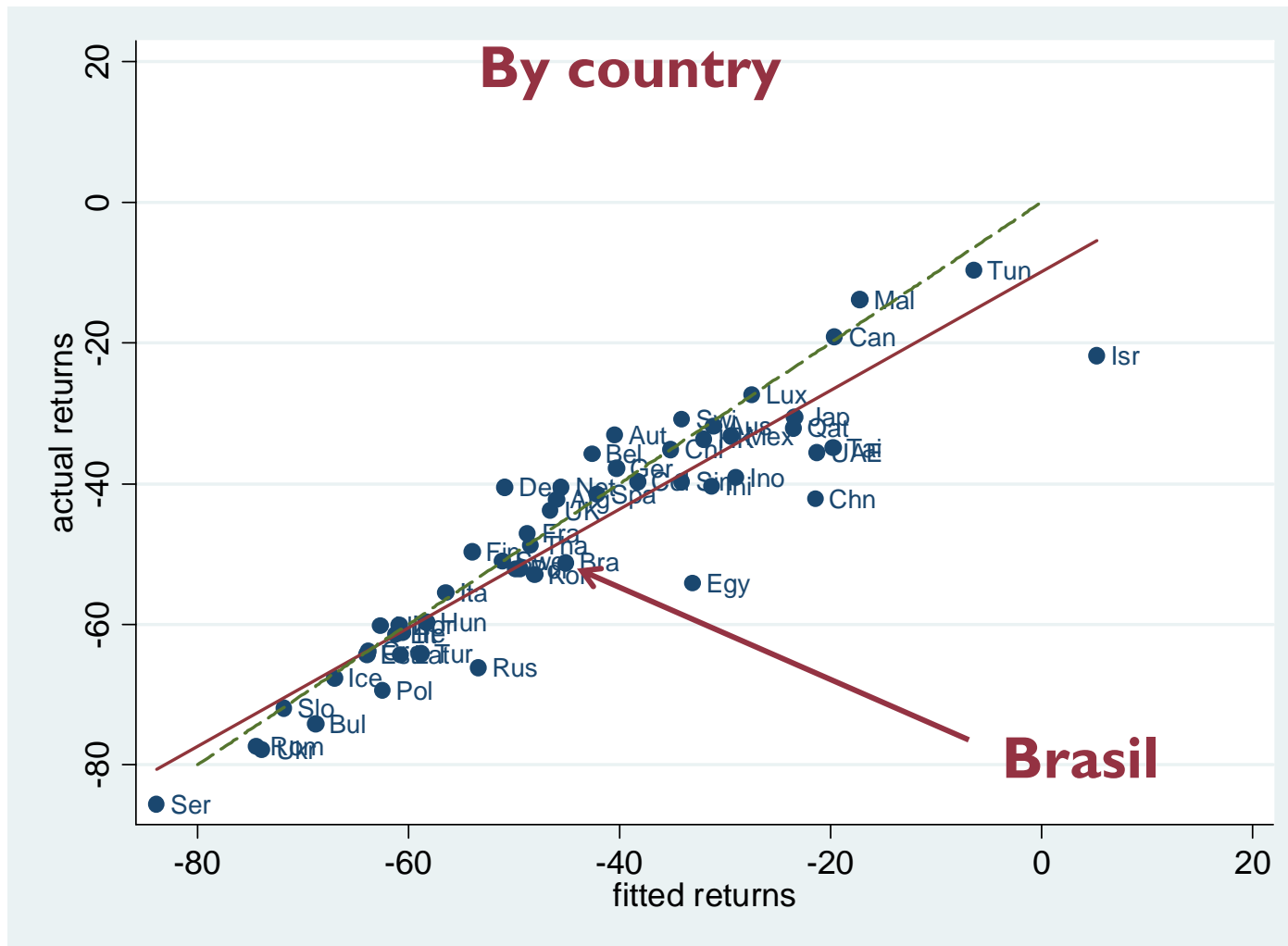
Goodness of fit – Contagion model



$$\hat{R}_i = 1.910 + 0.971\hat{R}_i + \varepsilon_i, \text{ adj. } R^2 = 0.843$$

(2.322) (0.033)

Goodness of fit – Contagion model



Contagion & interdep. – Past global crises

	Benchmark		Post-Lehman		LTCM crisis		TMT bust	
	coef	st.err.	coef	st.err.	coef	st.err.	coef	st.err.
Contagion								
γ_1^G	0.056 ***	0.013	0.047 ***	0.014	-0.089 ***	0.019	0.010	0.013
γ_1^U	0.133 ***	0.015	0.142 ***	0.018	-0.026 ***	0.002	-0.004 *	0.002
γ_1^D	0.249 ***	0.016	0.283 ***	0.021	-0.030	0.030	-0.013	0.026
Interdependence								
β_1^G	0.368 ***	0.012	0.375 ***	0.012	0.381 ***	0.012	0.365 ***	0.012
β_1^U	0.397 ***	0.016	0.405 ***	0.016	0.403 ***	0.016	0.398 ***	0.016
β_1^D	0.491 ***	0.014	0.517 ***	0.014	0.495 ***	0.014	0.498 ***	0.014
Other								
η_1	-0.038	0.025	-0.148 ***	0.048	-0.179 ***	0.042	-0.032 *	0.018
Observations	322216		322216		185223		185223	
R-squared	0.310		0.348		0.310		0.310	

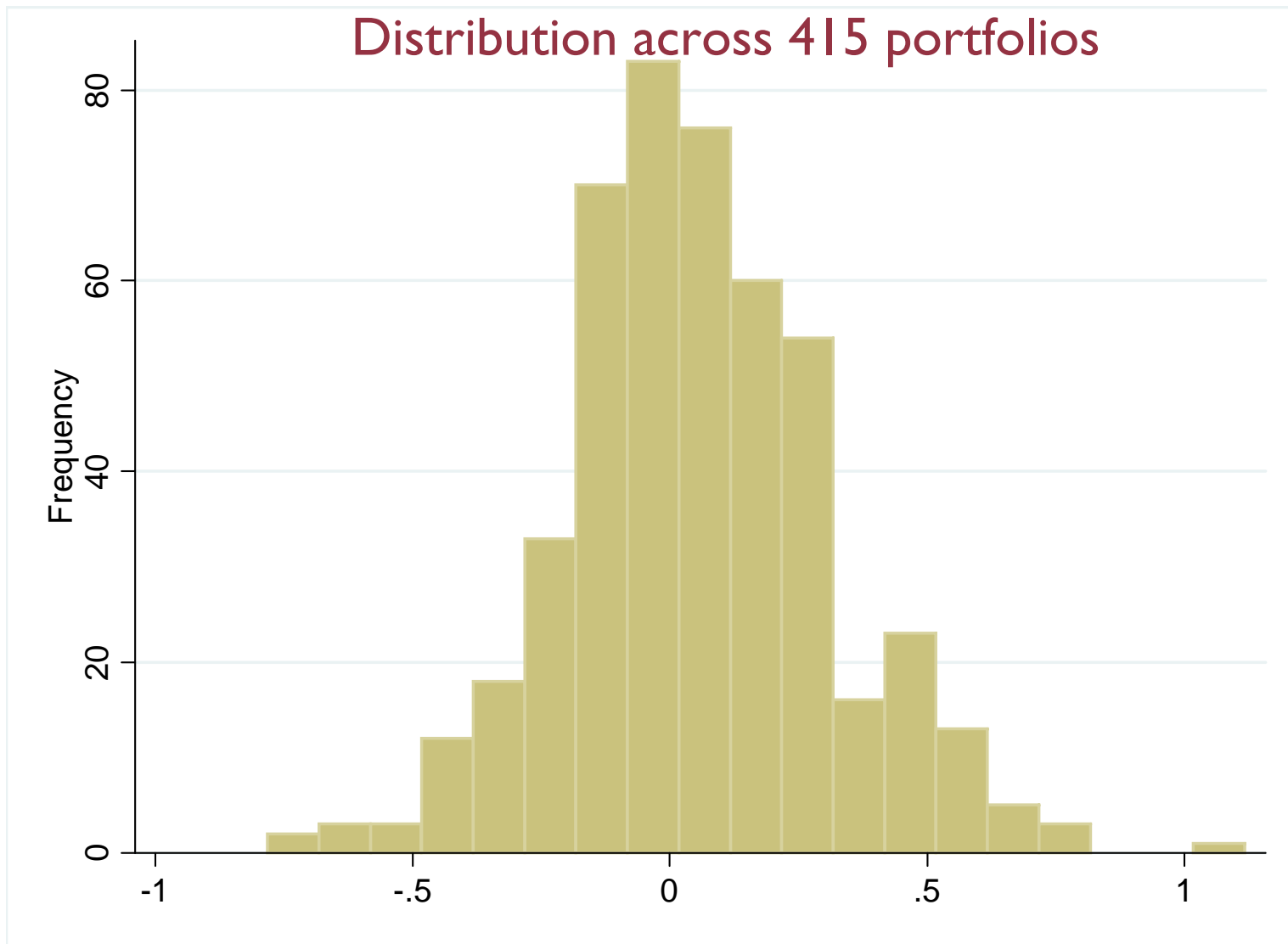
Goodness of fit – Contagion model

By region

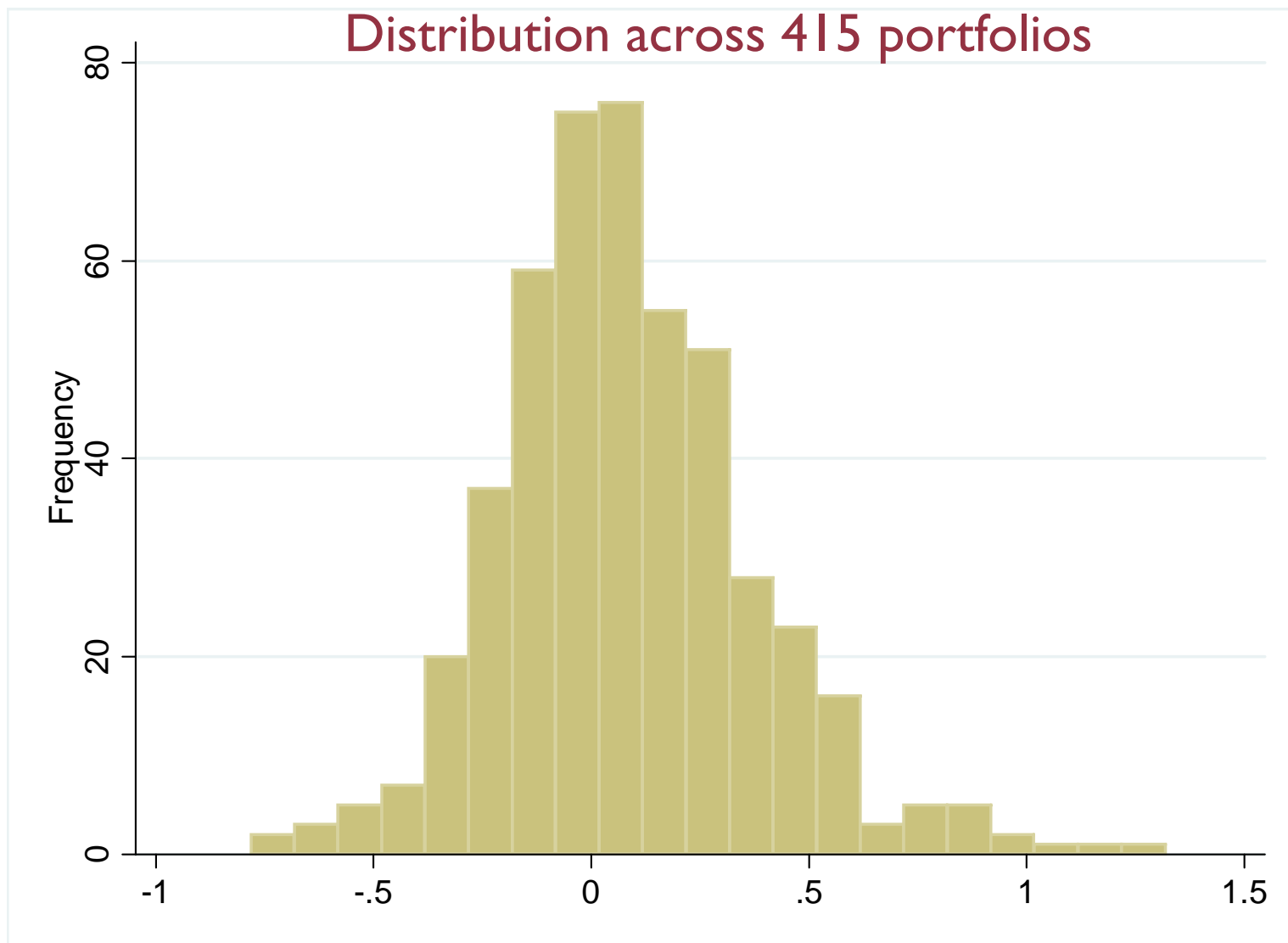
Region	Contagion			Interdependence			Other
	γ_0^G	γ_0^U	γ_0^D	β_0^G	β_0^U	β_0^D	η_0
Latin America	0.090 ***	0.223 ***	0.212 ***	0.305 ***	0.537 ***	0.575 ***	0.091
Western Europe	0.015	0.173 ***	0.241 ***	0.509 ***	0.588 ***	0.468 ***	-0.049
Emerging Europe	0.109 ***	0.167 ***	0.318 ***	0.281 ***	0.209 ***	0.405 ***	-0.160 ***
Middle East/Africa	0.082 *	-0.038	0.337 ***	0.127 ***	0.092 ***	0.406 ***	0.171 *
Developed Asia	0.016	0.156 ***	0.194 ***	0.507 ***	0.455 ***	0.617 ***	0.005
Emerging Asia	0.089 **	-0.004	0.197 ***	0.324 ***	0.261 ***	0.639 ***	-0.036

- Emerging Europe shows large estimates for η

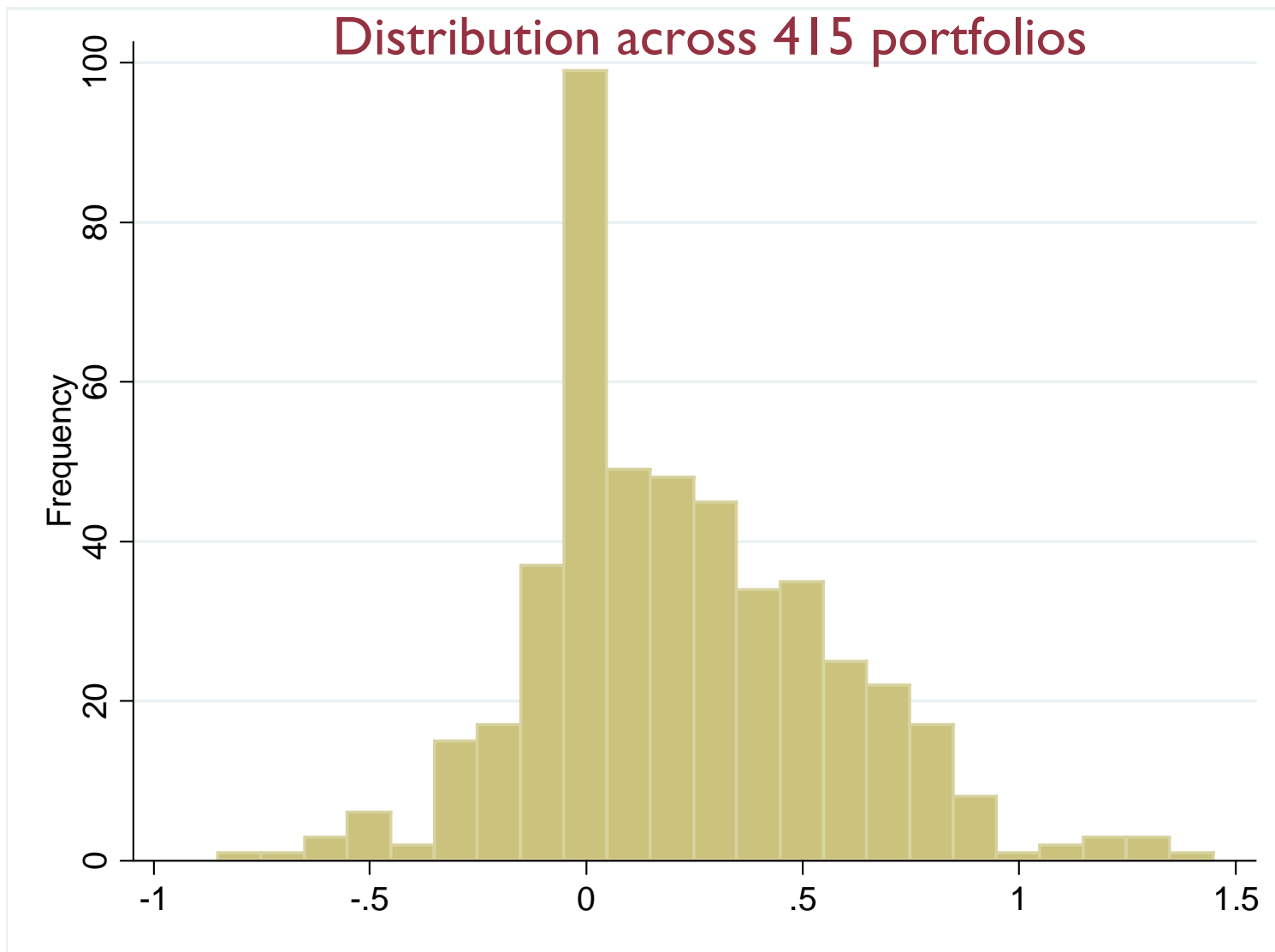
Contagion from global financial sector (γ)



Contagion from US market (γ)



Contagion from domestic market (γ)



Channels of interdependence & contagion

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

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

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

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

- Determinants (lagged by 2 quarters): **Z_{i,t}**
- Reduction of determinants in a general to specific procedure

Data: determinants

- Trade and financial openness
 - X+M, portfolio investment assets and liabilities vis-à-vis USA, equity market capitalization, exchange rate exposure
- Banking channel
 - Financing constraints, interest rate exposure
- Global risk aversion and liquidity
 - VIX, forex implied volatility, Ted spread
- Domestic macro fundamentals
 - Forex reserves, current account, rating, ...
- Financial policy
 - Debt and deposit guarantees, capital injections
- Value and size factor

Channels of interdependence & contagion

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

Conclusions

- No indiscriminate spread of the crisis but “wake-up call”
- More contagion to portfolios in countries with weak fundamentals and poor policies
- Investor re-focused in the crisis on country characteristics and punished markets with such poor fundamentals
- Debt and deposit guarantees instrumental in shielding domestic equity portfolios to some extent

Appendix

Data (55 countries, 10 sectors, 2000 firms, 415 portfolios)

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

Summary stats: Z instruments

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

Specification tests and diagnostics

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

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

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

Specification tests and diagnostics

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

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

Key results - *Interdependence*

By region

Region	Interdependence		
	β_0^G	β_0^U	β_0^D
Latin America	0.360 ***	0.594 ***	0.604 ***
Western Europe	0.539 ***	0.633 ***	0.512 ***
Emerging Europe	0.347 ***	0.273 ***	0.473 ***
Middle East/Africa	0.163 ***	0.084 ***	0.467 ***
Developed Asia	0.531 ***	0.494 ***	0.655 ***
Emerging Asia	0.350 ***	0.267 ***	0.679 ***

By sector

Sector	Interdependence		
	β_0^G	β_0^U	β_0^D
Basic Materials	0.446 ***	0.460 ***	0.586 ***
Communications	0.303 ***	0.448 ***	0.562 ***
Consumer, Cyclical	0.410 ***	0.416 ***	0.568 ***
Consumer, Non-cycl	0.358 ***	0.360 ***	0.492 ***
Diversified	0.471 ***	0.522 ***	0.762 ***
Energy	0.402 ***	0.393 ***	0.499 ***
Financial	0.583 ***	0.492 ***	0.476 ***
Industrial	0.421 ***	0.440 ***	0.561 ***
Technology	0.249 ***	0.679 ***	0.575 ***
Utilities	0.336 ***	0.291 ***	0.448 ***

Key results - Contagion

By sector

Sector	Contagion			Interdependence			Other
	γ_0^G	γ_0^U	γ_0^D	β_0^G	β_0^U	β_0^D	η_0
Basic Materials	0.009	0.324 ***	0.469 ***	0.391 ***	0.379 ***	0.494 ***	-0.103
Communications	0.015	-0.037	0.096 ***	0.305 ***	0.455 ***	0.539 ***	0.036
Consumer, Cyclical	0.039	0.096 ***	0.232 ***	0.379 ***	0.386 ***	0.519 ***	-0.068
Consumer, Non-cycl	-0.075 ***	0.091 ***	0.137 ***	0.366 ***	0.341 ***	0.462 ***	0.000
Diversified	0.037	0.157 *	0.163 ***	0.433 ***	0.477 ***	0.709 ***	-0.045
Energy	0.103 **	0.286 ***	0.401 ***	0.336 ***	0.320 ***	0.433 ***	0.172 ***
Financial	0.203 ***	0.106 ***	0.194 ***	0.495 ***	0.441 ***	0.439 ***	-0.217 ***
Industrial	0.033	0.196 ***	0.335 ***	0.379 ***	0.383 ***	0.498 ***	-0.148 *
Technology	0.192 ***	-0.157 **	0.083	0.217 ***	0.704 ***	0.574 ***	-0.105
Utilities	0.068	0.179 ***	0.310 ***	0.286 ***	0.236 ***	0.394 ***	0.172 ***

Exchange & interest rate exposure

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

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

- $R_{i,t}$: return of country-sector portfolio i on date t
- R_t^{US} : return of US stock market on date t
- $S_{i,t}$: bilateral exchange rate change vs. USD on date t
- $r_{i,t}$: change in domestic 3-month interest rate on date t
- Estimated prior to crisis

(Dominguez and Tesar, 2001 & 2006; Amer et al. 2009)

Financial constraints at the firm level

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

CF = cash flow-net asset ratio

DD = firm's dividend payments

DA = debt-net assets ratio

A = total net assets

IG = industry growth rate

FG = firm's growth rate in net assets

(Whited and Wu 2006)