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The Great Recession: Divide between Integrated and Less Integrated Countries

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No robust relationship has been found between the decline in growth of countries during the Great Recession and their level of trade or financial integration. We confirm the absence of such a monotonic relationship, but document instead a strong discontinuous relationship. Countries whose level of economic integration (trade and finance) was above a certain cutoff saw a much larger drop in growth than less integrated countries, a finding that is robust to a wide variety of controls. The paper argues that standard models based on transmission of exogenous shocks across countries cannot explain these facts. Instead it explains the evidence in the context of a multicountry model with business cycle panics that are endogenously coordinated across countries. [JEL E32, F41, F44]
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There are two important features of business cycle synchronization across countries during the 2008–09 Great Recession. The first is that synchronicity during this period was unparalleled historically. Perri and Quadrini (2014) show that business cycle correlations were much higher among industrialized countries during this period than any earlier time since 1965.[1] Remarkably, even though the origin of the recession is widely associated with the United States, the decline in

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[1] See also Imbs (2010) and International Monetary Fund (2013, Chapter 3).

GDP, investment, consumption, and corporate profits were of a very similar magnitude in the rest of the world as in the United States.[2] The decline was also similar in emerging economies as in industrialized countries, and was of a similar magnitude in Europe, the United States, and Asia.[3]

A second feature relates to the link between business cycle synchronization and economic integration. There is an existing empirical literature that finds no robust relationship between measures of trade and financial integration on the one hand and the decline in growth during the Great Recession on the other hand.[4] In this paper we confirm the absence of a robust monotonic relationship between business cycle synchronization and measures of trade and financial integration. However, we find that integration does matter beyond some threshold. When integration is sufficiently low, below a particular threshold, countries are considerably less impacted by the Great Recession. This finding is robust to introducing a wide variety of controls, different measures of crisis performance, and different subsets of countries. It holds for both trade and financial integration separately as well as for a combined index of trade and financial integration.

The paper develops a theory that accounts for these two features of business cycle synchronization during the Great Recession. It is useful to start though by pointing out that the evidence goes against most existing theories of business cycles in open economy models. In most models synchronicity occurs either because of a common shock that affects all countries or because an exogenous fundamental shock is transmitted across countries through trade and financial linkages. Regarding the former, shocks that are typically attributed to this period apply to the housing market and financial markets. Those shocks, however, originated largely in the United States rather than being common across countries. Regarding transmission of shocks, it is well known that this depends on the nature of the shocks and even perfect integration does not need to imply perfect business cycle synchronization.[5] Even when a model implies that higher trade or financial integration leads to higher business cycle synchronization, transmission of shocks across countries is significantly limited by home bias in both goods and financial markets.[6]

The theory we develop to explain the two features of business cycle synchronization during the Great Recession is based on an extension of Bacchetta

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[2]See Bacchetta and van Wincoop (2014).

[3]We are interested here in the unusual and sudden increase in synchronicity of business cycles during the Great Recession as opposed to trends in synchronicity over time. Regarding the latter, Bordo and Helbling (2011) find that there has been a trend toward increased integration during most of the twentieth century, while Hirata, Kose, and Otrok (2014) find that over the past 25 years the global component of business cycles has declined relative to local components (region and country-specific).

[4]Among many others, see Rose and Spiegel (2010 and 2011), Kamin and DeMarco (2012), Kalemli-Ozcan, Papaioannou, and Perri (2013) and International Monetary Fund (2013). Cecchetti, King, and Yetman (2013) contain an overview of all the relevant studies.

[5]For example, a standard open economy real business cycle model with perfect integration of goods and financial markets, such as Backus, Kehoe, and Kydland (1992), implies that output is negatively correlated across countries.

and van Wincoop (2014), from here on BvW. BvW explain the Great Recession as the result of a self-fulfilling expectations shock as opposed to an exogenous shock to fundamentals. When agents believe that income will be lower in the future, they reduce current consumption, which reduces current output and firm profits. This in turn reduces investment and therefore future output, making beliefs self-fulfilling. However, the novel aspect of BvW is not the idea of self-fulfilling expectations shocks to explain business cycles. There are many such models.[7] The novel aspect is to show that in an open economy context such self-fulfilling beliefs are necessarily coordinated across countries beyond a certain threshold of integration. This coordination occurs because their interconnectedness makes it impossible for one country to have very pessimistic beliefs about the future, while the other country has very optimistic beliefs. BvW show that partial integration is therefore sufficient to generate a perfectly synchronized decline in output across countries.

However, the model in BvW does not address the second feature of business cycle synchronization, the nonlinear relationship between economic integration and business cycle synchronization seen during the Great Recession. The model consists of only two countries, so that it cannot study cross-sectional variation in the degree of economic integration. Moreover, BvW only consider trade integration and abstract from financial integration. We therefore develop a model that extends the framework of BvW to analyze the case where there is a continuum of countries, with the extent of both trade and financial integration varying across countries.

The model is able to generate equilibria that are consistent with the empirical evidence. We find that a global panic will involve all countries whose level of integration is above a certain level, while in general at most a subset of the remaining less integrated countries will panic. The relationship between integration and business cycles is therefore discontinuous as in the data. Within these two groups of countries there is no relationship between their level of integration and the drop in their output, confirming that there is no monotonic relationship between integration and output during a global panic. We also find that trade and financial integration are substitutes in the threshold level of integration, which is confirmed as well by the evidence. Finally, in an extension with country-specific productivity shocks we can explain why not all integrated countries performed worse than less integrated countries. Such differences in performance due to country-specific shocks are unrelated to levels of integration.

Two other papers have looked at self-fulfilling beliefs in an open economy framework. Bacchetta and van Wincoop (2013) develop a two country model with self-fulfilling shifts in perceived asset price risk. Perri and Quadrini (2014) consider

[6]As an example of this, van Wincoop (2013) shows that under realistic financial home bias, transmission across countries of balance sheets shocks experienced by leveraged institutions is limited.

[7]These are generally closed economy models. Examples include Aruoba and Schorfheide (2013), Bacchetta, Tille, and van Wincoop (2012), Benhabib, Wang, and Wen (2016), Farmer (2012a and 2012b), Heathcote and Perri (2015), Liu and Wang (2014), Mertens and Ravn (2014), Schmitt-Grohe and Uribe (2012) and Schmitt-Grohe (1997).

self-fulfilling credit shocks in a two-country setup. If the resale price of assets of firms is low, collateral is weak and it is harder to borrow. This makes it more difficult for other firms to purchase the assets of defaulting firms, which indeed leads to a low resale value of their assets. These papers differ from the framework considered here in several ways. First, these papers do not highlight the coordination of self-fulfilling beliefs under partial integration. In Perri and Quadrini (2014) there is perfect business cycle synchronization, but this is a result of perfect financial and goods market integration and occurs also with exogenous credit shocks. In Bacchetta and van Wincoop (2013), risk panics are generally not synchronized across countries under either partial or perfect integration. Second, these papers have two-country models and therefore cannot consider the role of heterogeneity in financial integration in accounting for the different growth performance across countries during the Great Recession. Finally, the nature of self-fulfilling beliefs is quite different in this paper and is unrelated to asset prices or asset price risk.

Another related literature is that of complex financial networks. Some papers in this literature have shown that with limited financial interconnectedness there can be a tipping point where shocks are spread across the entire network of financial institutions.[8] But these tipping points refer to a general level of interconnectedness rather than the cross-sectional variation in interconnectedness that we will consider here. Moreover, it is much harder to tell such network stories based on a standard business cycle model with firms and households.[9]

The remainder of the paper is organized as follows. Section I discusses the empirical evidence on the relationship between output growth during the Great Recession and the extent of trade and financial integration. Section II describes the model and Section III analyzes the equilibria. Section IV concludes.

I. Empirical Evidence

We collect data for a sample of 151 countries, based on data availability. The precise sample of countries is tabulated in Table 1.[10] Our main data sources are the April 2014 World Economic Outlook (WEO) Database, and the World Development Indicators (WDI) from the World Bank Database. In addition, we get data on financial variables from the "External Wealth of Nations" data set, constructed by Lane and Milesi-Ferretti (2007), data on the exchange rate regime from the

[8]See for example Gai, Haldane, and Kapadia (2011) or Nier and others (2007).

[9]Although one can easily imagine a financial institution being a critical node in a broader network, it is much harder to argue so for an individual household or firm, particularly on a global scale.

[10]We also had data available for Armenia, Equatorial Guinea, and Luxembourg, but we decided to exclude these countries from all our regressions. We excluded Armenia because, in addition to being one of the most affected countries by the crisis, it is more integrated than what our measures of economic integration reflect due to remittances. We excluded Equatorial Guinea for overall problems with data quality (see Lane and Milesi-Ferretti, 2011), and Luxembourg because of its extreme value for financial openness, which is well known to be associated with measurement error. Including these three countries does not substantially change our main results, though.

Table 1. List of Countries

ALB	Albania	GEO	Georgia	NGA	Nigeria
DZA	Algeria	DEU	Germany	OMN	Oman
AGO	Angola	GHA	Ghana	PAK	Pakistan
ATG	Antigua and Barbuda	GRC	Greece	PAN	Panama
ARG	Argentina	GRD	Grenada	PRY	Paraguay
AUS	Australia	GTM	Guatemala	PER	Peru
AUT	Austria	GIN	Guinea	PHL	Philippines
AZE	Azerbaijan	GNB	Guinea-Bissau	POL	Poland
BHR	Bahrain	HTI	Haiti	PRT	Portugal
BGD	Bangladesh	HND	Honduras	QAT	Qatar
BLR	Belarus	HKG	Hong Kong SAR	COG	Republic of Congo
BEL	Belgium	HUN	Hungary	ROM	Romania
BLZ	Belize	ISL	Iceland	RUS	Russia
BEN	Benin	IND	India	WSM	Samoa
BTN	Bhutan	IDN	Indonesia	SAU	Saudi Arabia
BOL	Bolivia	IRL	Ireland	SEN	Senegal
BWA	Botswana	IRN	Islamic Republic of Iran	SYC	Seychelles
BRA	Brazil	ISR	Israel	SLE	Sierra Leone
BRN	Brunei Darussalam	ITA	Italy	SGP	Singapore
BGR	Bulgaria	JAM	Jamaica	SVK	Slovak Republic
BFA	Burkina Faso	JPN	Japan	SVN	Slovenia
BDI	Burundi	JOR	Jordan	ZAF	South Africa
CPV	Cabo Verde	KAZ	Kazakhstan	ESP	Spain
CMR	Cameroon	KEN	Kenya	LKA	Sri Lanka
CAN	Canada	KOR	Korea	KNA	St. Kitts and Nevis
CAF	Central African Republic	KWT	Kuwait	LCA	St. Lucia
TCD	Chad	KGZ	Kyrgyz Republic	VCT	St. Vincent and the Grenadines
CHL	Chile	LAO	Lao P.D.R.	SDN	Sudan
CHN	China	LVA	Latvia	SWZ	Swaziland
COL	Colombia	LBN	Lebanon	SWE	Sweden
COM	Comoros	LSO	Lesotho	CHE	Switzerland
CRI	Costa Rica	LBY	Libya	STP	São Tomé and Príncipe
HRV	Croatia	LTU	Lithuania	TJK	Tajikistan
CYP	Cyprus	MDG	Madagascar	TZA	Tanzania
CZE	Czech Republic	MWI	Malawi	THA	Thailand
CIV	Côte d'Ivoire	MYS	Malaysia	GMB	The Gambia
ZAR	Democratic Republic of the Congo	MDV	Maldives	TGO	Togo
DNK	Denmark	MLI	Mali	TON	Tonga
DJI	Djibouti	MUS	Mauritius	TTO	Trinidad and Tobago
DMA	Dominica	MEX	Mexico	TUN	Tunisia
DOM	Dominican Republic	MDA	Moldova	TUR	Turkey
EGY	Egypt	MNG	Mongolia	UGA	Uganda
SLV	El Salvador	MAR	Morocco	UKR	Ukraine
EST	Estonia	MOZ	Mozambique	ARE	United Arab Emirates
ETH	Ethiopia	NAM	Namibia	GBR	United Kingdom
MKD	FYR Macedonia	NPL	Nepal	USA	United States
FJI	Fiji	NLD	Netherlands	URY	Uruguay
FIN	Finland	NZL	New Zealand	VUT	Vanuatu
FRA	France	NIC	Nicaragua	VEN	Venezuela
GAB	Gabon	NER	Niger	VNM	Vietnam
				ZMB	Zambia

Table 2. Descriptive Statistics and Data Source

Variable	Mean	Std. Dev.	Min	Max	Source
Forecast error 09	−5.11	4.38	−20.35	5.80	WEO April 2008 and April 2014
GDP growth 09	−0.15	5.14	−17.70	11.96	WEO April 2014
GDP growth trend 96/07	4.43	2.28	0.70	15.29	WEO April 2014
Avrg. GDP growth 04/07	5.69	3.17	−0.71	24.03	WEO April 2014
Trade openness	92.95	50.55	25.21	398.66	World Bank WDI
Financial openness	290.33	418.86	47.75	2604.66	Lane and Milesi-Ferretti
GDPpc (thousands of 2007 dollars)	12.11	16.41	0.17	69.17	WEO April 2014
GDP (billions of 2007 dollars)	365.40	1334.82	0.14	14480.35	WEO April 2014
Population (in millions)	41.45	145.84	0.05	1321.29	WEO April 2014
Manufacturing share	13.55	6.91	1.99	40.78	United Nations database
Current account (% of GDP)	−2.34	13.02	−31.91	47.82	WEO April 2014
Net foreign assets (% of GDP)	−15.95	161.56	−201.39	1618.02	Lane and Milesi-Ferretti
Reserves minus gold (% of GDP)	19.26	17.92	0.21	117.31	Lane and Milesi-Ferretti
Private credit growth 04/07 (% of GDP)	33.39	45.93	−41.18	287.91	World Bank WDI

"Shambaugh exchange rate classification" data set, and data on the manufacturing share of GDP from the United Nations Database. Table 2 shows some descriptive statistics, together with the specific data source of each variable.

The set of countries and variables used in the regressions is similar to Lane and Milesi-Ferretti (2011). In particular, we use their same measures of integration, namely trade openness (defined as imports plus exports divided by GDP) and financial openness (defined as external assets plus external liabilities divided by GDP), both in percentage terms. We deviate from them, though, by choosing the forecast errors (the actual 2009 GDP growth rate minus the April 2008 WEO precrisis forecast) as our preferred measure of crisis performance. This measure, first proposed by Berkmen and others (2012), has the advantage of controlling for other factors unrelated to the impact of the crisis that may have affected countries' growth rates during this period. Nevertheless, we use the 2009 GDP growth rate as an alternative measure of the crisis intensity in the robustness checks, with similar results.

In our main regressions, we exclude from our sample countries with a GDP per capita below a thousand 2007 dollars (poor countries), as well as countries above the 95th percentile in financial openness (financial centers).[11] We exclude poor countries, both because of data quality issues and because extremely poor countries tend to rely heavily on official forms of international finance, thus being less exposed to private sector financial flows (see Lane and Milesi-Ferretti, 2011).

[11]These include Mauritius, Iceland, Bahrain, Switzerland, Hong Kong, Ireland, and Singapore.

For these countries, high values of financial openness can be quite misleading. Similarly, we exclude financial centers because their extreme values of financial openness tend to reflect their role as financial intermediaries rather than true integration. We have 34 countries classified as poor and 7 countries classified as financial centers, thus leaving us with a benchmark sample of 110 countries. We will consider specifications including these subsets of countries in our robustness analysis.

We follow the empirical literature by regressing the forecast errors on several 2007 precrisis variables, as a way to identify "initial conditions" that help to explain the slowdown during the crisis. These variables include our two measures of economic integration, plus the following controls: the average GDP growth rate from 2004 to 2007; the trend growth rate (proxied by the average GDP growth rate from 1996 to 2007); the growth in the ratio of private credit to GDP over the period 2004–07; the share of the manufacturing sector in GDP (in percentage terms); the current account to GDP ratio; the net foreign asset position (as a percentage of GDP); the external reserves to GDP ratio; the log of country population (in millions); the level of GDP per capita (in thousands of 2007 dollars); the level of GDP (in billions of dollars); a dummy that equals 1 if the country had a de facto fixed exchange regime during 2007; and an oil dummy.[12] All these variables have been widely used in the literature examining what factors played a role in the cross-country variation of business cycles during the Great Recession.[13]

In addition to this, we consider different integration dummies as we are mainly interested in whether the level of economic integration matters in a noncontinuous or monotonic way. We first experiment with simple trade and financial dummies, which take a value of 1 if the level of trade/financial openness is above some percentile level, and zero otherwise. We also consider a joint trade and financial integration dummy, constructed as follows. We first take a linear combination of our two measures of integration:

$$Integration_i = \alpha\ trade_i + (1-\alpha)\ financial_i,$$

where $trade_i$ and $financial_i$ are our two measures of trade and financial openness of country i, and $\alpha \in [0, 1]$ is a parameter to be chosen. The joint dummy then equals 1 when the combined integration measure is above some cutoff γ, and zero otherwise.

Since we have *a priori* no idea about the proper values for α and γ, we follow the Threshold Estimation literature and estimate them by means of Maximum Likelihood (MLE), in a way similar to Hansen (2000). Specifically, we want to

[12]We define as oil exporters the 2007 OPEC members, plus the following countries: Azerbaijan, Belize, Brunei, Chad, Gabon, Kazakhstan, Republic of Congo, Russia, Sudan, and Trinidad and Tobago.

[13]See Cecchetti, King, and Yetman (2013) for a summary of selected studies examining crisis impact, their main explanatory variables, and their findings.

estimate the following model:

$$y_i = \theta_0 + \beta' x_i + e_i, \qquad q_i(\alpha) \leq \gamma,$$

$$y_i = \theta_1 + \beta' x_i + e_i, \qquad q_i(\alpha) > \gamma.$$

where y_i is a measure of the crisis performance, x_i is our vector of precrisis controls, β' is a vector of coefficients, θ_0 and θ_1 are the intercepts, $q_i(\alpha)$ is our combined measure of integration described above, and e_i is an error term. Thus, in this model we allow the intercept θ to change when the threshold variable q is above some unknown cutoff γ, which is assumed to be restricted to a bounded set $[\underline{\gamma}, \overline{\gamma}] = \Gamma$. Moreover, the threshold variable depends on some unknown parameter α.[14] To write the model in a single equation, define the dummy variable

$$d_i(\alpha, \gamma) = \{q_i(\alpha) > \gamma\},$$

where $\{\cdot\}$ denotes the indicator function. Then, the model above can be rewritten as

$$y_i = \theta_0 + \eta d_i(\alpha, \gamma) + \beta' x_i + e_i,$$

where η is the dummy coefficient. The regression parameters are $(\beta', \theta_0, \eta, \alpha, \gamma)$, and the natural estimator is least squares (LS), which is also the MLE if one assumes that e_i is iid $N(0, \sigma^2)$. By definition, the LS estimators $(\hat{\beta}', \hat{\theta}_0, \hat{\eta}, \hat{\alpha}, \hat{\gamma})$ jointly minimize the sum of the squared errors S_n. To compute these estimators, we proceed as follows. First, we choose some values for $\alpha \in A$ and $\gamma \in \Gamma_n$, where A is an evenly spaced grid such that $0 = \alpha_0 < \alpha_1 < \ldots < \alpha_J = 1$, and $\Gamma_n = \Gamma \cap \{q_{(1)}, \ldots, q_{(n)}\}$, where $q_{(j)}$ denotes the jth percentile of the sample $\{q_1, \ldots, q_n\}$.[15] Conditional on these values, we run an OLS regression and obtain the sum of squared errors $S_n(\alpha, \gamma)$, where we just make explicit that S_n depends upon α and γ. Then, the MLE estimators $(\hat{\alpha}, \hat{\gamma})$ are those values for α and γ that minimize $S_n(\alpha, \gamma)$, or more formally,

$$(\hat{\alpha}, \hat{\gamma}) = \underset{\alpha \in A, \gamma \in \Gamma_n}{arg\,min}\ S_n(\alpha, \gamma).$$

In practice, this reduces to choosing the regression in the $A \times \Gamma_n$ space for which the sum of the squared residuals is the smallest. Finally, we can test whether the estimated threshold is significant or not just by checking the p-value of $\hat{\eta}$. After following this procedure for different subsets of the controls, we consistently find point estimates of $\hat{\alpha} = 0.10$ and $\hat{\gamma} = 137.61$, which corresponds to the 37th percentile of the combined integration variable.[16]

[14] The procedure described here also applies to the simpler case with a trade or a financial dummy. One just has to set either $\alpha = 1$ or $\alpha = 0$.

[15] In the numerical search, we use 0.05 increments for A.

[16] During the search process, we sometimes found another local minimum for a much higher value of γ around the 70th percentile, but this finding was not robust to different subsets of the controls.

Figure 1. Good and Bad Performers in the Trade/Financial Space

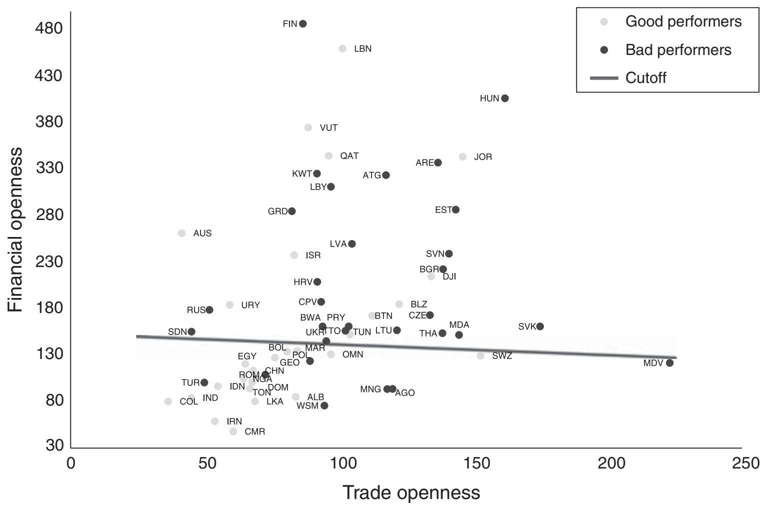


Figure 1 provides a visual illustration with raw data. In this picture, we plot two subsets of countries in the trade-financial openness space. Specifically, we distinguish between good performers (countries with a forecast error higher than the mean plus (1/2) of the standard deviation) and bad performers (with a forecast error lower than the mean minus (1/2) of the standard deviation).[17] The plotted line consists of all the values in the trade-financial space for which the combined integration variable, with $\alpha = 0.10$, takes a value of 137.61. We refer to the region above the line as the integrated region, and to the region below as the less-integrated region.

Two facts are immediate from Figure 1. First, we have both good and bad performers in each region. Second, the ratio of bad performers to good performers is much higher in the integrated region than in the less-integrated one (2.18 in the former, 0.41 in the latter). Finally, a simple regression of the forecast error on the joint dummy plus the logs of trade and financial openness gives a coefficient of −4.09 on the joint dummy with a *p*-value well below 0.01. It means that, on average, countries in the integrated region suffered an unexpected GDP growth downturn around 4 percentage points compared with the others. These initial results may look encouraging, but it remains to be seen whether they still hold after a more formal econometric analysis, introducing various controls, to which we turn next.

[17]Recall that in general the forecast errors are negative, meaning that countries tended to perform worse in the crisis than expected. Thus, a more negative forecast error implies a worse crisis performance.

Regression Results

Without Integration Dummies

Table 3 reports the results from regressions without integration dummies included. In Column 1 we regress the forecast error on the logs of trade and financial openness and the controls discussed above. We observe that neither the trade openness nor the financial openness variables are significant. Column 2 runs the

Table 3. Regressions without Integration Dummies

Variables	(1) Forecast Error	(2) GDP Growth 09	(3) Forecast Error	(4) Forecast Error	(5) Forecast Error	(6) GDP Growth 09
Log(Trade openness)	−1.774	−0.589	−1.906*	−2.080*	−2.301**	−1.660
	(1.1057)	(1.1415)	(1.0700)	(1.0962)	(1.0032)	(1.0556)
Log(Financial openness)	−0.679	−1.116	0.125	0.058	0.743	0.848
	(1.1011)	(1.1730)	(0.9351)	(0.9542)	(0.8433)	(0.9990)
Current account	0.044	0.013	0.027	0.109**	0.081*	0.090*
	(0.0734)	(0.0879)	(0.0546)	(0.0535)	(0.0455)	(0.0524)
Net foreign assets	−0.002	0.002	0.001	−0.007	−0.000	0.001
	(0.0068)	(0.0079)	(0.0017)	(0.0057)	(0.0017)	(0.0019)
Reserves	−0.021	−0.014	−0.012	−0.025	−0.021	−0.024
	(0.0333)	(0.0347)	(0.0316)	(0.0301)	(0.0295)	(0.0292)
Credit growth 04/07	−0.036**	−0.046**	−0.035**	−0.018*	−0.018*	−0.017
	(0.0172)	(0.0193)	(0.0169)	(0.0102)	(0.0106)	(0.0105)
Manufacturing share	−0.069	−0.151	−0.036	−0.085	−0.067	−0.150**
	(0.0869)	(0.0938)	(0.0740)	(0.0708)	(0.0613)	(0.0653)
Growth trend	0.042	0.396	0.062	0.158	0.169	0.440**
	(0.2597)	(0.2386)	(0.2507)	(0.2762)	(0.2589)	(0.2186)
Avrg. GDP growth 04/07	−0.187	0.108	−0.157	−0.272	−0.244	0.011
	(0.2061)	(0.2265)	(0.1978)	(0.2010)	(0.1891)	(0.2014)
Peg dummy	0.439	−0.087	−0.024	0.639	0.323	−0.130
	(0.8667)	(0.8715)	(0.8309)	(0.7240)	(0.7093)	(0.7591)
Oil dummy	−0.665	0.649	−0.490	−1.510	−1.658	−0.869
	(1.5216)	(1.6488)	(1.4453)	(1.2915)	(1.2445)	(1.3775)
GDPpc	−0.038	−0.069	−0.039	−0.082	−0.088*	−0.149**
	(0.0589)	(0.0730)	(0.0498)	(0.0557)	(0.0463)	(0.0625)
GDP	−0.000	−0.000	−0.000	0.000	−0.000	−0.000
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Log(Population)	0.203	0.512	0.151	0.129	0.122	0.392
	(0.3192)	(0.3543)	(0.2846)	(0.2806)	(0.2514)	(0.2785)
Constant	6.172	1.679	2.839	5.613	3.177	−0.115
	(9.6579)	(10.7313)	(8.0674)	(8.5209)	(7.1908)	(8.4511)
Observations	110	110	117	144	151	151
R^2	0.232	0.319	0.214	0.235	0.213	0.319

Robust standard errors in parentheses
***p<0.01, **p<0.05, *p<0.1

same regression but with 2009 GDP growth as the dependent variable. As we include both the growth trend and the precrisis average GDP growth in the regressors, this specification is the same as one where the dependent variable is the change in the growth rate relative to trend or relative to the period 2004–07. As before, both integration coefficients are insignificant.

Column 3 includes the financial centers and column 4 includes the poor countries. The inclusion of these subsets of countries makes trade openness significant at the 10 percent level, but financial openness remains insignificant. Columns 5 and 6 replicate our first two columns but including all the countries in our sample. In column 5 trade openness now becomes significant at the 5 percent level, but this is not a robust finding as it loses significance once we change our measure of crisis performance in column 6. Overall, we have little success finding any robust relationship between precrisis variables and measures of crisis performance, in line with the previous crisis literature.[18]

With Integration Dummies

In Table 4 we experiment with the different integration dummies discussed before. Column 1 regresses the forecast errors on all the explanatory variables plus a trade dummy that equals one when the value of trade openness is above the 42th percentile. The coefficient of this dummy alone is quite negative (−3.01) and significant at the 5 percent level. The coefficients of trade and financial openness are still insignificant, and the remaining controls follow the same pattern as in Table 3. In column 2 we run the same regression, but this time with a financial dummy that equals one if financial openness is above the 36th percentile instead. The coefficient of this financial dummy (−4.54) is even lower than the trade one, and strongly significant.

Column 3 includes the joint dummy in the regression. It has a coefficient of −4.72 that is significant at all the conventional levels. It means that, everything else equal, the forecast errors of countries above the 37th percentile in the combined integration measure were on average 4.72 percentage points lower. Given that the average forecast error was around −5, this represents a highly sizable effect. Moreover, the subset of countries for which this dummy equals 1 comprises a high share of World's GDP, as it includes the United States, Japan, and most of the E.U. countries.[19]

Robustness Checks

In this subsection we choose the joint dummy as our most preferred measure of a noncontinuous effect of integration on crisis performance, and run several robustness tests on it.

[18]See for example Rose and Spiegel (2011).

[19]Table 5 provides the specific list of countries for which the joint dummy equals 0 (the less integrated countries).

Table 4. Regressions with Integration Dummies

Variables	(1) Forecast Error	(2) Forecast Error	(3) Forecast Error
Trade dummy	–3.011**		
	(1.3572)		
Financial dummy		–4.541***	
		(1.1794)	
Joint dummy			–4.716***
			(1.2050)
Log(Trade openness)	0.779	–1.973*	–1.458
	(1.5560)	(1.0923)	(1.0370)
Log(Financial openness)	–0.408	2.019	1.963
	(1.1011)	(1.2854)	(1.2686)
Current account	0.054	0.036	0.031
	(0.0720)	(0.0731)	(0.0737)
Net foreign assets	–0.002	–0.005	–0.005
	(0.0069)	(0.0067)	(0.0068)
Reserves	–0.019	–0.004	–0.004
	(0.0327)	(0.0321)	(0.0321)
Credit growth 04/07	–0.035**	–0.038**	–0.038**
	(0.0155)	(0.0163)	(0.0161)
Manufacturing share	–0.060	–0.044	–0.055
	(0.0830)	(0.0711)	(0.0706)
Growth trend	–0.032	0.079	0.120
	(0.2246)	(0.2069)	(0.2102)
Avrg. GDP growth 04/07	–0.100	–0.169	–0.215
	(0.1844)	(0.1912)	(0.1923)
Peg dummy	0.484	0.356	0.164
	(0.8470)	(0.8264)	(0.8270)
Oil dummy	–0.376	–0.213	–0.065
	(1.5516)	(1.4742)	(1.4753)
GDPpc	–0.040	–0.042	–0.036
	(0.0589)	(0.0596)	(0.0599)
GDP	0.000	0.000	0.000
	(0.0002)	(0.0002)	(0.0002)
Log(Population)	0.035	0.060	0.082
	(0.3409)	(0.2898)	(0.2888)
Constant	–2.708	–2.926	–4.987
	(8.8620)	(9.2963)	(9.3826)
Observations	110	110	110
R-squared	0.265	0.325	0.330

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

First, in Table 6, we explore the sensitivity of the dummy to different choices of α and percentiles' cutoffs. In this table, different rows correspond to different values of α, ranging from 0 to 1, and different columns correspond to different choices of the percentile cutoff, ranging from the 19th percentile of the combined integration variable to the 45th percentile. The numerical entries in the table are the coefficient values of joint dummies from regressions with the same specification as

Table 5. List of Less Integrated Countries

Albania	India
Algeria	Indonesia
Angola	Islamic Republic of Iran
Argentina	Korea
Azerbaijan	Maldives
Belarus	Mexico
Bolivia	Mongolia
Brazil	Morocco
Cameroon	Nigeria
China	Oman
Colombia	Peru
Costa Rica	Philippines
Dominican Republic	Poland
Egypt	Romania
El Salvador	Samoa
Fiji	Sri Lanka
Gabon	Swaziland
Georgia	Tonga
Ghana	Turkey
Guatemala	Venezuela
Honduras	

in column 3 of Table 4. Bold numbers mean that the dummy is significant at the 10 percent level at least. We find that coefficients between the 19th and the 43th percentile tend to be significant at the 10 percent level, and in most cases (specially around our benchmark joint dummy with $\alpha = 0.10$ and the 37th cutoff) we achieve significance at the 5 or 1 percent level. These results suggest that the discontinuous effect of integration on crisis performance is not particularly sensitive to different choices of the parameter values or percentile cutoffs.

Next, in Table 7, we run additional robustness checks for alternative measures of crisis performance and different subsets of countries. Here, column 1 simply replicates our results from column 3 in Table 4, just for comparison purposes. In column 2 we change our measure of crisis performance and use the 2009 GDP growth as our dependent variable. As we see, the magnitude of the dummy coefficient (−4.41) is similar to column 1, and it is also significant at all the conventional levels.

In column 3 we recover the forecast error as our dependent variable and explore whether extreme outcomes in the forecast errors might be driving our results by excluding countries with forecast errors below the 5th percentile. In this case, the coefficient takes a value of −2.89, higher than in column 1 but still significant at the 1 percent level. Columns 4 and 5 include the financial centers and the poor countries. In both cases the coefficient on the dummy is higher than in column 1, but they remain strongly significant. In columns 6 and 7 we include all the countries in our sample. With the forecast errors as the dependent variable, we still achieve significance at the 1 percent level and a coefficient of −3.46, and with the 2009 GDP growth we achieve significance at the 5 percent level and a

Table 6. Sensitivity of the Integration Dummy

Percentile Alpha	19	21	23	25	27	29	31
0	**–2.72**	**–2.76**	**–2.65**	**–2.56**	**–2.36**	**–2.28**	**–2.76**
0.05	**–2.64**	**–2.76**	–2.12	**–2.56**	**–2.45**	**–2.28**	**–2.76**
0.1	**–2.64**	**–2.76**	–2.12	**–2.56**	**–2.45**	**–2.28**	**–2.54**
0.15	**–2.64**	**–2.23**	**–2.68**	**–2.31**	**–2.45**	**–2.25**	**–2.73**
0.2	**–2.64**	**–2.23**	**–2.49**	**–2.31**	**–2.45**	**–2.25**	**–2.73**
0.25	**–2.99**	**–2.52**	**–2.49**	**–2.31**	**–2.45**	**–2.52**	**–2.98**
0.3	**–3.17**	**–2.93**	**–2.49**	**–2.17**	**–2.45**	**–2.52**	**–2.98**
0.35	**–3.17**	**–2.93**	**–2.60**	**–2.17**	**–2.45**	**–2.49**	**–2.71**
0.4	**–3.17**	**–2.93**	**–2.60**	**–2.46**	–2.22	**–2.51**	**–2.23**
0.45	**–3.17**	**–2.93**	**–3.17**	**–2.90**	**–2.49**	–2.01	**–2.23**
0.5	**–3.36**	**–2.93**	**–3.17**	**–2.95**	**–2.46**	**–2.30**	**–2.26**
0.55	**–3.41**	**–2.86**	**–2.63**	**–2.95**	**–2.46**	**–3.08**	**–2.73**
0.6	**–3.41**	**–2.86**	**–2.63**	**–2.34**	**–2.44**	**–2.25**	–1.76
0.65	**–3.68**	**–3.06**	–2.16	**–2.34**	–1.71	–2.04	–1.87
0.7	**–2.74**	**–3.00**	–2.16	–1.41	–1.71	**–2.41**	**–2.71**
0.75	**–2.16**	–1.54	–1.73	–1.41	–1.77	–1.96	**–2.38**
0.8	**–2.16**	–1.34	–0.66	–2.09	**–2.63**	**–2.84**	**–2.77**
0.85	–0.58	–1.65	**–2.05**	–1.39	–1.48	**–2.82**	**–3.42**
0.9	–0.14	–1.27	**–2.05**	–1.72	–1.57	–1.54	**–2.74**
0.95	0.00	–0.26	–1.32	–1.88	–1.81	–1.64	–1.32
1	0.59	0.27	0.36	0.60	–0.83	–1.38	–1.87

Percentile Alpha	33	35	37	39	41	43	45
0	**–3.59**	**–4.35**	**–3.69**	**–3.90**	**–3.38**	**–2.51**	–0.61
0.05	**–3.59**	**–4.35**	**–3.69**	**–3.90**	**–3.17**	**–2.51**	–0.61
0.1	**–3.29**	**–3.91**	**–4.72**	**–3.90**	**–3.29**	**–2.51**	–0.61
0.15	**–3.09**	**–3.64**	**–4.32**	**–3.90**	**–3.29**	–1.87	–0.61
0.2	**–3.09**	**–3.64**	**–3.35**	**–3.13**	**–3.29**	–2.10	–0.37
0.25	**–3.06**	**–3.64**	**–3.35**	**–3.13**	–2.01	–1.57	–1.23
0.3	**–3.48**	**–3.41**	**–3.35**	**–3.13**	–2.04	–1.18	–0.64
0.35	**–2.84**	**–3.41**	**–3.35**	–1.51	–0.87	–1.18	–1.07
0.4	**–2.84**	**–3.41**	**–3.35**	–1.51	–1.29	–0.74	0.26
0.45	**–2.84**	**–3.41**	**–2.62**	–1.17	–1.38	–0.74	0.26
0.5	**–2.84**	**–3.41**	**–3.02**	–2.25	–1.38	–0.74	0.26
0.55	**–2.78**	**–2.81**	–2.01	–2.25	–0.58	–0.25	–0.07
0.6	**–2.30**	–1.98	–2.16	–2.36	–0.58	–0.70	0.35
0.65	**–2.38**	**–2.41**	**–2.82**	**–2.70**	–1.36	–0.54	–1.19
0.7	–2.15	**–2.22**	**–2.69**	**–3.33**	**–2.28**	–2.23	–1.19
0.75	**–3.21**	**–3.15**	**–2.90**	**–3.04**	**–2.24**	–1.66	–1.21
0.8	**–3.05**	**–3.47**	**–2.90**	**–2.65**	–1.91	–0.91	–1.02
0.85	**–2.88**	**–3.34**	**–3.12**	**–2.95**	**–2.64**	–1.67	–0.88
0.9	**–3.06**	**–2.96**	**–3.42**	**–3.12**	**–2.51**	–1.72	–1.08
0.95	–1.69	–2.09	**–3.24**	**–3.76**	**–4.13**	**–2.77**	–2.00
1	–1.23	–1.26	–2.13	–1.30	**–2.56**	**–2.50**	–2.33

Note: bold numbers imply significance at the 10 percent level at least.

Table 7. Robustness Checks

Variables	(1) Forecast Error	(2) GDP Growth 09	(3) Forecast Error	(4) Forecast Error	(5) Forecast Error	(6) Forecast Error	(7) GDP Growth 09	(8) Forecast Error
Joint dummy	−4.716***	−4.413***	−2.895***	−4.454***	−3.714***	−3.457***	−2.792**	
	(1.2050)	(1.2721)	(0.9886)	(1.0596)	(1.1579)	(1.0382)	(1.1807)	
Principal score dummy								−3.415***
								(1.2599)
Log(Trade openness)	−1.458	−0.294	−1.588	−1.716*	−2.057*	−2.310**	−1.667	0.604
	(1.0370)	(1.1670)	(0.9591)	(0.9934)	(1.0760)	(0.9952)	(1.0973)	(1.3252)
Log(Financial openness)	1.963	1.357	1.500	1.803*	2.305*	2.420**	2.203*	0.092
	(1.2686)	(1.3848)	(1.1052)	(1.0062)	(1.2180)	(1.0478)	(1.2796)	(1.1109)
Current account	0.031	0.000	−0.034	0.006	0.113**	0.076*	0.086*	0.057
	(0.0737)	(0.0884)	(0.0648)	(0.0535)	(0.0531)	(0.0445)	(0.0516)	(0.0709)
Net foreign assets	−0.005	−0.001	−0.001	−0.001	−0.011*	−0.003	−0.001	−0.003
	(0.0068)	(0.0080)	(0.0062)	(0.0019)	(0.0059)	(0.0021)	(0.0024)	(0.0066)
Reserves	−0.004	0.002	0.007	−0.004	−0.016	−0.018	−0.021	−0.026
	(0.0321)	(0.0333)	(0.0297)	(0.0281)	(0.0282)	(0.0266)	(0.0272)	(0.0316)
Credit growth 04/07	−0.038**	−0.048***	−0.029**	−0.040**	−0.019*	−0.019*	−0.018	−0.036**
	(0.0161)	(0.0183)	(0.0143)	(0.0157)	(0.0101)	(0.0107)	(0.0107)	(0.0152)
Manufacturing share	−0.055	−0.138*	−0.032	−0.039	−0.078	−0.060	−0.143**	−0.080
	(0.0706)	(0.0806)	(0.0617)	(0.0601)	(0.0626)	(0.0535)	(0.0610)	(0.0870)
Growth trend	0.120	0.469**	0.069	0.102	0.166	0.158	0.431**	0.001
	(0.2102)	(0.2252)	(0.2078)	(0.2031)	(0.2352)	(0.2216)	(0.2079)	(0.2516)
Avrg. GDP growth 04/07	−0.215	0.082	−0.046	−0.197	−0.265	−0.254	0.003	−0.121

	(0.1923)	(0.2266)	(0.1714)	(0.1857)	(0.1906)	(0.1802)	(0.2056)	(0.1975)
Peg dummy	0.164	–0.344	0.805	–0.095	0.454	0.165	–0.257	0.435
	(0.8270)	(0.8410)	(0.7240)	(0.7663)	(0.7030)	(0.6885)	(0.7590)	(0.8516)
Oil dummy	–0.065	1.210	0.085	0.070	–1.203	–1.252	–0.541	–0.681
	(1.4753)	(1.6049)	(1.2201)	(1.3980)	(1.2171)	(1.1742)	(1.3339)	(1.5382)
GDPpc	–0.036	–0.067	–0.042	–0.037	–0.086	–0.098*	–0.157**	–0.038
	(0.0599)	(0.0744)	(0.0496)	(0.0519)	(0.0584)	(0.0503)	(0.0672)	(0.0572)
GDP	0.000	–0.000	0.000	0.000	0.000	0.000	–0.000	0.000
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Log(Population)	0.082	0.398	0.161	0.038	0.045	0.015	0.306	0.075
	(0.2888)	(0.3288)	(0.2863)	(0.2552)	(0.2621)	(0.2343)	(0.2693)	(0.3069)
Constant	–4.987	–8.765	–5.614	–2.488	–2.932	–1.855	–4.180	–4.092
	(9.3826)	(10.6979)	(8.8354)	(7.9585)	(8.5642)	(7.4135)	(9.1567)	(8.9662)
Observations	110	110	103	117	144	151	151	110
R^2	0.330	0.383	0.240	0.326	0.294	0.278	0.349	0.273

Robust standard errors in parentheses
***$p<0.01$, **$p<0.05$, *$p<0.1$

coefficient of −2.79. Finally, in the last column we replace the joint dummy with the integration dummy computed based on the principal component of the trade and financial integration variables. This is another way of combining the two instead of the linear aggregate that we have used. The results are again very similar. The threshold now occurs at the 31st percentile. The integration dummy is again substantial and highly significant.

Additionally, we tested whether our integration dummy might just be capturing some nonlinear, but still continuous effect by including different combinations of second and higher order terms of trade and financial openness. The results (not reported) indicate that this is not the case, as all the higher order terms are insignificant whereas the dummy still shows a strong and statistical significant effect. If anything, the coefficient on the dummy decreases. We also tried to control for trade linkages with the United States using a measure analogous to the overall trade openness, but it did not affect our results. We experimented with different subsets of the controls as well. The coefficients on trade and financial openness may or may not become significant, depending on the specification, but we consistently find that the integration dummy is significant at the 5 percent level at least, and in most cases with a coefficient below −3.[20]

Finally, we turn our attention to the role of households' expectations during the Great Recession. In our theory, a coordinated self-fulfilling shift in expectations among countries in the integrated region is the key driver of a global panic. One implication of this theoretical result is a discontinuity in the growth performance across countries, which we have already documented. But we can also test whether there was a significant difference in expectations of integrated vs. less integrated countries. We do so by using a measure of consumer confidence. To perform this test, we collect cross-country data from the Nielsen's Global Consumer Confidence Trend Tracker, an index whose value is 100 if consumer confidence is neutral, below 100 if pessimistic and above 100 if optimistic. The data are quarterly and available for 43 of the countries in our sample, of which we classify 32 as integrated and 11 as less integrated using our previous results.[21] We take the difference between the index in Q3 of 2008 and Q1 of 2007 and regress this measure on the integration dummy in order to obtain the average difference between the two groups and see if this difference is statistically significant. We find that the drop in confidence for the integrated countries more than doubles the drop for the less integrated: 15.06 against 7.09, with an average difference of 7.97 that is statistically significant at the 5 percent level (p-value of 0.024).

In summary, the empirical evidence presented here suggests that there was indeed a strong, noncontinuous effect of trade and financial integration on crisis performance during the Great Recession. This effect is robust to the inclusion of a variety of controls, different parameter values or percentile cutoffs, different measures of crisis performance, and different subsets of countries. We now turn to a model aimed at explaining these empirical findings.

[21]The data can be found at www.viz.nielsen.com/consumerconfidence/.

II. Model Description

There are different modeling approaches one could adopt to illustrate the role of trade and financial integration heterogeneity in self-fulfilling business cycles. However, since the empirical evidence we aim to shed light on relates specifically to the Great Recession, we chose to extend the BvW setup as it connects well to the Great Recession along various dimensions. First, the model highlights particular vulnerabilities to a global panic that were in place at the time. One such vulnerability is tight credit, which plays a key role in the model. Another is limited flexibility of central banks as we were close to the ZLB. Finally, increased trade and financial integration in previous decades is a key source of vulnerability to global panics in the model. BvW show that if we relax such vulnerabilities, a global panic equilibrium would not exist. Second, a sharp drop in profits during a panic is a key ingredient of the model, which together with the tight credit drives the results. As BvW show, there was indeed a very steep synchronized global decline in profits during the Great Recession. Finally, the self-fulfilling expectation shock in the model leads to a sharp drop in demand. This is consistent with micro evidence that firms were affected more by a sudden drop in demand than sudden reduced access to credit (for example, Kahle and Stulz, 2013; Nguyen and Qian, 2014).[22]

The model has two periods and a continuum of countries distributed uniformly on the unit square. We will first describe households, firms, central banks and market clearing conditions. The entire model is then summarized in a condensed form that is used in the next section to analyze the equilibria. The model has a New Keynesian flavor in the sense that nominal wages are determined at the start of each period and are sticky within a period. This feature, together with a potential sunspot shock during period 1 that can generate self-fulfilling shifts in expectations, may lead to involuntary unemployment in the first period.[23]

Some words about notation are in order before describing the model. Countries are heterogeneous in two dimensions, trade and financial integration. Trade integration will be indicated by a country-specific parameter ψ_i, with $i \in [0, 1]$. Financial integration will be indicated by a country-specific parameter ϕ_k with $k \in [0, 1]$. Thus country (i, k) has parameters ψ_i and ϕ_k. When dealing with integrals, j will refer to the trade dimension and l to the financial dimension.

Households

Utility of households in country (i, k) is

$$\frac{\left(c_1^{ik}\right)^{1-\lambda}}{1-\lambda} + \beta \frac{\left(c_2^{ik}\right)^{1-\lambda}}{1-\lambda}, \tag{1}$$

[22]Tight credit is a parameter of the model. There is no shock to credit in the model.

[23]This is a small deviation from BvW, who introduce nominal rigidities through sticky prices. This makes little difference when we only consider heterogeneity in trade integration. But assuming wage stickiness simplifies the analysis when we also consider heterogeneous financial integration.

where c_t^{ik} is the period t consumption index:

$$c_t^{ik} = \left(\frac{c_{ik,t}^{ik}}{\psi_i}\right)^{\psi_i}\left(\frac{c_{F,t}^{ik}}{1-\psi_i}\right)^{1-\psi_i}, \tag{2}$$

where $c_{ik,t}^{ik}$ is an index of country (i, k) goods consumed by country (i, k) residents and $c_{F,t}^{ik}$ is an index of foreign goods consumed by country (i, k) residents:

$$ln\left(c_{F,t}^{ik}\right) = \int\int_0^1 \frac{1-\psi_j}{1-\overline{\psi}}\left(ln\left(c_{jl,t}^{ik}\right) - ln\left(\frac{1-\psi_j}{1-\overline{\psi}}\right)\right)djdl. \tag{3}$$

Here $\overline{\psi} = \int_0^1 \psi_j dj$ and

$$c_{jl,t}^{ik} = \left(\int_0^1 [c_{jl,t}^{ik}(m)]^{\frac{\sigma-1}{\sigma}} dm\right)^{\frac{\sigma}{\sigma-1}} \tag{4}$$

is an index of country (j, l) goods consumed by country (i, k) residents, with $c_{jl,t}^{ik}(m)$ being consumption at time t by country (i, k) of good m from country (j, l).

The parameter ψ_i is a measure of trade integration for country (i, k), ranging from 0 if it is perfectly integrated to 1 when it is in autarky. A couple of comments about this utility specification are in order. The friction we introduce to generate imperfect trade integration is home bias in preferences.[24] There are two types of home bias in preferences. First, country (i, k) has a bias toward its own goods and therefore a bias away from foreign goods. This is captured by the parameter ψ_i in the overall consumption index (equation (2)). In this case a larger ψ_i reduces imports. Second, to the extent that countries buy foreign goods, they have a different bias against goods from different countries. The index (equation (3)) implies that a larger ψ_j leads country (i, k) to have a larger bias against goods from country (j, l). Similarly, a larger ψ_i implies that all countries other than (i, k) have a larger bias against (i, k) goods, which reduces exports of country i. Putting the two together, a higher ψ_i simultaneously reduces imports and exports of (i, k). If we allowed a higher ψ_i only to reduce the imports by country (i, k), and not exports, a higher ψ_i would have a large effect on relative prices to generate balanced trade, which significantly complicates the analysis.

[24] An alternative would be to introduce trade costs, while leaving preferences the same for all countries. However, proportional trade costs have the disadvantage that no matter the level of these costs, as the relative size of countries goes to zero, the fraction of home goods countries consume approaches zero as well. One would need to introduce a fixed cost of goods trade to generate a positive fraction of home goods consumed for infinitesimally small countries, but this significantly complicates the analysis.

The budget constraint in period 1 is:

$$\int_0^1 P_1^{ik}(m)c_{ik,1}^{ik}(m)dm + \int\int\int_0^1 S_{ik,1}\frac{P_1^{jl}(m)}{S_{jl,1}}c_{jl,1}^{ik}(m)dmdjdl + B_{ik} + M_1^{ik}$$
$$= W_1^{ik}(1-u^{ik}) + \Pi_1^{ik} + \overline{M}_1^{ik} + S_{ik,1}T_1^{ik}. \tag{5}$$

Here $P_1^{ik}(m)$ is the price of good m from country (i,k) measured in the currency of country (i,k), $S_{ik,1}$ is units of country (i,k) currency per unit of a base currency (denoted by b) and B_{ik} is holdings of a domestic bond. The latter is only domestically traded. M_1^{ik} are money holdings and $\overline{M}_1^{ik}$ is a money transfer at period 1 from the central bank. W_1^{ik} is the nominal wage rate, u^{ik} is the unemployment rate, and Π_1^{ik} is profits from firms.[25] Thus, with a labor supply of 1, $W_1^{ik}(1-u^{ik})+\Pi_1^{ik}$ is nominal GDP of country (i,k) measured in its own currency. Finally T_1^{ik} is a net transfer from abroad measured in the base currency that will be discussed below.

The domestic bond of country (i,k) is in zero net supply and delivers R^{ik} units of country (i,k) currency in period 2. As we discuss further below, the absence of unexpected shocks in period 2 ensures that full employment is achieved in the last period. The period 2 budget constraint is then

$$\int_0^1 P_2^{ik}(m)c_{ik,2}^{ik}(m)dm + \int\int\int_0^1 S_{ik,2}\frac{P_2^{jl}(m)}{S_{jl,2}}c_{jl,2}^{ik}(m)dmdjdl + M_2^{ik} = W_2^{ik} + \Pi_2^{ik} + M_1^{ik}$$
$$+ R^{ik}B_{ik} + (\overline{M}_2^{ik} - \overline{M}_1^{ik}) + S_{ik,2}T_2^{ik}. \tag{6}$$

We assume a cash-in-advance constraint with the buyer's currency being used for payment:

$$\int_0^1 P_t^{ik}(m)c_{ik,t}^{ik}(m)dm + \int\int\int_0^1 S_{ik,t}\frac{P_t^{jl}(m)}{S_{jl,t}}c_{jl,t}^{ik}(m)dmdjdl \le M_t^{ik}. \tag{7}$$

Let P_t^{ik} denote the country (i,k) consumer price index in the local currency and $P_t(i,k)$ the price index of country (i,k) goods measured in the country (i,k) currency. $P_{F,t}$ is the price index of all Foreign goods measured in the base currency.

[25] In principle unemployment implies that some workers do not earn any labor income, but there may be a redistribution mechanism such that all households end up receiving $W_1^{ik}(1-u^{ik})$ regardless of their working status.

The first-order conditions are then[26]

$$\frac{1}{\left(c_1^{ik}\right)^{\lambda}} = \beta R^{ik} \frac{P_1^{ik}}{P_2^{ik}} \frac{1}{\left(c_2^{ik}\right)^{\lambda}}, \tag{8}$$

$$c_{ik,t}^{ik} = \psi_i \frac{P_t^{ik}}{P_t(i,k)} c_t^{ik}, \tag{9}$$

$$c_{F,t}^{ik} = (1-\psi_i) \frac{P_t^{ik}}{S_{ik,t} P_{F,t}} c_t^{ik}, \tag{10}$$

$$c_{jl,t}^{ik} = \frac{1-\psi_j}{1-\overline{\psi}} \frac{S_{jl,t} P_{F,t}}{P_t(j,\, l)} c_{F,t}^{ik} \quad (i,\, k) \neq (j,\, l), \tag{11}$$

$$c_{jl,t}^{ik}(m) = \left(\frac{P_t(j,\, l)}{P_t^{jl}(m)}\right)^{\sigma} c_{jl,t}^{ik} \quad \forall (i,\, k), (j,\, l), \tag{12}$$

where the price indices are

$$P_t^{i,k} = P_t(i,\, k)^{\psi_i} (S_{i,k,t} P_{F,t})^{1-\psi_i}, \tag{13}$$

$$P_t(i,\, k) = \left(\int_0^1 [P_t^{i,k}(m)]^{1-\sigma} djdl\right)^{\frac{1}{1-\sigma}}, \tag{14}$$

$$ln\left(P_{F,t}\right) = \int \int_0^1 \frac{1-\psi_j}{1-\overline{\psi}} ln\left(\frac{P_t(j,\, l)}{S_{jl,t}}\right) djdl. \tag{15}$$

Countries are linked through both trade and financial integration. Financial integration occurs through risk-sharing, which leads to net transfers between countries. Country (i, k) receives a net transfer T_t^{ik} from abroad. We assume

$$T_t^{ik} = \int \int_0^1 E_t^W \phi_k \phi_l ln\left(\frac{g_1^{jl}}{g_1^{ik}}\right) djdl. \tag{16}$$

Here E_t^W is nominal world exports in the base currency and g_1^{ik} is period 1 real output of country (i, k) relative to its expected value. The parameter ϕ_k is a measure of financial integration for country (i, k) and similarly ϕ_l for country (j, l). Under

[26]There is no expectation operator in the consumption Euler equation (8) as there are no unexpected period 2 shocks.

this specification, countries agree to pay to each other a fraction $\phi_k \phi_l ln\left(g_1^{jl}/g_1^{ik}\right)$ of nominal world exports. Country (i, k) receives a payment from country (j, l) when $g_1^{jl} > g_1^{ik}$ and makes a payment to (j, l) when $g_1^{jl} < g_1^{ik}$. Countries therefore make payments to each other based on their unexpected relative output performances. The size of these payments will be determined by their financial integration level, as well as by the integration level of the partners.[27] The transfers are scaled by world trade as transfers must necessarily vanish in the absence of trade. Transfers are only meaningful if countries can use them to buy goods from each other.

In Appendix III we show that the expression for T_t^{ik} can be seen as the result of a particular asset market structure with a limited commitment financial friction. Also note that the transfers are assumed to be the same fraction of world exports in periods 1 and 2. They only depend on unexpected period 1 relative output. There will be two shocks in the model, country-specific productivity shocks and sunspot shocks. The country-specific productivity shocks occur in period 1 and are permanent (last two periods). For simplicity we assume that the sunspot shock does not affect the risksharing scheme as it has infinitesimal probability from the perspective of period 0. Risk sharing is therefore based on the permanent productivity shocks.

Firms

In each country there is a continuum of firms of mass one. Each firm produces a different variety and sets its optimal price each period. Output of good m in period t of country (i, k) is

$$y_t^{ik}(m) = e^{x_{ik}} A_{ik,t}(m) L_t^{ik}(m), \tag{17}$$

where $L_t^{ik}(m)$ is labor input and $e^{x_{ik}} A_{ik,t}(m)$ is labor productivity. $A_{ik,t}(m)$ is an endogenous component of labor productivity that will be discussed below. The exogenous component x_{ik} is a country-specific i.i.d. shock with zero mean that is realized in period 1 and lasts both periods.

Since the production function is linear and all demands faced by the firm are CES with elasticity σ, the optimal price is a constant markup over marginal costs:

$$P_t^{ik}(m) = \frac{\sigma}{\sigma - 1} \frac{W_t^{ik}}{e^{x_{ik}} A_{ik,t}(m)}. \tag{18}$$

In equilibrium all firms will set the same price, produce the same amount and hire the same number of workers, so that $P_t^{ik}(m) = P_t(i, k)$, $y_t^{ik}(m) = y_t^{ik}$ and

[27] Also note that net payments are zero in aggregate because a positive payment to country (i, k) from country (j, l) implies a negative payment to country (j, l) by the exact same amount as measured by the base currency.

$L_t^{ik}(m) = L_t^{ik}$. Thus profits can be written as

$$\Pi_t^{ik} = P_t(i, k)y_t^{ik} - W_t^{ik}L_t^{ik} = \frac{1}{\sigma}P_t(i, k)y_t^{ik}. \tag{19}$$

That is, nominal profits are just a fraction 1/σ of nominal output. Dividing by the consumer price index, we obtain real profits:

$$\pi_t^{ik} = \frac{\Pi_t^{ik}}{P_t^{ik}} = \frac{1}{\sigma}\frac{P_t(i, k)}{P_t^{ik}}y_t^{ik}. \tag{20}$$

Next consider the firm's intertemporal problem. In period 1 the productivity component $A_{ik,1}$ is assumed to be 1 for all countries and firms. In period 2 firms can maintain this productivity level if they pay a fixed cost κ, which is real (in terms of the consumption index). Otherwise this endogenous productivity component decreases to $A_L<1$. The cost κ represents an investment required to maintain the productivity of the firm. This is a fixed cost. For example, a firm might shut down a department, branch, other facility or machine if it is unable or unwilling to bear the fixed costs associated with their operation. It might also shut down a worker training program, assuming again that this is a discrete choice. We assume that the cost κ is paid to intermediaries who bear no production costs and whose profits are simply returned to the households that own them. This simplifies in that the investment does not involve a real use of resources.

We assume that firms are borrowing constrained, so that they can only invest if they have sufficient internal funds. For simplicity, although this is not important, assume that firms cannot borrow at all and therefore need to finance the cost κ entirely from internal funds. The following borrowing constraint therefore holds if firms make the investment κ:

$$\pi_1^{ik} \geq \kappa. \tag{21}$$

We will refer to this constraint as the borrowing condition. It is important to the mechanism of the model as it leads to a feedback from profits in period 1 to investment, which in turn affects productivity in period 2. We could relax the condition by assuming that firms can only borrow up to an amount of say z. In that case κ on the right-hand side becomes $\kappa - z$. BvW show that if we relax the borrowing constraint enough, firms will always invest and we do not have self-fulfilling panics in the model. Tight credit is therefore an important vulnerability in the model, consistent with conditions during the Great Recession.

If firms can afford the real cost κ, they will invest as long as the present discounted value of profits when they invest is at least as high as when they do not invest. Using that the pricing kernel in this model is just β,[28] this condition can be summarized as

$$\Pi_1^{ik} + \beta\Pi_{2,I}^{ik}(m) - P_1^{ik}\kappa \geq \Pi_1^{ik} + \beta\Pi_{2,NI}^{ik}(m), \tag{22}$$

[28]This follows from the households' intertemporal consumption Euler Equation in equilibrium.

where $\Pi^{ik}_{2,I}(m)$ is second period profits if firm m invests and $\Pi^{ik}_{2,NI}(m)$ is second period profits if it does not invest. Rearranging this condition, we obtain

$$\frac{\beta\left(\Pi^{ik}_{2,I}(m)-\Pi^{ik}_{2,NI}(m)\right)}{P^{ik}_{1}} \geq \kappa. \tag{23}$$

We will refer to this constraint as the incentive condition. It follows that $A_{ik,2}(m)=1$ if and only if both the borrowing and the incentive condition are satisfied. Otherwise $A_{ik,2}(m)=A_L$.

Central Banks

We will be brief about central banks as they behave the same way as in BvW. They set the second period money supply to stabilize prices, so that $P^{ik}_2 = P^{ik}_1$. They set the first period interest rate such that $R^{ik}\beta=1$. This corresponds to the interest rate in the flexible price version of the model. BvW also consider countercyclical monetary policy, but they show that this will not help to avoid a self-fulfilling panic when the central bank has little room to maneuver close to the ZLB. This is again a feature that was relevant during the Great Recession.

Market Clearing

The market clearing equations are

$$y^{i,k}_t(m) = c^{i,k}_{i,k,t}(m) + \int \int_0^1 c^{j,l}_{i,k,t}(m)djdl \quad \forall(i,\, k), m, \tag{24}$$

$$\int_0^1 L^{i,k}_t(m)dm = L^{i,k}_{S,t} \quad \forall(i,\, k), \tag{25}$$

$$M^{i,k}_t = \overline{M}^{i,k}_t \qquad \forall(i,\, k), \tag{26}$$

$$B_{i,k} = 0 \qquad \forall(i,\, k), \tag{27}$$

where $L^{ik}_{S,1} = 1-u^{ik}$ in period 1 and $L^{ik}_{S,2} = 1$ in period 2. Equation (25) says that in both periods the number of workers hired by firms must equal the measure of employed workers. We assume that the wage is set at the start of each period. The wage is set such that the labor market is expected to clear without unemployment.[29] In period 2 there are no unexpected shocks, so that there will be full employment. In period 1 an unexpected sunspot shock will reduce demand for labor, which leads to unemployment.[30]

[29] See Taylor (1999) for a review of models using the expected market-clearing mechanism.

Condensed Version of the Model

Using the budget constraints, first-order conditions, optimal price setting, and market clearing equations, Appendix I derives a condensed version of the model that solves consumption, output and real profits as a function of second period productivity in all countries. From hereon we will denote the endogenous component of second period productivity as A_{ik}, omitting the period 2 subscript. It turns out that consumption, output, and real profits will be the same in both periods, so we also omit time subscripts. Appendix I shows that

$$c^{ik} = G^{ik}\left(\frac{V_{ik}}{D_{ik}}\right)^{\psi_i}\overline{V}^{1-\psi_i}, \tag{28}$$

$$y^{ik} = V_{ik}, \tag{29}$$

$$\pi^{ik} = \frac{1}{\sigma}V_{ik}^{\psi_i}\left(D_{ik}\overline{V}\right)^{1-\psi_i}, \tag{30}$$

where

$$V_{ik} = e^{x_{ik}}A_{ik}, \tag{31}$$

$$G_{ik} = 1+\left(\frac{1-\overline{\psi}}{1-\psi_i}\right)\phi_k\left(Q-\overline{\phi} ln\ V_{ik}\right), \tag{32}$$

$$D_{ik} = 1+\left(\frac{1-\overline{\psi}}{1-\psi_i}\right)\psi_i\phi_k\left(Q-\overline{\phi} ln\ V_{ik}\right), \tag{33}$$

$$Q = \int_0^1\int_0^1 \phi_l ln\ V_{jl} dj dl, \tag{34}$$

$$ln\ \overline{V} = \int_0^1\int_0^1 \frac{1-\psi_j}{1-\overline{\psi}} ln\left(\frac{V_{jl}}{D_{jl}}\right) dj dl \tag{35}$$

[30]The permanent productivity shocks do not lead to unemployment. Higher permanent productivity leads to a higher real wage in both periods as a result of a lower price level. This follows from the price setting equation.

and

$$\overline{\phi} = \int_0^1 \phi_l dl.$$

This gives the solutions of c^{ik}, y^{ik} and π^{ik} as a function of second period productivity in all countries. This is not a complete solution to the model though as we have not yet solved for the endogenous productivity component A_{ik}. This in turn depends on whether the borrowing and incentive conditions are satisfied. If both are satisfied, $A_{ik}=1$. Otherwise $A_{ik}=A_L$. We will refer to $A_{ik}=A_L$ as the panic state and $A_{ik}=1$ as the nonpanic state.

Appendix II shows that the incentive condition can be expressed as

$$\frac{\beta\left(1-A_L^{\sigma-1}\right)}{A_{ik}^{\sigma-1}}\pi^{ik}\geq\kappa. \tag{36}$$

When a country does not panic ($A_{ik}=1$), the term multiplying profits is lower than 1, so that the incentive condition is tighter than the borrowing condition. Under Assumption 1 below, when a country panics ($A_{ik}=A_L$) the term multiplying profits in the incentive condition is greater than 1, which implies that the borrowing constraint is more easily violated and is the binding condition.

Assumption 1

$$A_L<\sigma\kappa<\beta\left(1-A_L^{\sigma-1}\right),\ \textit{and}\ \sigma\geq2. \tag{37}$$

Therefore (see also Appendix II), it follows that

$$A_{ik} = A_L \text{ when } \pi^{ik}<\kappa, \tag{38}$$

$$= 1 \quad \text{when } \beta\left(1-A_L^{\sigma-1}\right)\pi^{ik}\geq\kappa. \tag{39}$$

The panic condition (38) is the violation of the borrowing condition when $A_{ik}=A_L$, which is the binding condition with a panic. The nonpanic condition (39) is the incentive condition when $A_{ik}=1$, which is the binding condition without a panic.

A full solution of the model now involves a set of A_{ik} for all (i,k) that is consistent with conditions (30)–(35) and conditions (38)–(39). Any such set of A_{ik} describes an equilibrium to the model. In the next section we analyze such equilibria.

III. Analysis of Equilibria

Equilibria of the model depend on the assumed distribution across countries of the integration parameters ψ_i and ϕ_k. We first consider the case where all countries are equally integrated, so that $\psi_i=\psi$ and $\phi_k=\phi$ are equal across all countries. This allows us to generalize the two-country results from BvW to a multicountry setup with both partial trade and financial integration. After that we consider the implications of introducing integration heterogeneity across countries. We first discuss analytical results in two particular cases, one with heterogeneous trade integration but no financial integration and another with heterogeneous financial integration but homogeneous trade integration. After that we present numerical results for the case of both heterogeneous trade and financial integration, which connects most closely to the empirical evidence. These results are all derived in the absence of country-specific productivity shocks x_{ik}. At the end of the section we provide numerical results for the case where heterogeneous trade and financial integration is combined with country-specific productivity shocks. The proofs of all propositions are available in a separate Online Technical Appendix.

Multiple Equilibria and Uniform Integration

Consider first the case of homogeneous integration: $\psi_i = \psi$ and $\phi_k = \phi$ for all (i, k) and $x_{ik} = 0$. It is easy to verify that under Assumption 1 there exists both an equilibrium where all countries panic and an equilibrium where none of the countries panic. To see this, when no country panics, we have $A_{ik} = 1$ for all (i, k). Then $Q = 0$, $D_{ik} = 1$ and $\overline{V} = 1$, so that condition (39) becomes $\beta\left(1 - A_L^{\sigma-1}\right) \geq \sigma\kappa$. This holds by Assumption 1. Similarly, when all countries panic we have $A_{ik} = A_L$ for all (i, k). This implies $Q = \overline{\phi} ln\, A_L$, $D_{ik} = 1$ and $\overline{V} = A_L$, so that condition (38) becomes $A_L < \sigma\kappa$. This again holds by Assumption 1.

The existence of both a symmetric panic and nonpanic equilibrium can be understood as follows. If all households in the world expect a high level of income in period 2, first period consumption will be strong. Profits will then be high enough, so that all firms will invest and productivity and income will be high in period 2, consistent with expectations of high future income. If instead all households in the world expect much lower income in period 2, they reduce consumption in period 1. This reduces demand for goods, which reduces period 1 output and profits. Since profits are now insufficient to cover the investment cost, productivity and output will be lower in period 2, consistent with expectations of lower income in period 2. Beliefs about future income are therefore self-fulfilling.

Next consider whether there exist asymmetric equilibria, where a subset of countries panic ($A_{ik} = A_L$), while subset does not ($A_{ik} = 1$). In the Online Technical Appendix we prove the following proposition:

Proposition 1 *When $\psi_i = \psi$ and $\phi_k = \phi$ for all countries, there exists a continuous function $h(\psi, \phi)$, with $h > 0$ under perfect integration and $h < 0$ under autarky, such that*

1. *when $h(\psi, \phi) > 0$, there exist only equilibria where either all countries panic or all countries do not panic;*
2. *when $h(\psi, \phi) \leq 0$, there also exist equilibria where only a subset of countries panic;*
3. *$h(\psi, \phi)$ is decreasing in ψ and increasing in ϕ.*

There is more integration when ψ is lower (trade integration) and ϕ is larger (financial integration). The third part of the proposition then says that the function h

(ψ, ϕ) is higher the more integration. Under perfect integration $h>0$, while under complete autarky $h<0$. The proposition then says that when countries are sufficiently integrated ($h(\psi, \phi)>0$), asymmetric equilibria do not exist. Either all countries panic or none of the countries panic. If instead countries are insufficiently integrated ($h(\psi, \phi)\leq 0$), asymmetric equilibria do exist where some countries panic and others do not.

Several points should be made about this result. First, only partial integration is sufficient to ensure that equilibria are coordinated across countries, where either all countries panic or none do. The function $h(\psi, \phi)$ will be positive under less than full integration.[31] Second, the two sources of economic integration are substitutes: with more financial integration, less trade integration is required to ensure that $h(\psi, \phi)$ is positive, so that a panic is necessarily global by part 1 of the proposition.

The proposition generalizes the results of BvW to a multicountry setup with both trade and financial integration. To understand these results, it is important to point out that there are positive linkages in the model through both trade and financial integration. A higher level of income in one region of the world leads to a higher demand for goods from the rest of the world (trade integration), while it also leads to higher net transfers to the rest of the world (financial integration). These positive linkages create an interdependence that leads to the coordination of panics when countries are sufficiently integrated.

Consider for example the case where a large subset of countries panics, while a smaller subset does not panic. When the level of integration is relatively high, this cannot be an equilibrium. The smaller subset is very negatively impacted by the panic in most of the world. This will reduce their income and profits through both trade and financial linkages, so that condition (39) does not hold and they must necessarily panic as well. Similarly, it is not possible for only a small subset of countries to panic under sufficient integration. They will be positively affected by the absence of a panic in most of the world. Their profits will then be high, so that they can cover the investment cost, condition (38) does not hold and they cannot panic in equilibrium. Sufficient integration assures that countries share a common fate.[32]

Integration Heterogeneity

We can provide theoretical results for two intermediate cases of integration heterogeneity. The first is one of heterogeneous trade integration, but no financial integration, where $\psi_i = 1-i$ and $\phi_k = 0$. The second is one with heterogeneous financial integration and homogenous trade integration, where $\phi_k = k$ and $\psi_i = \psi$. In the latter case, trade integration cannot be too low as financial integration is meaningless without the ability to trade goods. At the same time, trade integration

[31]Note that $h(\psi, \phi)$ is positive under perfect integration. Together with the fact that it is a continuous function that is decreasing in ψ and increasing in ϕ, it follows that the cutoff $h(\psi, \phi) = 0$ occurs under partial integration.

[32]The same intuition applies as well when half the countries panic and half do not. This brings us essentially in the BvW framework of a two-country model.

cannot be too high as it would obviate the need for financial integration by generating endogenous risksharing through the terms of trade familiar from Cole and Obstfeld (1991). After discussing these two cases, we consider numerically the case of both trade and financial integration heterogeneity.

Trade Integration Heterogeneity

First consider the case where countries are in financial autarky and trade integration varies uniformly across countries from 0 (perfect integration) to 1 (autarky), with $\psi_i = 1 - i$. It follows that $\overline{\phi} = 0$, $Q = 0$ and $D_{ik} = 1$. Conditions (38)–(39) and Equation (35) then become

$$A_{ik} = A_L \quad \text{when} \quad A_L^{\psi_i}\overline{V}^{1-\psi_i} < \sigma\kappa, \tag{40}$$

$$= 1 \quad \text{when} \quad \beta\left(1 - A_L^{\sigma-1}\right)\overline{V}^{1-\psi_i} \geq \sigma\kappa, \tag{41}$$

$$ln\,\overline{V} = \int\int_0^1 \frac{1-\psi_j}{1-\overline{\psi}}\, ln\, A_{jl} dj dl. \tag{42}$$

Define $\tilde{\psi}_1(\overline{V})$ as the value of ψ_i for which the panic condition (40) holds with equality and $\tilde{\psi}_2(\overline{V})$ as the value of ψ_i for which the nonpanic condition (41) holds with equality. The Online Technical Appendix defines $\overline{\sigma}$, $\overline{V}_1$ and $\overline{V}_2$ as a function of model parameters, with $A_L < \overline{V}_2 < \overline{V}_1 < 1$. It then provides a proof for the following proposition:

Proposition 2 *Assume that* $\psi_i = 1 - i$, $\phi_k = 0$, *and* $\sigma > \overline{\sigma}$. *Then there exists a continuum of equilibria of two types:*

1. *There is an interval* $[\overline{V}_1, 1]$ *such that for each* $\overline{V}$ *in the interval there are equilibria with two features. First, none of the countries in the interval* $\psi_i \in [0, \tilde{\psi}_1(\overline{V})]$ *panic. Second, when* $\overline{V} < 1$ *at least some of the remaining countries will panic.*
2. *There is an interval* $[A_L, \overline{V}_2]$ *or* $[A_L, \overline{V}_2\rangle$ *such that for each* $\overline{V}$ *in the interval there are equilibria with two features. First, all countries in the interval* $\psi_i \in [0, \tilde{\psi}_2(\overline{V})]$ *panic. Second, when* $\overline{V} > A_L$ *at most a subset of remaining countries will panic.*

There is a continuum of equilibria characterized by different values for $\overline{V}$ and, for a given $\overline{V}$, by different sets of countries that panic that is consistent with that $\overline{V}$. The first part of the proposition is relevant for large values of $\overline{V}$. In all of these equilibria none of the most integrated set of countries $(\psi_i \leq \tilde{\psi}_1(\overline{V}))$ will panic, while in general a subset of the less integrated countries does panic. From the point of view of the Great Recession, the second type of equilibria in Proposition 2 is of most interest. It is relevant for low values of $\overline{V}$. In all of these equilibria all of the most integrated countries $(\psi_i \leq \tilde{\psi}_2(\overline{V}))$ will panic together, while at most a subset of the less integrated countries panic. In the second set of equilibria there is a minimum set of integrated countries that panics, defined as $\psi_i \in [0, \tilde{\psi}_2(\overline{V}_2)]$. When this minimum set of integrated countries panics, none of the less integrated countries will panic.

The most integrated countries either panic together as a group or do not panic as a group, while the less integrated countries generally do not share their fate. The intuition for this is exactly the same as for Proposition 1. The interdependence of the integrated countries through trade and financial linkages implies a coordination of equilibria among the most integrated countries. The less integrated countries generally do not share this fate as they are less affected by what is happening in the rest of the world.

Financial Integration Heterogeneity

The second case that is analytically tractable allows for financial integration heterogeneity ($\phi_k = k$) while keeping constant the level of trade integration for all countries ($\psi_i = \psi$). As already discussed, in this case the level of trade integration cannot be too low or too high. We assume that $\psi \in (\psi_{low}, \psi_{high})$, where ψ_{low} and ψ_{high} are defined in the Online Technical Appendix as a function of model parameters. Rather than considering all possible equilibria, we will focus here on the ones most relevant in the context of the Great Recession, where the most integrated countries panic. This is analogous to the second part of Proposition 2 for the case of trade heterogeneity.[33] In the Online Technical Appendix, we are able to prove the following proposition:

Proposition 3 *Assume that $\phi_k = k$ and $\psi_i = \psi$. For each $\psi \in (\psi_{low}, \psi_{high})$, the following equilibria exist:*

1. *There is an equilibrium where $(\overline{V}, Q) = (\overline{V}^*, Q^*)$, such that all countries on the interval $\langle \tilde{\phi}, 1]$ panic and none of the countries in the interval $[0, \tilde{\phi}]$ panic.*
2. *In addition, there are equilibria where $(\overline{V}, Q) < (\overline{V}^*, Q^*)$, such that all countries on the interval $[\tilde{\phi}(\overline{V}, Q), 1]$ panic, with $\tilde{\phi} < \tilde{\phi}^*$. When $(\overline{V}, Q) > (A_L, \overline{\phi} \ln A_L)$, a subset of the remaining countries also panics.*

The message from this proposition is analogous to what we found for the second type of equilibria in Proposition 2, as we now have that countries that are sufficiently financially integrated must panic together as a group. There is a minimum set of integrated countries that panics in these equilibria, defined as $\phi_k \in [\tilde{\phi}^*, 1]$. When this minimum set of integrated countries panics, none of the less integrated countries will panic.

Trade and Financial Integration Heterogeneity

We now consider the general case with both trade and financial integration heterogeneity. This case is too complex for a general analytical solution and we proceed numerically. Using the equilibrium expression for profits, we can write

[33] One can show that equilibria analogous to the first part of Proposition 2 still exist as well.

conditions (38)–(39) as

$$A_{ik} = A_L \text{ when } A_L^{\psi_i}\left[1+\left(\frac{1-\overline{\psi}}{1-\psi_i}\right)\psi_i\phi_k\left(Q-\overline{\phi}ln\ A_L\right)\right]^{1-\psi_i}\overline{V}^{1-\psi_i}<\sigma\kappa, \tag{43}$$

$$= 1 \quad \text{when } \beta\left(1-A_L^{\sigma-1}\right)\left[1+\left(\frac{1-\overline{\psi}}{1-\psi_i}\right)\psi_i\phi_k Q\right]^{1-\psi_i}\overline{V}^{1-\psi_i}\geq\sigma\kappa. \tag{44}$$

In the cases discussed above that we could solve analytically, we saw that there is a minimum set of integrated countries that panics. If only this minimum set of integrated countries panics, none of the less integrated countries panic. We can associate this equilibrium with a pair $(Q^*, \overline{V}^*)$. We will focus on this equilibrium in the numerical solution. In general, as we have seen, there will also be equilibria where a larger group of integrated countries panics and a subset of the less integrated countries panics as well.

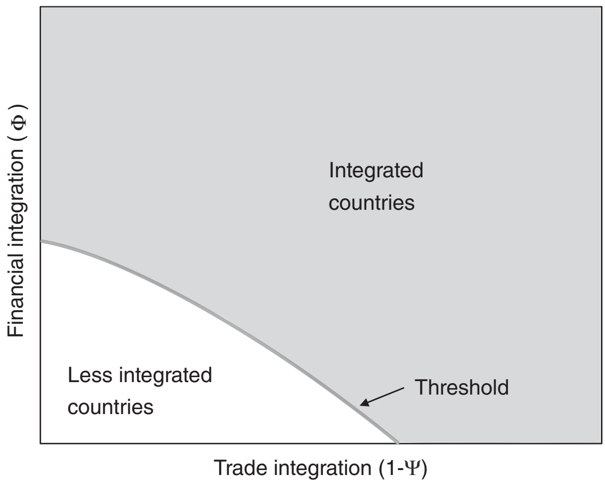
We briefly describe the numerical solution method. We start with a given pair $(Q_0, \overline{V}_0)$ large enough so that $(Q_0, \overline{V}_0)>(Q^*, \overline{V}^*)$ but low enough so that condition (43) holds even for the most integrated countries. For each country we then evaluate condition (44). If this condition does not hold, only the panic equilibrium is feasible for this country and we correspondingly assign $A_{ik}=A_L$. If condition (44) holds, we assume that the country does not panic, so $A_{ik}=1$, as we are seeking the minimum set of countries that must panic. These solutions for A_{ik} imply new values Q_1 and $\overline{V}_1$ such that either $Q_1<Q_0$ or $\overline{V}_1<\overline{V}_0$ or both hold.[34] It follows that the original pair $(Q_0, \overline{V}_0)$ cannot be an equilibrium, because setting $A_{ik}=A_L$ for any set of countries that also satisfy condition (44) only decreases Q_1 and $\overline{V}_1$ even further. We then proceed as before by picking the new pair $(Q_1, \overline{V}_1)$, solving the A_{ik} and continue to iterate along this line until Q and $\overline{V}$ converge to the equilibrium pair $(Q^*, \overline{V}^*)$. Thus the numerical method allows us to establish that there are only equilibria such that $(Q, \overline{V})\leq(Q^*, \overline{V}^*)$, and at the same time it provides an iterative procedure to find the equilibrium.[35]

The process of numerical convergence is closely connected to the economic intuition behind these equilibria. When a sufficiently large set of countries panics, the interdependence of the integrated countries through trade and financial linkages implies that even more countries must panic. In turn this increased set of countries triggers a panic in some of the less integrated countries. This process continues

[34]We compute these values of Q and $\overline{V}$ using the concept of the Riemann sum as an approximation to the Riemann integral. We first set a grid of 200^2 points in the unit square to approximate a continuum of countries, and then we approximate the integrals (conditions (34)–(35)) computing the corresponding Riemann sums for all small increments in the two-dimensional grid. We test the accuracy of this method by calculating the equilibrium value of $\overline{V}_2$ in the context of Proposition 2, which can also be computed with a standard numerical solver as the solution of a nonlinear equation. Owing to the density of the two-dimensional grid we employ, we find that both methods provide the exact same solution.

[35]Given that the left-hand-side of condition (44) is decreasing in Q and $\overline{V}$, other possible equilibrium pairs necessarily involve a larger set of countries that panic than the set associated with $(Q^*, \overline{V}^*)$.

Figure 2. Countries in the Trade/Financial Space



until the remaining countries are sufficiently disconnected from the rest of the world that they can avoid a panic even if most of the world panics.

Figure 2 provides an illustration. We assume that countries are distributed such that $\psi_i = (1-\theta_T)(1-\alpha_T i)$ and $\phi_k = \theta_F + \alpha_F k$, where $\theta_T = 0.07$, $\alpha_T = 0.34$, $\theta_F = 0$ and $\alpha_F = 1.83$. These values are chosen such that the most integrated country enjoys full risk-sharing in normal times (when $A_{ik} = 1$ for all countries), while at the same time there are no countries in complete autarky.[36] The remaining parameter values $\sigma = 28.95$, $\kappa = 0.03$, $\beta = 1$ and $A_L = 0.9$ are chosen such that Assumption 1 holds, monetary policy is constrained at the ZLB, and output drops by 10 percent during a panic.

The figure is in the space of trade and financial integration. On the horizontal axis we have $1-\psi_i$, a measure of trade integration. On the vertical axis we have ϕ_k, a measure of financial integration. These correspond well to the counterparts of trade and financial integration in the empirics. In Appendix I we show that total exports by country (i, k) are proportional to $(1-\psi_i)$. Similarly, we show in Appendix III that ϕ_k can be seen as the theoretical counterpart of the measure of financial integration from the empirics.

In the equilibrium that we analyze all the integrated countries panic, while all the less integrated countries do not panic. All the integrated countries are above the threshold line shown in Figure 2, while all the less integrated countries are below the threshold line. This corresponds well to the empirical results for the Great Recession. First, it is consistent with the result that the drop in output was larger during the Great Recession for countries whose integration level was beyond some

[36]The values also ensure that conditions (38)–(39) cannot hold simultaneously for very integrated countries. This way we ensure the existence of the same type of equilibria as in the second part of Proposition 2.

threshold than for countries that were less integrated.[37] Second and related, it is consistent with evidence that there is no monotonic relationship between integration and the drop in output. Within each group of countries the level of output is identical. Integration only matters in terms of what side of the threshold countries are. Third, trade and financial integration are substitutes. As a country's trade integration increases, a lower level of financial integration is needed to reach the threshold line. It follows that it is a combination of the two types of economic integration that matters in classifying countries as integrated or less integrated.

Finally, it is worth noting the crucial role that financial integration plays in this example. If all countries were in financial autarky ($\phi_k = 0$), with the remaining parameter values the same, there do not exist coordinated equilibria as the level of trade integration is too low. It is the extent of heterogenous financial integration across countries that makes the difference here, by strengthening the positive linkages within the integrated group.

Allowing for Random Shocks

We finally consider the most general possible case, with both trade and financial integration heterogeneity and country-specific productivity shocks x_{ik} that last both periods. From a mathematical perspective, little changes relative to the previous subsection. Using the Law of Large Numbers, we can replace each random term inside the integrals (equations (34)–(35)) by its expectation.[38] The aggregate solution of the model will therefore not depend on which particular countries are hit by good or bad shocks, or the magnitude of these shocks. In terms of $(Q, \overline{V})$ space, the equilibria are therefore the same as before: $(Q, \overline{V}) \leq (Q^*, \overline{V}^*)$, with the latter solved with the same iteration procedure as before.

Once we have the pair $(Q^*, \overline{V}^*)$, we can evaluate the nonpanic condition (39), which now depends on ψ_i, ϕ_k, and x_{ik}, to decide which countries necessarily panic. What changes now is that relatively integrated countries can avoid a panic if they get hit by a big enough positive shock x_{ik} because good domestic conditions keep profits strong so that lucky countries can invest and avoid a panic. Similarly some relatively less integrated countries hit by a negative shock can fall in a panic because bad domestic conditions exacerbate the impact of poor foreign conditions.

An intuitive way to illustrate the role of trade and financial integration is in terms of probabilities of experiencing a panic. Conditional on the pair $(Q^*, \overline{V}^*)$, these probabilities are given by

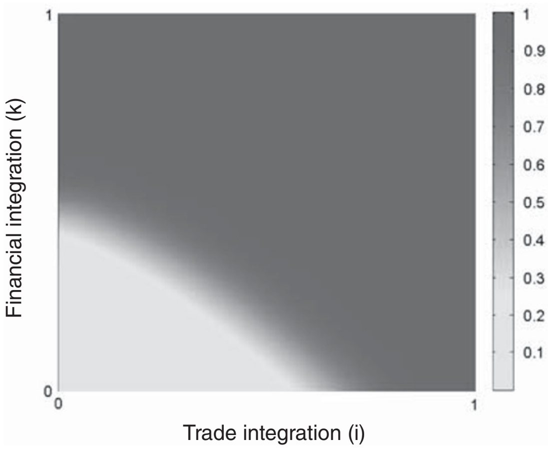
$$Pr(\pi^{ik}(\psi_i, \phi_k, x_{ik}, Q^*, \overline{V}^*) < \frac{\kappa}{[\beta(1 - A_L^{\sigma-1}))]}. \tag{45}$$

This is the probability that condition (39) does not hold, so that the country must panic. A panic then occurs when $x_{ik} < x(\psi_i, \phi_k)$, where $x(\psi_i, \phi_k)$ is the value of

[37]Output equals respectively A_L and 1 for integrated and less integrated countries.

[38]See Uhlig (1996).

Figure 3. Probability Contour Map



x_{ik} such that $\pi^{ik} = \kappa/[\beta(1 - A_L^{\sigma-1})]$ as an equality. Solving for $x(\psi_i, \phi_k)$ then easily lets us compute the panic probability for a given distribution of the x_{ik}.

Figure 3 provides an illustration. The equilibrium $(Q^*, \overline{V}^*)$ is computed for the same parameter values as in the previous subsection and we plot the continuum of countries in the unit square.[39] We assume $x_{ik} \sim N(0, 0.005)$ for all countries. The figure plots the probability contour map associated with the equilibrium pair $(Q^*, \overline{V}^*)$.

It is clear from this picture that it is no longer the case that necessarily all integrated countries panic as a group. The probabilities of a panic are much higher for integrated countries, but it is now possible that an integrated country does not panic if it gets a very positive productivity shock. Similarly, less integrated countries may be hit by a very bad shock and together with the negative spillovers from the global panic could fall into a panic. This leads to differences across countries in growth that are unrelated to levels of integration. It remains the case that there is a strong threshold, but consistent with the data there are now some less integrated countries that perform very poorly and some integrated countries that perform well. This is consistent with Figure 1, where we saw that not all integrated countries are bad performers and not all less integrated countries are good performers. Integration matters in a threshold type of way, but pure country-specific randomness certainly plays a role as well.

IV. Conclusion

In the introduction we argued that two features characterize cross-country business cycle synchronicity during the Great Recession. The first is that the degree of

[39] Since the expressions for ψ and ϕ are linear in i and k, the unit square can also be interpreted as the trade/financial space.

business cycle synchronicity at this time was historically unparalleled. The second feature is about the relationship between economic integration and the extent that countries were impacted by the Great Recession. Although there is no robust monotonic relationship between levels of integration and the drop in output during the Great Recession, we have developed evidence of a strong nonlinear relationship. Countries below a certain threshold of integration, capturing both trade and financial integration, were much less affected than those above the threshold.

We have shown that these features are consistent with a model that extends the two-country BvW model of self-fulfilling business cycles to a multicountry setting with heterogeneity across countries with regard to both trade and financial integration. We find that integrated countries necessarily panic as a group as their interconnectedness makes it impossible to have widely varying outlooks on the future. At the same time less integrated countries are less dependent on other countries and therefore in equilibrium may not panic even if most of the rest of the world panics. This creates a dichotomy, with a larger drop in output for countries whose level of integration is above a certain threshold cutoff than those that are less integrated. Within both groups of countries the theory implies no relationship between the decline in output and the level of integration. This explains why integration only matters in a discontinuous way.

APPENDIX I

Condensed Version of the Model

In this Appendix we derive the condensed version of the model. We first establish that all prices are constant across periods, from which it follows that real variables are also constant. This allows us to solve the relevant variables of the model as a function of second period productivities. Throughout the process we will drop the time index from those variables that are known to be constant over time.

As a starting point, we know that the assumed monetary policy and the consumption Euler Equation imply that both P^{ik} and c^{ik} are constant. The transfer component $ln(g_1^{jl}/g_1^{ik})$ is also constant as it only depends on first period real outputs. To see this, note that by definition $g_1^{ik} = y_1^{ik}/E_0[y_1^{ik}]$. Prior to the realization of any shock all countries are expected to have the same real output, hence $ln(g_1^{jl}/g_1^{ik}) = ln\, y_1^{jl} - ln\, y_1^{ik}$.

In equilibrium all firms in country (i, k) set the same price and output in all firms is the same, hence goods market equilibrium is described by

$$y_t^{ik} = c_{ik,t}^{ik} + \int \int_0^1 c_{ik,t}^{jl} djdl. \tag{A.1}$$

Substituting the expressions for consumption we have

$$P_t(i,\, k)y_t^{ik} = \psi_i P^{ik} c^{ik} + S_{ik,t} E_t^{ik}, \tag{A.2}$$

where E_t^{ik} is nominal exports of country (i, k), measured in the base currency and given by

$$E_t^{ik} = (1-\psi_i)\int\int_0^1 \frac{1-\psi_j}{1-\overline{\psi}}\frac{P^{jl}}{S_{jl,t}}c^{jl}djdl.$$

Integrating E_t^{jl} over j and l we obtain world exports:

$$E_t^W = \int\int_0^1 E_t^{jl}djdl = (1-\overline{\psi})\int\int_0^1 \frac{1-\psi_j}{1-\overline{\psi}}\frac{P^{jl}}{S_{jl,t}}c^{jl}djdl.$$

It follows that

$$E_t^{ik} = \frac{(1-\psi_i)}{(1-\overline{\psi})}E_t^W$$

so that Equation (A.2) becomes

$$P_t(i,\ k)y_t^{ik} = \psi_i P^{ik}c^{ik} + S_{ik,t}\frac{(1-\psi_i)}{(1-\overline{\psi})}E_t^W. \tag{A.3}$$

Using the budget constraint of country (i, k), and imposing money and bond market equilibrium, we can write

$$P^{ik}c^{ik} = P_t(i,\ k)y_t^{ik} + S_{ik}E_t^W\phi_k\left(Q-\overline{\phi}ln\ y_1^{ik}\right), \tag{A.4}$$

where $Q = \int\int_0^1 \phi_l\ ln\ y_1^{jl}djdl$ and $\overline{\phi} = \int_0^1 \phi_l dl$. If we substitute this expression into Equation (A.3) and rearrange terms we get

$$\frac{P^{ik}c^{ik}}{S_{ik,t}G^{ik}} = \frac{E_t^W}{1-\overline{\psi}}, \tag{A.5}$$

where $G_{ik} = 1+(1-\overline{\psi}/1-\psi_i)\phi_k(Q-\overline{\phi}ln\ y_1^{ik})$. Then, using that the previous equation also holds for the base country b and that for this country $S_{b,t} = 1$ we obtain the following equivalence

$$\frac{P^{ik}c^{ik}}{G_{ik}S_{ik,t}} = \frac{P^b c^b}{G_b} \tag{A.6}$$

which implies that $S_{ik,t}$ is constant. Now, take logs on both sides of the consumer price index equation and rearrange terms such that

$$ln\ P_t(i,k) = \frac{ln\ P^{ik}}{\psi_i} - \frac{(1-\psi_i)}{\psi_i}ln\ S_{ik} - \frac{(1-\psi_i)}{\psi_i}ln\ P_{F,t}. \tag{A.7}$$

Substituting this expression into the Foreign price index equation and rearranging terms delivers

$$ln\ P_{F,t} = \left(1+\int\int_0^1 \frac{(1-\psi_j)^2}{(1-\overline{\psi})\psi_j}djdl\right)^{-1}\int\int_0^1 \frac{1-\psi_j}{(1-\overline{\psi})\psi_j}ln\left(\frac{P^{jl}}{S_{jl}}\right)djdl \tag{A.8}$$

which implies that $ln\ P_{F,t}$ is also constant, as all the elements of the RHS of this equation are constant. In turn, Equation (A.7) now implies that $P(i, k)$ is also constant. Thus, we have established that all prices are constant across periods.[40] Finally, we note from Equations (A4) and (A5) that world exports and output must also be the same in both periods, which means that all nominal and real variables of the model are constant.

Note that in period 2 $L_2^{ik} = 1$ and that in equilibrium all firms in country (i, k) will make the same investment decision so that $A_{ik,2}(m) = A_{ik}$, where A_{ik} can be either 1 or A_L depending on whether firms incur the investment cost or not. Using (17) it follows that country (i, k) output is given by

$$y^{i,k} = V_{ik}, \tag{A.9}$$

where $V_{ik} = e^{x_{ik}} A_{ik}$. In period 1 we have $A_{ik,1}(m) = 1$ and $L_1^{ik} = 1 - u^{ik}$ from the labor market equation. Since output is the same in both periods, $u^{ik} = 1 - A_{ik}$.

Next, combine Equations (A.5) and (A.9) with the budget constraint to find

$$\frac{P^{ik} c^{ik}}{G_{ik}} = \frac{P(i,k) V_{ik}}{D_{ik}}, \tag{A.10}$$

where $D_{ik} = 1 + (1 - \overline{\psi}/1 - \psi_i)\psi_i \phi_k \left(Q - \overline{\phi} ln\ V_{ik}\right)$. Substituting this equation into Equation (A.6) for both (i, k) and the base country we find an expression for the exchange rate:

$$S_{ik} = \frac{D_b P(i,\ k) V_{ik}}{D_{ik} P(b) V_b}. \tag{A.11}$$

Taking logs on this equation and substituting it into the Foreign price index formula gives

$$ln\ P_F = \int \int_0^1 \frac{1 - \psi_j}{1 - \overline{\psi}} \left(ln\ P(b) V_b - ln\ D_b + ln\ D_{jl} - ln\ V_{jl}\right) djdl. \tag{A.12}$$

Define

$$ln\ \overline{V} = \int \int_0^1 \frac{1 - \psi_j}{1 - \overline{\psi}} ln \left(\frac{V_{jl}}{D_{jl}}\right) djdl \tag{A.13}$$

so that the Foreign price index becomes

$$P_F = \frac{P(b) V_b}{D_b \overline{V}}. \tag{A.14}$$

Substituting Equations (A.11) and (A.14) into the consumer price index formula delivers

$$\frac{P(i,\ k)}{P^{ik}} = \left(\frac{\overline{V} D_{ik}}{V_{ik}}\right)^{1 - \psi_i}. \tag{A.15}$$

[40]The only exception is the second period wage. Using that $P_1(i, k) = P_2(i, k)$ and Equation (18) for both periods, we get $W_2^{ik} = A_{ik} \overline{W}^{ik}$, where $\overline{W}^{ik}$ is the nominal wage in period 1 that is predetermined.

Then, if we substitute this last expression into Equation (A.10), we can solve for country (i, k) consumption as follows:

$$c^{ik} = G^{ik}\left(\frac{V_{ik}}{D_{ik}}\right)^{\psi_i}\overline{V}^{1-\psi_i}. \tag{A.16}$$

We finally need to derive an expression for profits. We can substitute into the formula for real profits Equation (20) $y^i = V_{ik}$ and Equation (A.15). Rearranging, the expression for profits becomes

$$\pi^{ik} = \frac{1}{\sigma}V_{ik}^{\psi_i}\left(D_{ik}\overline{V}\right)^{1-\psi_i}. \tag{A.17}$$

APPENDIX II

Incentive and borrowing conditions

If all firms in country (i, k) are investing, we must make sure that any individual firm indeed must be able and willing to invest. If no firm is investing, we must make sure that for an individual firm either profits are not enough to cover the fixed cost or investing lowers the present discounted value of its profits. To check all this, we have to look at the incentive and borrowing conditions for an individual firm. We therefore need to derive expressions for second period profits for an individual firm m. We first derive an expression for second period profits of an individual firm, then derive the incentive and borrowing conditions, and finally we establish which condition is the relevant one to look at for each of the two possible states of the economy (panic or nonpanic).

Using the optimal price equation and the production function, we can rewrite second period profits as

$$\Pi_2^{ik}(m) = \frac{1}{\sigma-1}\frac{W_2^{ik}y_2^{ik}(m)}{e^{x_{ik}}A_{ik,2}(m)}.$$

To determine firm's demand $y_2^{ik}(m)$, use the market-clearing condition for good m (equation (24)), substitute the CES demands (equation (12)) and rearrange terms to get

$$y_2^{ik}(m) = \left(c_{ik,2}^{ik} + \int\int_0^1 c_{ik,2}^{jl}djdl\right)\left(\frac{P_2(i,k)}{P_2^{ik}(m)}\right)^{\sigma}.$$

From Equation (A.1) we know that the first term in brackets equals y^{ik}. In any equilibrium we have that $P(i,\ k) = [\sigma/(\sigma-1)](W^{ik}/(e^{x_{ik}}A_{ik}))$. Using again the optimal price equation, the price ratio becomes

$$\frac{P(i,k)}{P_2^{ik}(m)} = \frac{A_{ik,2}(m)}{A_{ik}}.$$

Substituting this ratio and the solution for output gives

$$y_2^{ik}(m) = V_{ik}\left(\frac{A_{ik,2}(m)}{A_{ik}}\right)^{\sigma}.$$

Together with the fact that $W^{ik} = ((\sigma - 1)/\sigma)P(i,k)V_{ik}$ (just rearrange the optimal price in equilibrium) second period profits become

$$\Pi_2^{ik}(m) = \frac{1}{\sigma}P(i,k)V_{ik}\left(\frac{A_{ik,2}(m)}{A_{ik}}\right)^{\sigma-1}.$$

We have that $A_{ik,2}(m) = 1$ if the firm invests and $A_{ik,2}(m) = A_L$ otherwise. Substituting the corresponding expressions into the incentive condition (equation (23)), together with Equation (A.15) and rearranging, we obtain the condensed version of the incentive condition:

$$\frac{\beta\left(1-A_L^{\sigma-1}\right)}{\sigma A_{ik}^{\sigma-1}}V_{ik}^{\psi_i}\left(D_{ik}\overline{V}\right)^{1-\psi_i} \geq \kappa. \tag{A.18}$$

Using Equation (A.17), we also can write it as:

$$\frac{\beta\left(1-A_L^{\sigma-1}\right)}{A_{ik}^{\sigma-1}}\pi^{ik} \geq \kappa. \tag{A.19}$$

whereas the condensed version of the borrowing condition is

$$\pi^{ik} \geq \kappa. \tag{A.20}$$

Now suppose that country (i,k) is not in a panic state, so that $A_{ik} = 1$. Since we have that $\beta(1-A_L^{\sigma-1}) < 1$, it follows that Equation (A.19) is a necessary and sufficient condition to ensure that (i,k) is not in a panic. Suppose instead that country (i,k) is in a panic state, so that $A_{ik} = A_L$. This will be the case if the incentive condition (equation (A.19)) does not hold, or the borrowing condition (equation (A.20)) does not hold, or neither holds. Using Assumption 1, we have

$$A_L^{\sigma-1} \leq A_L < \sigma\kappa < \beta\left(1-A_L^{\sigma-1}\right). \tag{A.21}$$

It follows that $\beta(1-A_L^{\sigma-1}) > A_L^{\sigma-1}$, which in turn implies that

$$\pi^{ik} < \kappa \tag{A.22}$$

is a sufficient and necessary condition to ensure that country (i,k) is in a panic state.

APPENDIX III

Microfoundations behind the transfer function

In this Appendix we argue that the transfer function T^{ik} can be seen as the reduced form of a country's net payouts structure under a particular asset market structure. The setup is related to previous work (Mendoza and Quadrini, 2010), and aims to capture in a simple way (with only one parameter) cross-country variation in financial integration and partial risk-sharing.

Suppose that, in addition to periods 1 and 2, there is a period 0 where households can trade assets that will generate payouts in the following two periods. Households from country (i,k) can sell a_{jl}^{ik} units of the asset to country (j,l) residents, with a promised payment of each asset equal to a fraction $ln((g^{ik})/(g^{jl}))$ of nominal world exports if $g^{ik} - g^{jl} \geq 0$ and zero otherwise. Recall that $g^{ik} = y_1^{ik}/E_0 y_1^{ik}$. The asset provides income to country (j,l) residents when (j,l) performs unexpectedly worse in terms of output, with larger payments received the higher the unexpected output difference. Equal payments happen both periods as exogenous productivity shocks are permanent and the probability of a period 1 sunspot is assumed infinitesimal from the perspective of time 0.

The asset is obviously valuable so its price will be positive in equilibrium. Also note that all countries make the same type of promise and that all of them have the same independent distribution of the shocks. Therefore the price of each of these assets is the same and we can normalize them to one.

In principle full risk-sharing is possible with these assets, but we assume a standard financial friction in the form of a commitment problem. For each pair $((i, k).(j, l))$, country (i, k) can avoid the payment by paying a penalty p of

$$p = \phi_k \phi_l E^W ln\left(\frac{g^{ik}}{g^{jl}}\right). \tag{A.23}$$

Therefore

$$a_{jl}^{ik} \leq \phi_k \phi_l. \tag{A.24}$$

This puts a limit on the size of the contracts that each country pair can trade. If $\phi_k \phi_l$ is low enough the constraint will be binding, so that country (i, k) will make a payment of

$$a_{jl}^{ik} E^W ln\left(\frac{g^{ik}}{g^{jl}}\right) = \phi_k \phi_l E^W ln\left(\frac{g^{ik}}{g^{jl}}\right) \tag{A.25}$$

to country (j, l) if $g^{i,k} - g^{j,l} \geq 0$, and zero otherwise. By symmetry country (i, k) receives a payment if its income is unexpectedly low relative to that of (j, l). Putting the two together, (i, k) receives a net transfer (positive or negative) from (j, l) equal to

$$\phi_k \phi_l E^W ln\left(\frac{g^{jl}}{g^{ik}}\right). \tag{A.26}$$

Integrating over all the countries, the net transfer received by (i, k) is

$$\int \int_0^1 \phi_k \phi_l E^W ln\left(\frac{g^{jl}}{g^{ik}}\right) djdl = T^{ik} \tag{A.27}$$

which is the same transfer function we assume in the paper.

It remains to be seen under which circumstances $a_{jl}^{ik} \leq \phi_k \phi_l$ is binding. From Appendix I, the solution for consumption in normal times (the nonpanic state) is given by

$$c^{ik} = G^{ik} \left(\frac{e^{x_{ik}}}{D_{ik}}\right)^{\psi_i} \overline{V}^{1-\psi_i}, \tag{A.28}$$

where $\overline{V}$ is the aggregate component common to all countries. The key risk-sharing component is the ratio $G^{ik}/D_{ik}^{\psi_i}$. In order for the assets to provide risk-sharing, this ratio should move in the opposite direction of the country-specific component $e^{\psi_i x_{ik}}$: if this component increases then $G^{ik}/D_{ik}^{\psi_i}$ must decrease, and vice versa. In addition, the opposite effect of $G^{ik}/D_{ik}^{\psi_i}$ cannot more than offset the change in $e^{\psi_i x_{ik}}$ or we would not have full risk-sharing either. In the good equilibrium we find that the derivative dc^{ik}/dy^{ik} evaluated at $x_{ik} = 0$ (an approximation for shocks of small magnitude) is given by

$$\left|\frac{dc^{ik}}{dx^{ik}}\right|_{x^{ik}=0} = \psi_i - \phi_k \overline{\phi}(1+\psi_i)(1-\overline{\psi}) \tag{A.29}$$

the constraint is that this derivative must be nonnegative.[41] If $dc^{ik}/dx^{ik} = 0$ we have full risk-sharing, as (i, k) consumption does not depend on the country-specific component $e^{x_{ik}}$. If $\phi_k = 0$ we have the well-known result that risk-sharing depends on the level of trade integration. We will make the following risk-sharing assumption: for the most integrated country (1, 1) we have that

$$\phi_1 \leq \frac{1}{\bar{\phi}} \frac{\psi_1}{(1+\psi_1)(1-\overline{\psi})}. \tag{A.30}$$

As $(\psi)/(1+\psi)$ is increasing in ψ, $(\psi_1)/(1+\psi_1)$ is the minimum this object can be, and ϕ_1 is the maximum value that ϕ_k can take. It follows that if the risk-sharing assumption is satisfied then $dc^{ik}/dx^{ik} \geq 0$ for all countries. Also, note that dc^{ik}/dx^{ik} is decreasing in the size of ϕ_k. This means that (a) countries are partially insured at best, and (b) the level of risk-sharing (lower dc^{ik}/dx^{ik}) increases when we relax the constraint $a_{jl}^{ik} \leq \phi_k \phi_l$ by increasing the country-specific parameter ϕ_k. More risk-sharing is therefore always desirable, so that the constraint $a_{jl}^{ik} \leq_l \phi_k \phi_l$ is always binding.

Finally, let us point out a nice connection between the theory and the empirics under this setup. From the discussion above, the total value of the assets bought by country (i, k) in period 0 is

$$\int \int_0^1 a_{ik}^{jl} dj dl = \int \int_0^1 \phi_k \phi_l dj dl = \bar{\phi} \phi_k. \tag{A.31}$$

It follows that the total value of (external) assets is proportional to the level of financial integration, which by symmetry also equals the total value of liabilities. But the total value of external assets and liabilities is precisely the measure we use in the empirical section.

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[41]To derive this result, note that $Q = 0$ by a Law of Large Numbers (see Uhlig, 1996) and that $\overline{V}$ equals 1 when $x^{jl} = 0$.

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