Connected to Whom? International Bank Borrowing During the Global Crisis

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Abstract

The global financial crisis that started off in August 2007 led to an unprecedented collapse in international bank borrowing. This paper examines whether the credit retrenchment from 32 banking systems in advanced and emerging economies during the crisis was related to their exposure to banking distress and macroeconomic fragilities. The analysis looks at both creditor and borrower banking system fragilities using novel risk-weighted indexes. The results suggest that both creditor push factors and borrower pull factors contributed to the decline in international bank borrowing during the crisis.

JEL Classification Numbers: F30, F34, F41, F42, G15, G21.

Keywords: liquidity risk, counterparty risk, financial interconnectedness, international bank credit.

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1. Introduction

The global financial crisis triggered an unprecedented collapse in international bank borrowing. The turbulence that started off in August 2007 in international interbank markets was an early sign of the impending meltdown. The strains in international interbank markets intensified in the wake of the Bear Stearns debacle in March 2008 and grew into a global market collapse after the Lehman Brothers' bankruptcy in September 2008. The interbank turmoil affected key financial centers and required concerted policy actions. International bank borrowing recovered in late 2009-early 2010 in emerging markets but remained subdued in Europe amidst growing banking fragilities and rising sovereign risks.

The purpose of this paper is to investigate the driving forces behind the collapse in international bank borrowing in advanced and emerging economies during the global crisis. The paper aims to answer the following questions. Was the interbank market turmoil driven by indiscriminate panic or countries' risk characteristics mattered? If countries' risk characteristic mattered, which characteristics mattered most? Was the retrenchment triggered by borrower risks or creditor fragilities? Were lenders mainly wary of banking sector risks or avoided also countries with macroeconomic fragilities?

Earlier research has highlighted the role of creditor effects in the international propagation of crises. Kaminsky and Reinhart (2000) show how international creditors' retrenchment from lending to particular regions has played an important role in the regional propagation of crises. In this channel, the fragilities of global lenders emerge as a push factor because they constrain their ability to lend to emerging markets.[2] In the emerging literature on the global financial crisis global lenders also represent an important channel of shock propagation.[3]

[2] Push factors are typically related to global shocks and contagion that are outside of the country's control. Pull factors are related to the domestic economic, financial and regulatory environment.

[3] See for example Cetorelli and Goldberg (2010), Milesi-Ferretti and Tille (2011), De Haas and van Lelyveld (2011), Claessens and Van Horen (2012).

The approach proposed in this paper adds to the existing research on the global credit retrenchment in three ways. First, the approach extends the analysis to examine the importance of domestic borrower fragilities, in particular those related to banking system soundness. This "borrower channel" is a "pull factor" that drives access to international credit. Second, the paper considers also the risk profile of borrowers' international lending, which is seen as another pull factor determining access to credit. Third, the paper attempts to decompose the borrower and creditor effects using novel counterparty risk indexes.

The empirical findings suggest that both borrower and creditor fragilities played an important role in the collapse of international interbank markets during the global crisis. The decline in international borrowing during the period appears related to borrowers' soundness and macroeconomic fragilities, and to the risk profile of their international credit portfolios. However, borrowers that relied on distressed foreign creditors suffered reduced access to funding regardless of their risk characteristics. Borrower and creditor effects are statistically significant and economically meaningful both in advanced economies and in emerging markets. Borrower effects appear more pronounced in emerging markets, while creditor effects seem stronger in advanced economies.

The paper proceeds as follows. Section II provides a brief review of the literature. Section III documents stylized facts. Section IV provides some conceptual underpinnings of the creditor and borrower channels. Section V discusses the empirical model. Section VI summarizes the empirical findings. Section VII conducts sensitivity analysis. Section VIII concludes.

2. Related literature

The literature on the determinants of international borrowing (and capital flows in general) is extensive, and the section below summarizes briefly some of the main schools of thought and key findings. Earlier research on this topic has highlighted the role of the creditor channel, the trade channel, global risk aversion and financial integration.

The conceptual underpinnings of the paper can be traced back to the literature on the creditor channel of international shock transmission. The seminal paper on this topic, Kaminsky and Reinhart (2000), highlights the relationship between international creditor fragilities and contagious financial crises. In this channel, international creditors' losses in a crisis-stricken country cause a reduction in lending to other emerging market countries.

The vast literature on capital flows has attributed "sudden stops" to both push and pull factors. Push factors are related to global shocks and contagion (a shock to a country or groups of countries that spreads to other countries), whereas pull factors are attributed to domestic fundaments (Forbes and Warnock, 2011). Groundbreaking papers on capital flows (Calvo et al., 1993, 1996; Chuhan et al., 1998) highlight the role of push factors such as interest rates and economic growth differentials in explaining flows to emerging markets but have also found a role for pull factors (e.g., country credit ratings).

The literature has examined a variety of pull factors. Kaminsky (2008) focuses on fiscal and current account deficits and economic growth as pull factors and shows that high integration in international markets would expose countries to sudden stops even in the absence of such vulnerabilities. Calvo et al., (2008) highlight the destabilizing role of short-term bank funding, while the findings in Forbes (2010) suggest a role for financial market development.

The literature on the credit retrenchment during the global crisis has highlighted the role of creditor effects as an important push factor. Cetorelli and Goldberg (2010) show how international creditors propagate liquidity pressures across emerging markets. Kamin and Pounder (2010) find spillover effects also in advanced economies through financial firms' dependence on U.S. dollar funding. Cerutti (2013), Cerutti and Claessens (2014), and Cerutti (2014) provide evidence of the importance of global financing conditions as a transmission channel in international financial markets. De Haas and van Lelyveld (2011) and Claessens and Van Horen (2012) show that countries with larger foreign bank presence experienced a larger reduction in international borrowing. The role of bank capitalization in the choice of syndicated vs. non-syndicated loan instruments is studied in Cerutti et al. (2014).

Another important topic in the research on the global credit retrenchment is related to the possibility of contagion through exposure to distressed foreign assets. Rose and Spiegel (2009) find that exposure to the United States through financial or trade channels did not have contagious effects on other countries. Milesi-Ferretti and Tille (2011) attribute the credit retrenchment to a rise in global risk aversion triggered by the size of risky financial assets, which affected more financially integrated countries.

In a ground-breaking paper, Shin and Adrian (2008) show the relationship between the credit retrenchment during the global crisis and the procyclicality of bank leverage. The rationale is based on the rules of mark-to-market accounting under which changes in asset prices are reflected in banks' capital. During asset booms, higher asset prices are associated with higher bank balance sheet asset values and higher bank capital ratios, which lead to an increase in lending. Conversely, asset price busts lead to lower balance sheet asset values and capital ratios. Banks' weaknesses reduce their demand for borrowing as they need to shrink their balance sheets to adjust to their lower capital levels. This causes a decline in bank lending (see Appendix I). The role of local currency appreciation as an important push factor boosting bank leverage and risk taking is highlighted in Bruno and Shin (2013).

This paper broadens the empirical analysis of the credit retrenchment to consider borrower fragilities. It also contributes to the universe of indicators used to analyze risks from financial interconnectedness. Prior research has typically focused on the size of international exposures, abstracting from their risk characteristics. The paper proposes novel indexes of cross-border counterparty risk that are calculated using Bank for International Settlements (BIS) International Banking Statistics and Moody's KMV bank distress probabilities.

The risk-based approach of the paper has several advantages. First, incorporating counterparties' risk characteristics provides another dimension for the analysis. Second, the use of high frequency counterparty risk indicators sheds light on the evolution of cross-border risks during the crisis. Third, risk-weighted exposures are a more reliable measure of the riskiness of banks’ international portfolios. Although creditors tend to reduce their exposure to crisis-stricken countries, their risk-weighted exposure may still be substantial due to the concomitant increase in counterparties’ distress probabilities. Finally, the indexes by construction would capture simultaneous risks from multiple counterparties.

3. Stylized facts

The analysis is based on the BIS Consolidated International Banking Statistics, which provide information about member banking systems' international risk exposures.[4]

The International Banking Statistics are available on locational and consolidated bases. The two data compilation methods differ in their treatment of banks' foreign affiliates. In the consolidated statistics, a banking system's cross-border lending is consolidated with lending by its foreign affiliates. However, intra-group lending is netted out and only the net exposure is included in the total. Conversely, in the locational statistics, cross-border lending is not consolidated with that by foreign affiliates and intra-group lending is not netted out.

The analysis was based on the consolidated dataset for the following reasons. First, this dataset provides a comprehensive measure of lending, which includes both cross-border lending by the head office and local lending by foreign subsidiaries. This is important for example for the measurement of deleveraging effects at the group level, which may affect lending through foreign subsidiaries. Second, netting out intra-group lending helps assess the net external exposure of the group. Third, the bilateral exposures needed for the construction of counterparty risk indexes are publicly available only from the consolidated statistics.

The international interbank market is an informal market, where banks lend to one another. The amounts contracted are large, typically above one million U.S. dollars, and the maturities vary between overnight and six months, but sometimes exceed one year (BIS Paper 8). The

[4] BIS defines "banks" as depository institutions other than the central bank, which include commercial banks, savings banks and other nonbank depository institutions (BIS Paper No 16).

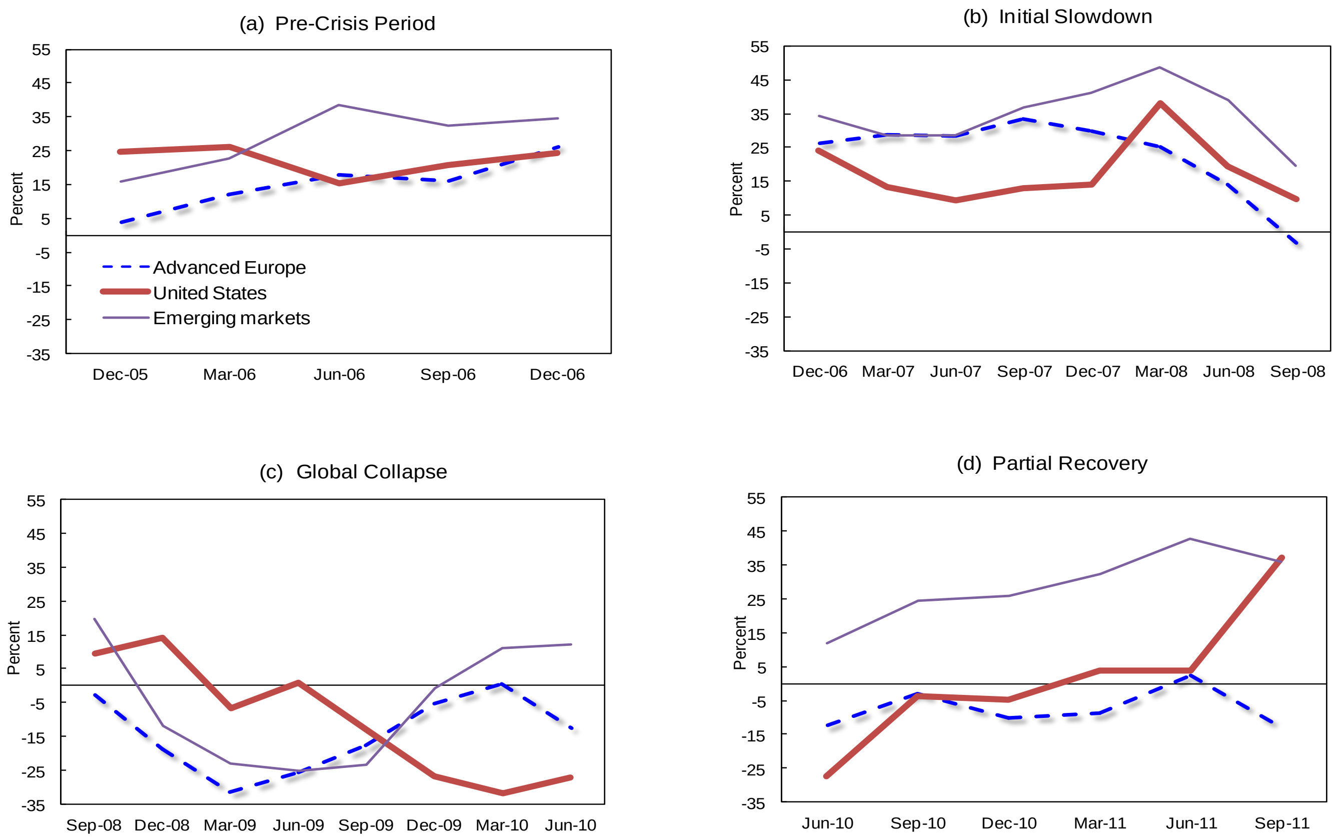
market has substantial cross-border volume. Interbank flows are sensitive to counterparty risk considerations since bank dealers differentiate between banks based on their creditworthiness in determining the credit limits granted to clients and the price of the on-lent funds. International bank borrowing collapsed dramatically in the wake of the global financial crisis. Total international claims on banks stood at 7.6 trillion U.S. dollars at end-June 2012, down from 12 trillion U.S. dollars in March 2008. The evolution of international bank borrowing during this period could be divided in three periods with distinct characteristics: (i) an initial slowdown from September 2007 to September 2008; (ii) a global collapse from September 2008 to June 2010; and (iii) a partial recovery in emerging markets from June 2010 to June 2011.[5] The first period shows divergent trends, with borrowing decelerating in advanced Europe but advancing in emerging markets and the United States (Figure 1). The second period starts with the Lehman Brothers' failure in September 2008, when bank borrowing contracted on a global scale. In the third period, lending to emerging markets mostly recovered, but lending to advanced Europe remained depressed.

Overall, the BIS data suggest that advanced banking systems were hit harder by the retrenchment. International lenders shifted some of their lending away from advanced economies into emerging markets during the first and last periods under investigation. Therefore, emerging market borrowing continued to grow during these periods, although at a decelerating pace. Figure 2 shows the cumulative change in international borrowing from December 2007 until September 2011. The data reveal a continued slowdown in lending to advanced economies and a partial rebound in lending to emerging markets.

[5] Milesi-Ferretti and Tille (2011) document similar trends for total capital flows.

Figure 1. International Bank Borrowing, December 2005–September 2011

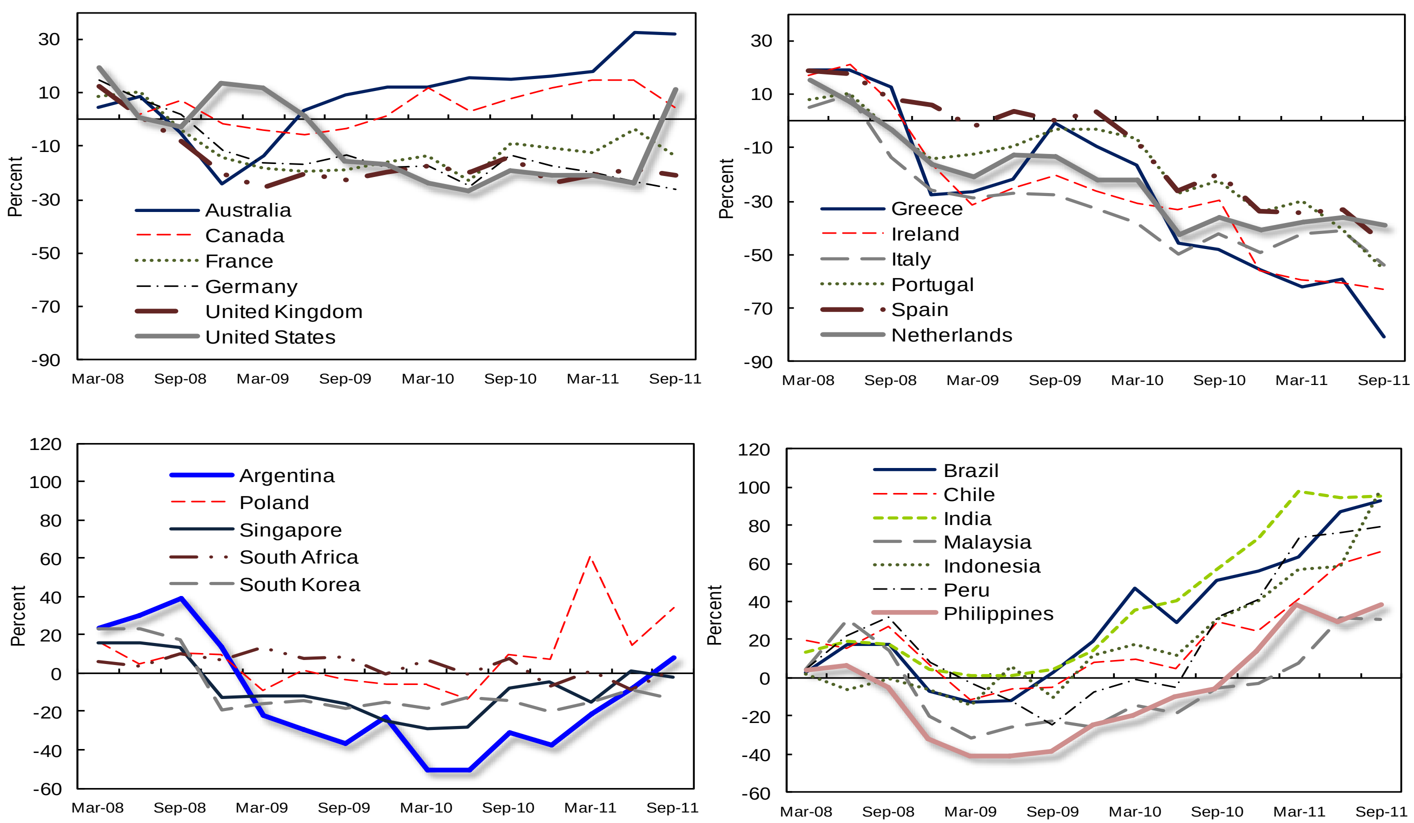
(Percentage change, y-o-y)



Source: Bank for International Settlements Consolidated International Banking Statistics (immediate borrower basis).

Figure 2. Cumulative Change in International Bank Borrowing, December 2007–September 2011

(Cumulative percentage change from December 2007)



Source: Bank for International Settlements Consolidated International Banking Statistics (immediate borrower basis).

4. The borrower and creditor channels

I argue that the liquidity pressures in international interbank markets during the global crisis were to a large extent driven by increased cross-border counterparty risk. By definition, counterparty risk is the risk to each party of a contract that the counterparty may default on its contractual obligations. In a lending contract, a creditor agrees to provide funds to a borrower, who assumes the obligation to repay them. Hence, banks are exposed to counterparty risk both through their borrowing and lending. Lenders are exposed to credit risk since their borrower may default on the loan. Borrowers are exposed to liquidity risk since their lender may default on its obligation to provide the agreed upon funds.

A banking system may have difficulties accessing interbank markets for various reasons. First, the borrower country may already have domestic banking problems. Second, its banking system may have risky international exposures, which could lead to future problems. Third, there may be domestic macroeconomic fragilities, which increase the probability of banking distress. Finally, a banking system may still face liquidity pressures even in the absence of all these risks if it relies for funding on distressed foreign creditors, whose problems may spill over into the domestic market.

It follows from above that a banking system's liquidity pressures may be driven by its own fragilities or by its dependence on distressed foreign creditors. In the first case, creditors would reduce lending to that banking system to decrease their exposure to credit risk. I define this case as a "borrower channel" because its effects are driven by borrower fragilities.

In the second case, foreign creditors curtail lending to a borrower regardless of its risk characteristics in order to adjust to their lower capital levels or to offset risks stemming from other borrowers. The effects in this case are related to the "creditor channel" because they are caused by creditor fragilities.

Both channels can lead to direct and indirect spillover effects. Direct effects are triggered by direct linkages to a crisis-stricken country. However, the absence of direct linkages would not always shield a banking system from distress, because it could be still affected by indirect spillovers through common counterparties.

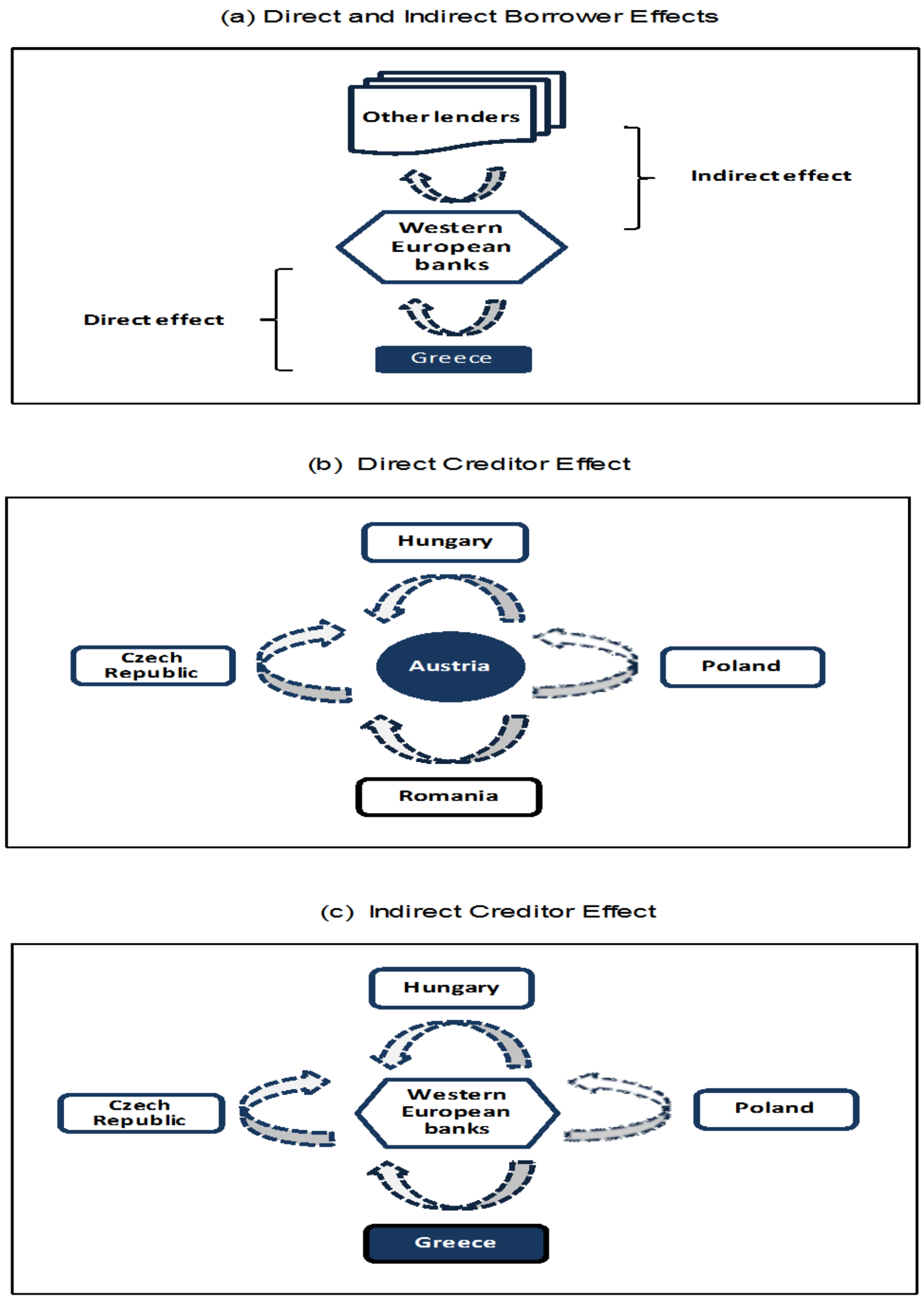
Indirect spillovers can arise in the context of the creditor channel. For example, Kaminsky and Reinhart (2000) show that dependence on a common creditor can trigger indirect spillovers from a crisis country to other borrower countries that are otherwise not directly exposed to the initial crisis using data on foreign bank exposures to Asia and Latin America.

Indirect effects may also arise in the context of the borrower channel. For example, lenders that do not lend directly to a crisis-stricken country may still be affected through their lending to other banking systems that are exposed to an initial crisis. Such lenders may precautionary reduce lending to banking systems that are heavily exposed to the crisis country. In this case, banking systems with large exposures to a distressed common borrower could be simultaneously cut off from funding by other lenders.

Figure 3a illustrates the mechanism that leads to borrower effects in the context of the global crisis. In this figure, Western European banks are exposed directly to Greece, while other advanced banking systems are exposed to Greece only indirectly, through their lending to Western European banks. Western European banks may pull back from Greece because they are directly exposed to the Greek crisis. However, other advanced banking systems may reduce lending to Western European banks to limit their indirect exposure to the Greek crisis.

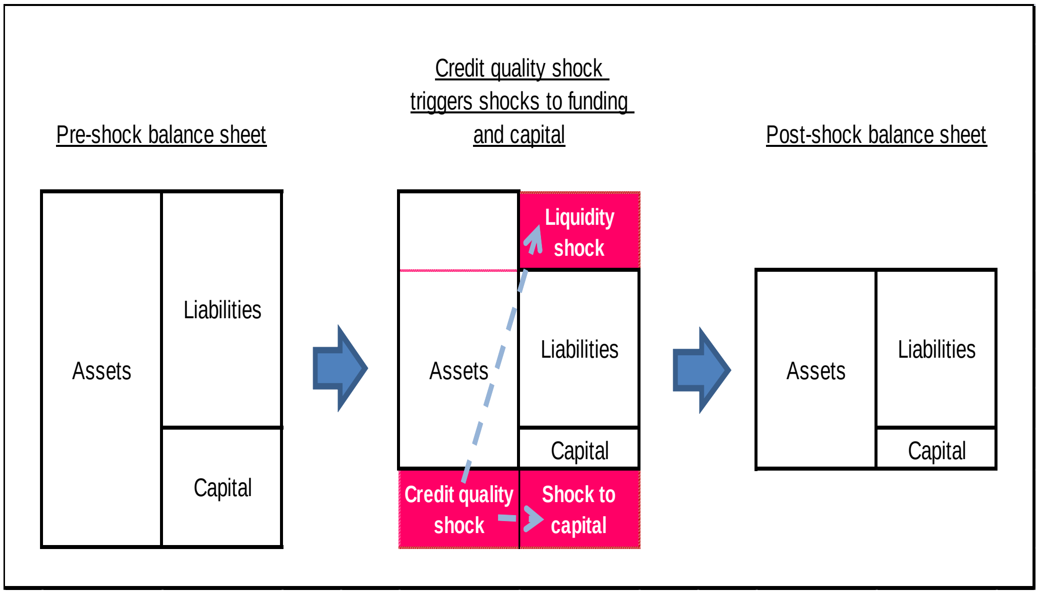
Figures 3 b-c show hypothetical examples of direct and indirect creditor effects. The examples focus on Western European banking systems, which are important providers of liquidity to banks from Eastern Europe. On the one hand, Figure 3b shows an example of a direct creditor effect, in which Austrian banks' soundness deteriorates and they cut back on lending to Eastern Europe. On the other hand, Figure 3c shows another example, in which the pullback of Western European banks from Eastern Europe is triggered by a crisis event in a third country (e.g., Greece), to which most East European banks are exposed only indirectly.

Figure 3. Borrower and Creditor Effects [1/]



1/ These are hypothetical and highly stylized examples used only for illustration purposes. Trigger countries are in blue, dashed arrows indicate a reduction in cross-border lending.

Figure 4. The Bank Balance Sheet Effects of Credit Quality Shocks



The global crisis originated in advanced banking systems, which tend to play a dual role as lenders and borrowers in international interbank markets and are therefore prone to mutually reinforcing borrower and creditor effects. On the one hand, banks facing liquidity pressures may retrench from international lending. On the other hand, banks facing credit quality problems are likely to suffer also from liquidity pressures. Figure 4 shows how simultaneous credit and liquidity pressures could exacerbate banks' balance sheet contraction.

5. Empirical model

The empirical analysis aims to decompose the factors driving international bank borrowing during the global crisis using a cross-country panel model. In the model, a banking system's international bank borrowing is a function of a set of borrower and creditor risk characteristics:

$$\%\Delta Borrowing_{j,t} = \alpha + \beta' \, BorrowerRisk_{j,t-1} + \gamma' \, CreditorRisk_{j,t-1} + \varepsilon_{j,t} \qquad (1)$$

where $\%\Delta Borrowing_{j,t}$ denotes the percentage change in total international liabilities of banking system *J* to all BIS-reporting banking systems in quarter *t* (year-on-year).

$BorrowerRisk_{j,t-1}$ is a vector of variables capturing the fragility of banking system *J* and its macroeconomic environment at time *t-1*, $CreditorRisk_{j,t-1}$ is a vector of variables capturing the fragilities of banking systems lending to banking system *J*, α is the intercept, β and γ are vectors of coefficients, and $\varepsilon_{j,t}$ is a random disturbance.

The dependent variable is defined as the change in international claims by all BIS lenders on each of the banking systems in the sample. According to the BIS definition, international claims include both cross-border claims and local claims of the banking systems' foreign affiliates in the country, denominated in foreign currency.

The model assumes that creditors are able to differentiate among borrowers based on their risk characteristics. Thus, the borrower risk vector includes indicators of each borrower's banking system distress probability, the risk profile of its international lending, and the fragility of its macroeconomic environment.

5.1 Borrower distress probability (credit risk index)

I use Moody's KMV Expected Default Frequencies (EDFs) to measure the distress probabilities of the banking systems in the sample. EDFs are calculated for individual banks and nonbanks from equity prices and accounting information. They measure economic solvency, which is a more reliable and timely indicator than book capital (see Appendix II for details on the methodology and Appendix V for summary definitions of the variables).

I employ the median EDF of each banking system as a summary measure of its distress probability. The variable represents a credit risk index because it measures the risk to international creditors from lending to a particular banking system. Hence, the index summarizing the credit risk of banking system J is defined as follows:

$$CreditRiskIndex_{j,t} = \text{median}(EDF_{Bank1}, EDF_{Bank2}, \ldots, EDF_{BankN}) \quad (2)$$

where EDF_{Bankj}, $(j=1,\ldots,N)$ are the EDFs of individual banks in banking system J.

The banking system distress probability enters in the estimation as a measure of the credit risk that each banking system represents to its international lenders. As a market-based indicator, EDFs should reflect the effects of both domestic and international risk factors. Ideally, to separate domestic from international effects, one needs to use different variables for each factor in the regressions. However, indicators that capture the effects of purely domestic risk factors on bank distress are not readily available. Therefore, I include in the model the EDF of the domestic banking system and the international exposure indexes in the next section. In this specification, the EDF would capture "residual" domestic banking fragilities that are not explained by the banking system's international exposures.

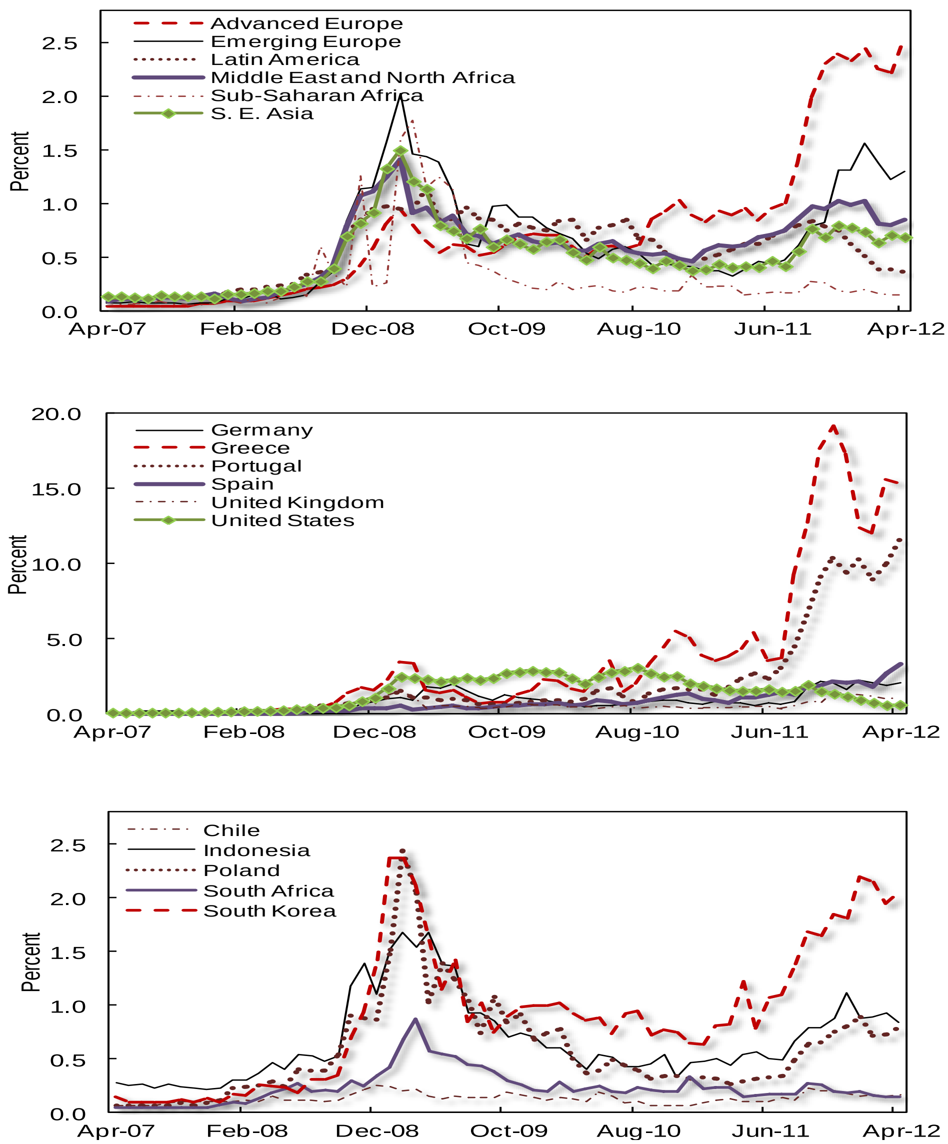
Figure 5 plots the evolution of EDFs for selected banking systems during the crisis. The EDFs show substantial variation. They remain low until mid-2008 but then increase sharply in countries reporting subprime losses. The increase is particularly steep and broad based in the wake of the Lehman Brothers' collapse in September 2008. The EDFs come down in late 2009 – early 2010 with the gradual stabilization of the U.S. and European banking systems but rise sharply again in Europe in 2011 on the eve of the euro area sovereign crisis.

5.2 Indirect credit risk index

Banking systems could face reduced access to international borrowing even in the absence of a domestic crisis if their credit portfolio is heavily exposed to a crisis-hit country. For example, if a banking system has large exposures to Greece, other lenders may reduce their lending to that banking system to limit their indirect exposure to the Greek crisis. In this context, banking systems with large exposures to an initial trigger country that is in crisis may also become secondary targets of credit withdrawals by other lenders.

Figure 5. Banking System Expected Default Frequency (EDF)

(Moody's KMV 1-year median EDF)



Source: Moody's KMV Creditedge.

To measure indirect credit risk, I construct an index that combines each banking system's bilateral international credit exposures with the distress probabilities of its borrower banking systems. The index summarizes the risk profile of each banking system's lending to the rest of the world. In the index, each banking system's bilateral credit exposures are multiplied by its borrowers' distress probabilities and divided by its domestic credit. The index could be interpreted as the banking system's expected loss rate on international lending. These potential losses may not be fully incorporated in banking systems' distress probabilities (EDFs) at any point in time owing to informational asymmetries and lags in the shock transmission. The indirect credit index of banking system *J* at time *t* is given by:

$$IndirectCreditRiskIndex_{j,t} = \sum_{i=1}^{k} w_{i,t} EDF_{i,t} \qquad (3)$$

where $w_{i,t}$ denotes total lending by banking system *J* to banking system *I* at time *t* , expressed as a percent of banking system *J's* domestic credit, $EDF_{i,t}$ denotes the median distress probability of banking system *I* at time *t*, and *k* is the number of banking systems borrowing from banking system *J*. [6]

5.3 Liquidity risk index

As discussed above, undercapitalized lenders tend to reduce lending to adjust to their lower capital levels. The deleveraging process shrinks their balance sheets, causing a liquidity squeeze to their major borrowers. Therefore, banking systems that rely heavily for funds on distressed creditors are likely to experience liquidity pressures. Hence, borrower banking systems' exposure to liquidity risk emanating from distresses creditors is summarized by the following liquidity risk index:

$$LiquidityRiskIndex_{j,t} = \sum_{i=1}^{l} V_{i,t} EDF_{i,t} \qquad (4)$$

[6] Ideally, the weights should measure lending by banking system *J* to banking system *I*. However, since bilateral bank credit is not publicly available, I use as a proxy the total foreign claims of banking system *J* on country *I*, which include bank lending to both banks and nonbanks.

where $v_{i,t}$ denotes the liabilities of banking system *J* to banking system *I* at time *t*, expressed as a percent of banking system *J's* domestic credit, $EDF_{i,t}$ denotes the median distress probability of banking system *I* at time *t*, and *l* is the number of banking systems that lend to banking system *J*.[7]

By analogy with borrower solvency, creditor solvency depends on both domestic and international factors. Ideally, to isolate the two effects, one would use different variables for domestic and international factors. Since such variables are not readily available, I use the banking system median EDF as a catch-all measure of solvency. In some specifications, I focus specifically on indirect liquidity effects triggered by creditors' lending to other banking systems, which are summarized by the indirect liquidity risk index below.

5.4 Indirect liquidity risk index

I attempt to differentiate between the impact of domestic and cross-border risk factors on global liquidity conditions. Hence, I construct another variant of the index, in which the international liabilities of banking system *J* are multiplied by the indirect credit risk indexes of its creditors and divided by its domestic credit. The indirect credit risk index is a measure of the risk profile of each creditor's international portfolio.

The variable represents an "indirect liquidity risk index" because it captures spillover effects through distressed banking systems that do not lend directly to banking system *J* but may still impact its liquidity by affecting the capital position of their common creditors. Common creditors may withdraw from lending to banking system *J* when confronted with rising risks in their international portfolios. The indirect liquidity risk index is defined as follows:

[7] Ideally, the index should be based on the bilateral liabilities of banking system *J* to other banking systems. However, since this information was not publicly available, the index was calculated using the liabilities of country *J* to banking system *I*, which include liabilities of both banks and nonbanks.

$$IndirectLiquidityRiskIndex_{j,t} = \sum_{i=1}^{l} V_{i,t}\, IndirectCreditRiskIndex_{i,t} \qquad (5)$$

where $V_{i,t}$ denotes the liabilities of banking system *J* to banking system *I* at time *t*, expressed as a percent of banking system *J*'s domestic credit, $IndirectCreditRiskIndex_{i,t}$ is the indirect credit risk index of banking system *I* at time *t* as defined in (3), and *l* is the number of banking systems lending to banking system *J*.

Appendix III Figure 7 shows the credit and liquidity risk indexes of the banking systems in the sample. By and large, the decline in international borrowing appears related to banking systems' exposure to cross-border counterparty risk. While the pullback from countries like Greece and Portugal seems largely driven by their domestic fragilities, indirect credit risk seems to matter for banking systems with extensive international lending (e.g., France, Switzerland, Sweden). Finally, direct and indirect liquidity effects appear relevant for emerging markets and smaller European banking systems (e.g., Mexico, Singapore, Poland).

5.5 Macroeconomic fragilities

The global crisis was associated not only with cross-border financial risks but also with domestic macroeconomic fragilities. First, dollar shortages triggered sharp currency depreciations against the U.S. dollar. Second, the crisis led to a significant deterioration in countries' fiscal performance. Third, demand for international credit shrank sharply during the crisis because of the sharp slowdown in global demand and growth.

Therefore, I use variables measuring currency risk, economic growth, and fiscal performance to control for borrower countries' macroeconomic fragilities. The first variable measures currency depreciation and is defined as quarterly percentage change in the bilateral exchange rate against the U.S. dollar, expressed as U.S. dollars per unit of borrower currency. The third variable is defined as the ratio of borrower country's fiscal balance to GDP and measures fiscal pressures. The third variable measures growth in real Gross Domestic Product (GDP) and is used as a proxy for aggregate demand effects.

5.6 Data caveats

The analysis faced data limitations, which do not detract from the generality of the results.

First, data on bilateral lending needed for the indirect credit risk indexes are available only for BIS members. However, the sample still has adequate coverage since these banking systems account for the bulk of total international lending. Second, EDFs were not available for some of the major borrowers of the Australian and Greek banking systems. However, in the case of Australia, the missing data are for New Zealand, which was not significantly affected by the crisis. In the case of Greece, the missing data are for some countries from Eastern Europe (e.g., Bulgaria, Cyprus and Romania), which were not among the crisis countries during the sample period. The EDFs cover at least 80 percent of the international credit portfolios of the remaining banking systems in the sample.

The interpretation of the indexes should also take into account the following considerations. First, the credit and liquidity risk indexes have different composition, and thus, limited direct comparability. The indirect credit risk index covers exposures to 57 banking systems, while the liquidity indexes cover exposures only to 22 banking systems due to data limitations. Since both borrowing and lending exposures are scaled by the same denominator, the indirect credit risk index would generally have higher values.

Second, the numerator and denominator of the indexes are compiled on different bases. The numerator represents consolidated data for domestic banks, while the denominator is based on credit to the private sector obtained from the International Monetary Fund's International Financial Statistics and therefore includes lending by all resident banks, including foreign subsidiaries.[8]

Third, there are also differences between the compilation of the dependent variable and the cross-border indexes. While international bank borrowing on immediate borrower basis is

[8] However, this is suitable for the analysis because excluding foreign subsidiaries from the denominator would significantly underestimate the size of systems with large foreign bank ownership.

compiled on a "residency" basis and includes borrowing by all banks resident in the country, the cross-border indexes measure risks faced only by domestic banks. Nevertheless, the banking systems in many advanced economies, where such risks are pronounced, are composed mainly of domestic banks. An important advantage of using immediate borrower basis is that borrowers' risk characteristics can be linked to the risk condition of particular countries, including their macroeconomic environment.[9]

5.7 Breaks in the series and exchange rate conversion effects

Since BIS data have multiple breaks, I include in the model a dummy identifying the date of each break. Moreover, I adjust the data directly in the sensitivity analysis that follows for breaks using the values provided by BIS on their website. It is also worth noting that the BIS data are an aggregation of exposures in different currencies, which are converted into U.S. dollars at the market exchange rate and would be affected by exchange rate movements. However, adjusting for exchange rate effects requires some assumptions. Therefore, I start with unadjusted data and then re-estimate the model with adjusted data in Section 7.

6. Empirical findings

My sample consists of 38 countries that are covered both by the BIS International Consolidated Banking Statistics and by the IMF Global Data Source Database (GDS). GDS was used to obtain quarterly macroeconomic variables for the regression analysis. I divide the sample in three subsamples covering advanced economies (18), advanced Europe (15), and emerging markets (15) (Table 1).

The formal analysis was conducted in two steps. In the first step, I use statistical techniques in order to investigate whether there is sufficient heterogeneity in the dependent credit variable and to show that the change in borrowing does do represent a generalized outflow. I perform mean-comparison tests that search for heterogeneity in the dependent variable within subsamples, across subsamples, and across time periods. For that purpose, I divide

[9] For example, borrowers would be more concerned about lending to a Greek bank in Greece than about a Greek-owned subsidiary in another country with more sound macroeconomic fundamentals.

the sample in two periods covering the immediate crisis from September 2007 to June 2010 and the partial recovery in emerging markets from September 2010 to September 2011.

Table 1. Country Sample

Advanced economies	**Emerging markets**
Australia	Argentina
Austria	Brazil
Belgium	Chile
Canada	Colombia
Denmark	Hong Kong SAR
Finland	India
France	Indonesia
Germany	Israel
Greece	Malaysia
Ireland	Mexico
Italy	Peru
Japan	Philippines
Netherlands	Poland
Portugal	Singapore
Spain	South Africa
Sweden	South Korea
Switzerland	Thailand
United Kingdom	Turkey
United States	Venezuela

The tests compared the mean changes in international bank borrowing in the top and bottom quartiles of each subsample, between subsamples, and between time periods. The results revealed statistically significant heterogeneity, confirming the anecdotal evidence that advanced economies, particularly in Europe, were hit harder by the retrenchment (Table 2).

Table 2. International Bank Borrowing: Mean-Comparison Tests, September 2007–September 2011

(Percentage change, y-o-y)

	Mean 1 [1/]	Mean 2 [2/]	Difference (Mean1-Mean 2)	T-statistic	Pr(|T| > |t|)
Cross-quartile tests					
Full sample	-27.1	48.0	-75.1	-50.4	0.00
Advanced banking systems	-30.0	32.5	-62.5	-34.4	0.00
Advanced Europe	-32.5	32.2	-64.7	-31.8	0.00
Emerging banking systems	-21.9	60.5	-82.4	-39.1	0.00
Cross-sample tests					
Advanced banking systems/Emerging banking systems	-0.5	16.1	-16.6	-7.3	0.00
Advanced Europe/Other banking systems	-3.2	14.7	-17.8	-7.7	0.00
Cross-period tests					
Full sample	4.9	10.9	-6.0	-2.3	0.02
Advanced banking systems	3.1	-9.3	12.4	4.2	0.00
Advanced Europe	1.4	-14.2	15.6	4.5	0.00
Emerging banking systems	8.2	33.4	-25.2	-6.5	0.00

Note: Large outliers (Colombia, Israel, Peru, Venezuela, Mexico, and Poland) have been excluded from the mean comparison tests.

1/ The column shows: (i) in the section "Cross-quartile tests" the mean percent change in international bank borrowing in the bottom quartile of each subsample; (ii) In the section "Cross-sample tests" the mean percent change in international bank borrowing by advanced and European banking systems, and (iii) in the section "Cross-period tests" the mean value in the respective subsample over the September 2007-June 2010 period.

2/ The column shows: (i) in the section "Cross-quartile tests" the mean percent change in international bank borrowing in the top quartile of each subsample; (ii) in the section "Cross-sample tests" the mean percent change in international bank borrowing by emerging and non-European banking systems, and (iii) in the section "Cross-period tests" -- the mean value in the respective subsample over the September 2010-September 2011 period.

Several emerging markets emerged as outliers and were excluded from the analysis. Large outliers defined as countries in which the change in international liabilities exceeded 80 percent in at least one quarter were excluded both from the mean comparison tests and the regression analysis. These countries include Israel, Mexico, Peru, and Poland in the first period, and Colombia, Israel, Peru, and Venezuela in the second period. Among advanced economies, Japan was excluded from the regression analysis because of its large credit inflows at the height of the crisis, which appear mainly related to the reversal of yen carry trades. Standard influential observation tests identified Japan, Mexico, Peru, and Venezuela as outliers (see Section 7). The results are qualitatively similar when all outliers are included in the estimation.

Next, I use multivariate panel regression analysis in order to disentangle the drivers of international bank borrowing during the crisis period. The regression model was estimated on quarterly data for the period September 2007-June 2010, which covers both the slowdown and collapse stages of the crisis (immediate crisis period). Additional analysis was also performed on available data up to September 2011 (extended period).

I fit the model on the full sample and three subsamples covering advanced economies, advanced Europe, and emerging markets.[10] The estimation explored the significance of up to four lags of the explanatory variables and several econometric specifications, including fixed effect and random effect panels. The preferred specification is with fixed effects and the borrower distress probability is included contemporaneously, while all other variables are included with one lag. The liquidity risk indexes are included separately in alternative specifications because they are collinear by construction[11] For comparability, specifications 1-8 omit the indirect credit risk index, which is available only for advanced banking systems.[12] Tables 3-4 summarize the findings for the immediate crisis period and for the extended period, respectively.

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[10] The groups of advanced economies and advanced Europe overlap substantially.

[11] For each country they depend on the same portfolio of international liabilities.

[12] BIS data on lending to other countries on immediate borrower basis for the period under investigation is available only for 22 banking systems from 18 advanced and 4 emerging economies in the sample. Therefore, I can construct the indirect credit risk index only for advanced and European banking systems.

Table 3. Panel Data Analysis: Immediate Crisis Period

Estimation period: September 2007–June 2010, quarterly data, fixed effects
Dependent variable: percent change in international bank borrowing (y-o-y)

	Full Sample		Advanced Banking Systems		Advanced Europe		Emerging Banking Systems		Advanced Banking Systems 1/		Advanced Europe 1/	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
Cross-border counterparty risk												
Credit risk index (t)	-6.699***	-6.905***	-5.024***	-4.043***	-3.525**	-2.680	-9.034***	-9.814***	-5.771***	-4.814***	-4.325**	-3.441**
	(1.400)	(1.425)	(1.546)	(1.546)	(1.688)	(1.661)	(2.482)	(2.509)	(1.580)	(1.576)	(1.734)	(1.713)
Indirect credit risk index (t-1)									-5.580**	-5.549**	-5.589*	-4.938*
									(2.827)	(2.659)	(3.117)	(2.961)
Liquidity risk index (t-1)	-28.960***		-30.368***		-28.127***		-24.429***		-24.121***		-22.327***	
	(5.189)		(7.433)		(7.865)		(7.713)		(8.025)		(8.451)	
Indirect liquidity risk index (t-1)		-21.641***		-28.261***		-27.327***		-17.654**		-24.659***		-24.051***
		(4.811)		(5.570)		(5.772)		(8.527)		(5.782)		(6.065)
Control variables												
Depreciation (t-1) 2/	1.125***	1.146***	1.608***	1.588***	1.834***	1.804***	0.526*	0.533*	1.555***	1.530***	1.753***	1.727***
	(0.168)	(0.170)	(0.184)	(0.180)	(0.227)	(0.220)	(0.306)	(0.312)	(0.184)	(0.180)	(0.230)	(0.224)
Real GDP growth (t-1)	1.694***	1.684***	2.367***	2.228***	2.738***	2.542***	1.694***	1.697***	1.968***	1.740***	2.317***	2.106***
	(0.328)	(0.352)	(0.547)	(0.515)	(0.593)	(0.549)	(0.457)	(0.504)	(0.579)	(0.561)	(0.634)	(0.605)
Fiscal balance to GDP (t-1)	0.289	0.399*	0.053	0.099	0.062	0.102	0.771*	0.915**	0.089	0.110	0.094	0.114
	(0.225)	(0.226)	(0.243)	(0.233)	(0.250)	(0.240)	(0.419)	(0.424)	(0.241)	(0.231)	(0.249)	(0.239)
Statistical breaks dummy	-3.091	-3.161	-1.598	-1.913	-1.259	-1.490	-20.407	-20.073	-1.893	-2.156	-1.559	-1.731
	(3.314)	(3.365)	(2.899)	(2.835)	(3.031)	(2.945)	(12.803)	(13.065)	(2.880)	(2.812)	(3.014)	(2.931)
Constant	16.711***	14.930***	14.578***	15.079***	13.138***	14.052***	19.382***	16.514***	16.391***	17.336***	15.173***	16.156***
	(2.182)	(2.180)	(2.267)	(2.086)	(2.551)	(2.330)	(4.347)	(4.492)	(2.430)	(2.333)	(2.775)	(2.637)
Number of observations	372	372	204	204	168	168	156	156	204	204	168	168
R-squared	0.44	0.42	0.55	0.55	0.57	0.58	0.39	0.34	0.59	0.59	0.61	0.61

Note: standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

1/ The estimates in these columns include indirect credit risk effects.
2/ Quarterly percentage change in the nominal exchange rate, defined as US dollars per unit of domestic currency.

Table 4. Panel Data Analysis: Extended Period

Estimation period: September 2007–September 2011, quarterly data, fixed effects
Dependent variable: percent change in international bank borrowing (y-o-y)

	Full Sample		Advanced Banking Systems		Advanced Europe		Emerging Banking Systems		Advanced Banking Systems 1/		Advanced Europe 1/	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
Cross-border counterparty risk												
Credit risk index (t)	-9.595***	-9.478***	-7.890***	-8.300***	-7.663***	-8.284***	-10.903***	-10.492***	-8.035***	-8.295***	-7.792**	-8.228**
	(1.074)	(1.061)	(0.943)	(0.942)	(0.984)	(0.993)	(2.692)	(2.675)	(0.931)	(0.921)	(0.969)	(0.964)
Indirect credit risk index (t-1)									-7.454***	-8.985***	-8.284***	-10.347***
									(2.587)	(2.428)	(2.898)	(2.764)
Liquidity risk index (t-1)	-9.643**		-39.127***		-43.176***		5.560		-29.047***		-32.081***	
	(4.135)		(5.159)		(5.474)		(6.036)		(6.176)		(6.639)	
Indirect liquidity risk index (t-1)		-14.089***		-31.662***		-33.749***		0.447		-22.939***		-23.381***
		(4.178)		(4.452)		(4.780)		(7.552)		(4.947)		(5.407)
Control variables												
Depreciation (t-1)	1.025***	0.980***	1.221***	1.114***	1.249***	1.103***	0.446	0.453	1.172***	1.079***	1.184***	1.063***
	(0.175)	(0.175)	(0.173)	(0.178)	(0.204)	(0.214)	(0.337)	(0.338)	(0.172)	(0.174)	(0.202)	(0.208)
Real GDP growth (t-1)	1.440***	1.292***	0.436**	0.283	0.366*	0.234	2.787***	2.790***	0.349*	0.211	0.269	0.150
	(0.212)	(0.217)	(0.208)	(0.215)	(0.217)	(0.227)	(0.414)	(0.428)	(0.207)	(0.211)	(0.216)	(0.221)
Fiscal balance to GDP (t-1)	0.765***	0.685***	0.377	0.530**	0.391	0.572**	0.845**	0.781*	0.377	0.461**	0.381	0.494**
	(0.227)	(0.227)	(0.235)	(0.232)	(0.247)	(0.246)	(0.406)	(0.408)	(0.232)	(0.227)	(0.243)	(0.240)
Statistical breaks dummy	-0.722	-0.577	-1.005	-1.039	-0.744	-0.926	-5.362	-5.012	-0.927	-0.893	-0.640	-0.722
	(3.400)	(3.379)	(2.823)	(2.854)	(2.974)	(3.041)	(11.568)	(11.587)	(2.785)	(2.788)	(2.926)	(2.955)
Constant	15.011***	16.458***	18.842***	18.169***	19.127***	18.144***	9.807**	11.737***	20.202***	20.317***	20.773***	20.653***
	(1.969)	(1.980)	(1.884)	(1.887)	(2.134)	(2.178)	(4.165)	(4.393)	(1.918)	(1.933)	(2.178)	(2.219)
Number of observations	527	527	289	289	238	238	221	221	289	289	238	238
R-squared	0.30	0.31	0.42	0.40	0.43	0.41	0.25	0.26	0.48	0.48	0.49	0.49

note: *** p<0.01, ** p<0.05, * p<0.1

1/ The estimates in these columns include indirect credit risk effects.
2/ Quarterly percentage change in the nominal exchange rate, defined as US dollars per unit of domestic currency.

The empirical findings indicate that the effects of both the creditor and borrower channels on international bank borrowing are statistically significant. On the creditor side, international creditors' deleveraging appears to have contributed significantly to the decline in international borrowing. The liquidity risk index is statistically significant (typically at the 1 percent level) and economically meaningful for advanced economies and Europe in both periods and for emerging markets in the immediate crisis period. The size of the coefficient is larger during the immediate crisis period, when a 1 percentage point increase in the index leads to a 29 percent reduction in borrowing.

The analysis also reveals statistically significant indirect creditor effects. An increase of 1 percentage point in the indirect liquidity risk index leads to declines in international borrowing of 22 percent and 14 percent in the immediate and extended periods, respectively. Indirect liquidity effects are stronger in the immediate crisis period and for advanced and European economies.

On the borrower side, the results point to a strong association between borrower banking systems' distress probabilities and their access to international funding. An increase of 1 percentage point in the borrower banking system distress probability is associated with a decline in its international borrowing of 6.7 percent and 9.6 percent in the two periods, respectively. The borrower effect appears stronger in emerging markets, where a 1 percentage point increase in the borrower banking system's distress probability leads to a 10 percent decline in borrowing.

The significance of borrower risk characteristics is consistent with anecdotal evidence of increased segmentation in interbank markets during the crisis. This evidence suggests that international creditors became more selective in their lending decisions, particularly with regards to higher risk borrowers. Previous empirical research on the global retrenchment seems to have ignored this effect, which may lead to overestimation of the impact of other factors. The borrower effect appears stronger in the extended period, when creditors may have become less panic driven and more discriminating in their lending decisions.

Indirect borrower effects are also statistically significant. This result suggests that banking systems with riskier international lending faced a larger reduction in their access to international funding. The indirect credit risk index is statistically significant and economically meaningful for banking systems from advanced economies and Europe.[13] The indirect credit risk index is significant at the 5 percent level for advanced economies in the immediate crisis period and at the 1 percent level in the extended period. In the extended period, a 1 percentage point increase in indirect credit risk is associated with a decline of 8 percent in international borrowing.

The results indicate that borrowers' access to international funding during the crisis was also related to their macroeconomic fragilities. The variable measuring currency depreciation is statistically significant at the 1 percent level across a range of specifications. Although this effect may be partially driven by the mechanical conversion of credit in other currencies to U.S. dollars, sharp depreciations would typically be reflected in widening of the credit risk premiums and tightening of borrowing conditions.

Apart from currency risk, economic growth and fiscal risks also emerged as important macroeconomic determinants of borrowers' access to international bank funding. GDP growth is statistically significant (at the 1 percent level) across all specifications for the immediate crisis period. The fiscal variable is significant for emerging markets in both periods and for advanced and European economies in the extended period.

7. Sensitivity analysis

In the section that follows I conduct sensitivity tests with the view to test the robustness of the results, which may be negatively affected by exchange rate conversion effects, breaks in the series, and omitted variables. First, I adjust the data for exchange rate conversion effects. Second, I control for statistical breaks in the series. Third, I estimate an extended model specification, which controls for the presence of foreign banks in borrower countries. Fourth, I add the outliers that were previously excluded from the analysis and re-estimate the model.[14] Finally, I perform post-estimation diagnostic tests of the model's statistical properties.

[13] Data limitations prevented the assessment of such risks in emerging markets.

[14] I include previously excluded outliers such as Mexico, Peru, Poland, Colombia, and Israel but still exclude Japan because its large positive inflows during the crisis are largely related to the reversal of carry trades. I also exclude

7.1 Exchange rate adjustments

First, I adjust the dependent variable for the effects of foreign currency conversions. BIS data are expressed in U.S. dollars but some of the countries' international exposures are denominated in other currencies. Therefore, changes in the dependent variable would partly reflect the effects of the currency conversion. This analysis was constrained by data limitations because exchange rate adjustments are available from BIS only for the Locational International Banking Statistics.

Given these limitations, I adjust for exchange rate conversion effects following the approach in Cerutti (2013). Cerutti (2013) uses the currency composition of lending in the BIS locational statistics to make adjustments to the consolidated statistics. The methodology rests upon the assumption that the currency composition of the locational and consolidated statistics is similar. Thus, I adjust the data using the exchange rate adjusted changes reported in the locational statistics after controlling for differences in the size of the claims with the consolidated statistics.

7.2 Breaks in the series

Second, I adjust the data for reported breaks in series. The adjustment exploits information provided by the BIS on its website on changes in the reporting methodology followed by each country. Such changes can be broadly divided in three categories:

The first category includes changes in the reporting population. For instance, in March 2009 the addition of the former U.S. investment banks to the reporting population increased the international claims reported by the United States by 734 billion U.S. dollars. Not correcting for this statistical discrepancy may distort the pattern of U.S. lending during this period.

The second category includes adjustments for previous misreporting due to data quality issues, changes in accounting principles, etc. For instance, in March 2010 there was an upward

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Venezuela from the estimation for the extended period due to four extreme observations in the period June 2010-June 2011. The conclusions of the analysis do not change if they are included in the estimation.

adjustment to Australia's international claims in the amount of 9.98 billion U.S. dollars due to improvements in data quality.

The third category includes bank restructurings, closures, sales, mergers and acquisitions. For example, in December 2009, France acquired a foreign bank and reported an increase of 229 billion U.S. dollars in its international claims. It is worth noting that some of the merger and acquisition claims may not have an impact on total BIS lending if they simply represent a transfer of claims from one BIS reporter to the other. However, information on this is often missing. There are 46 breaks in the period September 2007-September 2011. I adjust for 40 breaks, excluding six mergers and acquisitions that seem unlikely to affect total BIS lending.

7.3 Controlling for foreign bank presence

Third, I extend the model to control for foreign bank presence in the borrower country. Earlier research has shown that foreign bank presence was negatively correlated with access to international funding during the crisis (Claessens and Van Horen, 2012; De Haas and Van Lelyveld, 2011).

To investigate the effects of foreign bank presence, I include in the model a variable measuring the percentage of bank assets owned by foreigners in each borrower country. The variable was taken from a recent research paper on foreign bank ownership (Claessens and Van Horen, 2012). Consistent with prior research, I expect that banking systems with larger foreign bank presence would suffer from steeper declines in international borrowing.

7.4 Results of the robustness analysis

I fit the regression model on the adjusted data, using an extended specification that also includes the foreign bank ownership variable. The results, reported in Table 5, are broadly consistent with prior findings.

First, the borrower distress probability is significant at the 1 percent level across the various specifications, suggesting that the soundness of borrower banking systems mattered for their access to international funding. Second, the liquidity risk index is also statistically significant. One difference with the previous results is that the bank deleveraging effects are now significant also for emerging markets in both periods. Third, the indirect credit risk index is statistically significant at the 5 percent and 10 percent levels in advanced economies and Europe, respectively, for the immediate crisis period and at the 1 percent level for the extended period.

Fourth, the foreign bank presence variable is statistically significant at 5 percent and 10 percent in the full sample and for emerging markets, respectively but it is not significant for advanced and European banking systems.[15] The significance of this variable for emerging markets is consistent with previous findings that larger dependence on foreign banks during the crisis was associated with steeper declines in international borrowing.

The impact of the macroeconomic variables is qualitatively similar. GDP growth is significant in most specifications with the exception of that for advanced and emerging economies during the extended period. Depreciation is statistically significant in most specifications excluding that for emerging economies, while the fiscal balance to GDP variable is not statistically significant.

Overall, the results of the sensitivity analysis indicate that the findings are robust to the adjustments for exchange rate effects and breaks in the series, which improve the statistical significance of some of the variables. They also suggest that emerging markets with higher foreign bank presence suffered from a steeper deterioration in access to international borrowing.

7.5 Diagnostic tests

I perform several post-estimation diagnostic tests. First, I examine the residuals and test for influential observations. Second, I calculate standard measures of collinearity such as the variance inflation factor and the condition index. Third, I perform a Hausman specification test in order to compare the results under alternative fixed effect and random effect specifications.

[15] Although the variable is statistically significant, the cross-sectional fit of the regression deteriorates markedly, leading to a large decline in R-squared.

Table 5. Panel Data Analysis: Sensitivity Tests on Adjusted Data

Estimation period: September 2007–September 2011, quarterly data, fixed effects
Dependent variable: percent change in international bank borrowing adjusted for exchange rate effects and breaks (y-o-y)

	Immediate crisis period				Extended period				Immediate crisis period (with foreign bank presence)	
Variables 1/	**Full Sample**	**Advanced Banking Systems**	**Advanced Europe**	**Emerging Banking Systems**	**Full Sample**	**Advanced Banking Systems**	**Advanced Europe**	**Emerging Banking Systems**	**Full Sample**	**Emerging Banking Systems**
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Cross-border counterparty risk										
Credit risk index (t)	-8.013***	-5.973***	-4.543**	-11.320**	-10.238***	-7.781***	-7.546***	-13.919***	-8.628***	-12.144**
	(2.740)	(1.799)	(2.015)	(5.389)	(1.737)	(1.037)	(1.092)	(4.755)	(2.742)	(5.369)
Inidirect credit risk index (t-1)		-6.932**	-6.568*			-9.225***	-9.462***			
		(3.215)	(3.619)			(2.882)	(3.268)			
Liquidity risk index (t-1)	-37.424***	-28.533***	-25.516***	-35.714***	-25.267***	-38.827***	-42.191***	-17.192**	-35.727***	-36.915***
	(8.684)	(9.132)	(9.824)	(13.331)	(5.686)	(6.874)	(7.482)	(8.590)	(8.679)	(13.255)
Foreign bank presence (t)									-0.847**	-1.404*
									(0.391)	(0.722)
Control variables										
Depreciation (t-1) 2/	0.652**	1.200***	1.436***	0.067	0.645**	0.924***	0.987***	-0.012	0.625**	0.063
	(0.301)	(0.210)	(0.267)	(0.555)	(0.260)	(0.191)	(0.228)	(0.501)	(0.300)	(0.551)
GDP growth (t-1)	1.715***	1.830***	2.257***	1.794*	1.321***	-0.091	-0.177	2.804***	1.868***	2.047**
	(0.607)	(0.658)	(0.734)	(0.937)	(0.336)	(0.231)	(0.244)	(0.704)	(0.609)	(0.939)
Fiscal balance to GDP (t-1)	0.020	-0.040	-0.034	0.445	0.444	0.187	0.194	0.561	-0.038	0.311
	(0.429)	(0.274)	(0.289)	(0.867)	(0.359)	(0.258)	(0.273)	(0.704)	(0.428)	(0.864)
Constant	25.512***	22.463***	21.197***	30.780***	26.416***	26.678***	27.320***	27.623***	43.952***	69.460***
	(3.968)	(2.700)	(3.121)	(8.175)	(2.909)	(2.097)	(2.400)	(6.528)	(9.381)	(21.487)
No. of observations	444	204	168	228	612	289	238	306	444	228
R-square	0.19	0.55	0.57	0.14	0.16	0.47	0.48	0.14	0.06	0.01

Note: Standard errors in parenthesis. ***p<0.01, **p<0.05, *p<0.1.

1/ The data are adjusted for exchange rate effects and breaks in the series.All variables are expressed as percentages.

2/ Quarterly percentage change in nominal exchange rate (U.S. dollars per unit of domestic currency).

I use a standard DFITS test to identify influential outliers. The DFITS statistic represents roughly the number of standard deviations by which the fitted value changes when each observation is removed from the dataset. Outliers are defined as observations for which |DFFITS| > 1 for small to medium size datasets or DFITS > 2*sqrt (K/n) for large datasets.

Since I have a large dataset, I use the second criterion. I identify 15 outliers based on a cutoff value of the DFITS statistic of 0.19. I have 11 positive outliers (Venezuela, Peru, Mexico, and Japan) and four negative outliers (Spain, Greece, and Portugal). Venezuela stands out as an extreme outlier with a DFITS value of 1.7 on one observation in the period June 2010-June 2011. Appendix IV Figure 8 plots fitted values versus residuals after excluding these outliers.

Next, I test for multicollinearity using standard measures such as the variance inflation factor and the condition index. The tests did not detect serious problems with multicollinearity. The inflation factor and the condition index are well below standard cutoff points. The variance inflation factor has an average value of 2.26, which is well below the cutoff point of 10 (Appendix IV Table 6). The condition number is 8, which is below the cutoff point of 30.

I also run pairwise regressions on cross-border counterparty risk indexes, where collinearity issues may be more pronounced. The regressions indicate that collinearity is an issue only for the direct and indirect liquidity risk indexes, while other variables have low pairwise correlations. The two liquidity risk indexes are collinear by construction since for each country they are weighted by the same portfolio of bank liabilities. Hence, I estimate their impact separately.

Finally, I perform a Hausman test for fixed versus random effects. The test compares the differences in the estimated coefficients with fixed and random effects. The null hypothesis is that there are no systematic differences. Under the null, a random effects model would be the preferred option since it is the efficient estimator. However, a random effects estimator would be inconsistent if the null is rejected. In this case, a fixed effects model would be preferable because it is always consistent. I ran the test on data for both the immediate and extended periods. The null was rejected at the 1 percent level for both periods (Appendix IV Table 7). These results suggest that a fixed effect model would be more appropriate. This confirms the validity of the fixed effects panel regression approach used in the analysis.

7.6 Other robustness analysis

The estimation results above should be interpreted with caution since the model so far has not controlled for heteroskedasticity, residual autocorrelation, and endogeneity problems. First, cross-country heterogeneity may lead to heteroskedasticity problems. Second, regressing annual changes in the dependent variable on quarterly explanatory variables is likely to give rise to a third-order moving average process for the residuals. Third, the comovement in the dependent and independent variables may be driven by common shocks.

To control for heteroskedasticity and residual autocorrelation, I reestimate the regressions with the Driscoll-Kraay estimator, which controls for heteroskedasticity and correlated errors with moving average structure. The estimator can be implemented for panels with fixed effects. By contrast, panel data models are not supported by alternative estimators that control for residual autocorrelation (e.g., Newey-West estimator). Moreover, the Newey-West estimator does not correct for heteroskedasticity. The new estimates are consistent with prior findings (Table 8).

The dependent and independent variables can move together if they are exposed to common shocks that are not controlled for in the regressions. Such common shocks could trigger for example simultaneous changes in bank borrowing and bank fragility. To control for common shocks, I add to the model time-fixed effects and report the estimates in Table 9.

Overall, controlling for heteroskedasticity, residual autocorrelation, and common trends in global markets (proxied by the time-fixed effect), does not change significantly the results. The coefficients remain largely unchanged, with the exception of the coefficient of the liquidity risk index, which decreases somewhat but remains statistically and economically significant.

8. Conclusion

This paper uses an integrated framework to assess the impact of the borrower and creditor channels on international bank lending during the global crisis. The analysis, based on novel risk-weighted international exposure indexes, suggests that the credit retrenchment was not entirely driven by panic but related to borrowers' and creditors' risk characteristics. The paper finds that international lenders differentiated among borrower countries based on their banking system soundness, macroeconomic fragilities, and the risk profile of their international lending. Nevertheless, countries with heavy dependence on distressed international creditors faced reduced access to funding regardless of their risk profile.

Appendix I: The Balance Sheet Drivers of Bank Borrowing

The global financial crisis has spurred research on the linkages between banks' balance sheet fragilities and bank borrowing. The literature has proposed two main channels through which banks' balance sheet fragilities affect borrowing.

In the first channel, weaker banks borrow less because they need to shrink their balance sheets to adjust to their lower capital. In a seminal paper, Shin and Adrian (2008) show how mark-to-market accounting leads to procyclical bank leverage. They also and provide empirical evidence that banks adjust the size of their balance sheets in response to changes in asset prices. Under mark-to-market accounting rules, changes in asset prices are reflected in changes in banks' capital. Hence, asset price booms lead to higher balance sheet asset values and higher capital ratios while asset price busts lead to lower asset values and lower capital ratios.

A key proposition in the paper is that banks target a fixed leverage ratio (asset to capital ratio). Thus, banks borrow more when the value of their assets and capital increase. Conversely, they borrow less when the value of their assets and capital decrease. The argument is illustrated by the following stylized example, in which a bank holds on its balance sheet 100 worth of marked to market securities, financed with debt worth 90 and equity worth 10. The bank targets a fixed leverage ratio of 10 (100/10=10).

Assets	Liabilities
Securities, 100	Equity,10
	Debt, 90

Suppose the price of securities decreases by 1 percent to 99. On the liability side, the loss reduces the bank's capital from 10 to 9, while the value of debt remains constant.

Assets	Liabilities
Securities, 99	Equity,9
	Debt, 90

The shock drives up the bank's leverage ratio from 10 to 11 (99/9=11). To reduce leverage to the target level of 10, the bank sells securities worth 9 and uses the proceeds to pay down 9 worth of debt. Hence, the bank's balance sheet after the adjustment would be as follows:

Assets	Liabilities
Securities, 90	Equity,9
	Debt, 81

Although leverage is back to the target level, the bank's balance sheet has shrunk from 100 to 90. The marked to market loss of 1 is fully reflected in the reduction in capital, while the sale of assets leads to an equal reduction in the bank's debt holdings. Hence, the initial loss causes the bank to reduce lending, which in turn causes the bank to need less borrowed funds. The loss triggers a balance sheet contraction, resulting in a lower demand and supply of bank credit.

The above analysis links individual banks' demand for borrowing to the strength of their balance sheets. On the one hand, weaker banks borrow less in interbank markets because they are shedding assets and shrinking their balance sheets to adjust to their lower capital levels. On the other hand, the analysis shows that weaker banks that are confronted with balance sheet losses would cut down lending to stop the decline in their capital ratios.

The second set of models posits a link between interbank borrowing and counterparty risk. This line of argument is represented by Furfine (2001) and Flannery and Sorescu (1996). In these models, lenders have perfect knowledge of borrowers' condition and rationally differentiate among borrowers with different risk characteristics, charging higher interest rates to weaker borrowers. This leads to increased market segmentation and greater divergence in borrowing costs. In this framework, increased counterparty risk pushes up weaker banks' borrowing costs and they are unable to lend at competitive rates.

Empirical investigations of the factors driving the drying up of the federal funds market during the global financial crisis provide evidence of the effects of counterparty risk. Afonso et al., (2010) show that loan terms in the U.S. interbank market became more sensitive to borrower characteristics in the period immediately after Lehman Brothers' bankruptcy.

Appendix II. Moody's KMV Default Risk Methodology [16]

This appendix briefly reviews key features of Moody's KMV default risk modeling approach. Moody's KMV methodology is based on a proprietary model, which is a commercial application of the Merton (1974) structural, option-theoretic approach.

The Merton approach

A distinguishing feature of the Merton (1974) model is that it models explicitly the economic process underlying default. Corporate debt and equity are viewed as derivative securities on the firm's assets. The model assumes a firm that is financed only with common equity and one zero-coupon bond. With limited liability, equity holders have "the right" but not the obligation to "purchase" the assets from the bondholders by repaying the debt. Therefore, equity could be modeled as a call option on the firm's assets with a strike price equal to the debt payments. If at maturity the value of assets exceeds the value of the promised debt payments, equity holders will exercise the option to receive the residual payoff. Otherwise, they will default on the debt.

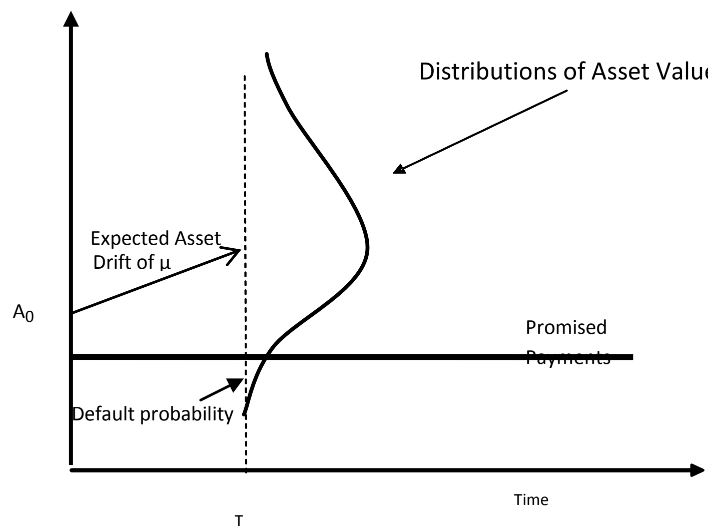
A central concept in the Merton (1974) model is the distance to default (DD), which measures the difference between the expected asset value and the default point, expressed in numbers of standard deviations. Lower DD is associated with higher probability of default. The DD formula follows directly from the assumed stochastic process for the firm's assets (see Gray et al., 2008). Let A(t) denote the value of the firm's assets at time *t*. The asset return process is defined as:

$$dA/A = \mu_A dt + \sigma_A \varepsilon \sqrt{t} \tag{6}$$

[16] The discussion in the appendix builds upon Gray et al., (2008).

where μ_A is the drift rate, σ_A is equal to the standard deviation of the drift rate, and ε is normally distributed, with zero mean and unit variance. The probability distribution at time T is shown in Figure 6 below.

Figure 6. Probability of Default in the Merton Model



Since default occurs when the value of the assets falls to or below the promised payments, B_t, the probability of default is the probability that $A_t \le B_t$ so that:

$$\Pr(A_t \le B_t) = \Pr\left(A_0 \exp\left[\left(\mu_A - \sigma_A^2/2\right)t + \sigma_A \varepsilon \sqrt{t}\right] \le B_t\right) = \Pr\left(\varepsilon \le -d_{2,\mu}\right) \qquad (7)$$

where the DD is given by:

$$d_{2,\mu} = \left[\ln\left(A_0/B_t\right) + \left(\mu_A - \sigma_A^2/2\right)t\right]\left(\sigma_A\sqrt{t}\right)^{-1} \qquad (8)$$

The probability of default is the area below the default barrier. Since the stochastic disturbance term is assumed to be normally distributed with zero mean and unit variance, the probability of default is $N(-d_{2,\mu})$, where $N(.)$ is the cumulative standard normal distribution.

Intuitively, the DD indicator can be interpreted as the firm's expected market net worth, adjusted for business risk. Leverage and asset volatility are key drivers of the DD and default risk in the model. Default is a function of the capital structure of the firm since higher leverage implies higher default point and lower DD. Default is also a function of asset volatility, which affects the likelihood that the asset value will fall below the default point.

The Moody's KMV approach

The Moody's KMV model is proprietary and its exact structure is not publicly disclosed. However, Moody's KMV has discussed key elements of the model in several methodological notes. Moody's KMV has modified the initial Merton approach in several areas. First, equity is assumed to be a perpetual option on the underlying assets, which never expires and can be exercised at any point in time. Therefore, default can occur at any point in time.

Second, the default point is time-varying and acts as absorbing barrier for the firm's asset value. Modeling the default barrier at different points in time enables the estimation of a default point term structure, which is used to calculate DDs and PD values at different time horizons. Finally, the default point is determined from financial statement data. For nonfinancial firms, the default point is set to equal short-term liabilities plus one half of long-term liabilities. For financial firms, the default point represents a fraction of total adjusted liabilities.

Moody's KMV calibrate the EDFs on real-world default rates using a proprietary database. Since credit risk is not normally distributed in practice, Moody's KMV map the DD values into EDFs using the empirical distribution of default rates. Under this approach, company-month observations are grouped into buckets with similar one-year DDs. Using thirty years of default information for a large number of companies, Moody's KMV can determine how many firms have defaulted in that bucket one year later.

The mapping process is based on the empirical default rate, defined as the ratio of the number of defaults to the number of DD observations. Moody's KMV repeats the mapping exercise for all buckets and fits a smooth function through each bucket that determines the EDF as a function of the DD. The EDF values are capped at 35 percent, the highest default rate observed in the data.

The two unknowns in the model, leverage and asset volatility, are estimated from equity prices and accounting information. Leverage is defined as the ratio of the default barrier to the economic (market) value of the firm's assets. To derive the economic value of assets, Moody's KMV exploits the market's assessment of the enterprise value as reflected in the firm's equity price. The market value of the firm's equity is derived by multiplying its equity price by the number of outstanding shares.

Although equity markets provide an assessment of a firm's future prospects, they generally do not reflect the firm's creditworthiness, which is a function of leverage and volatility. Therefore, the market value of equity and the firm's equity volatility and default barrier are used in an iterative procedure to derive the implied asset value and asset volatility, using the following relationships. First, the historical equity volatility is estimated from daily stock returns. Second, an initial guess for the asset volatility is substituted in the Black-Sholes-Merton formula. Finally, the asset value implied by the formula and the initial guess for the asset volatility are used to estimate the new asset return and its volatility, which are used in the next iteration. The procedure is repeated until two consecutive estimates converge.

Appendix III. Supplementary Figures and Tables

Figure 7. Cross-Border Counterparty Risk Indexes

(a) Advanced Banking Systems

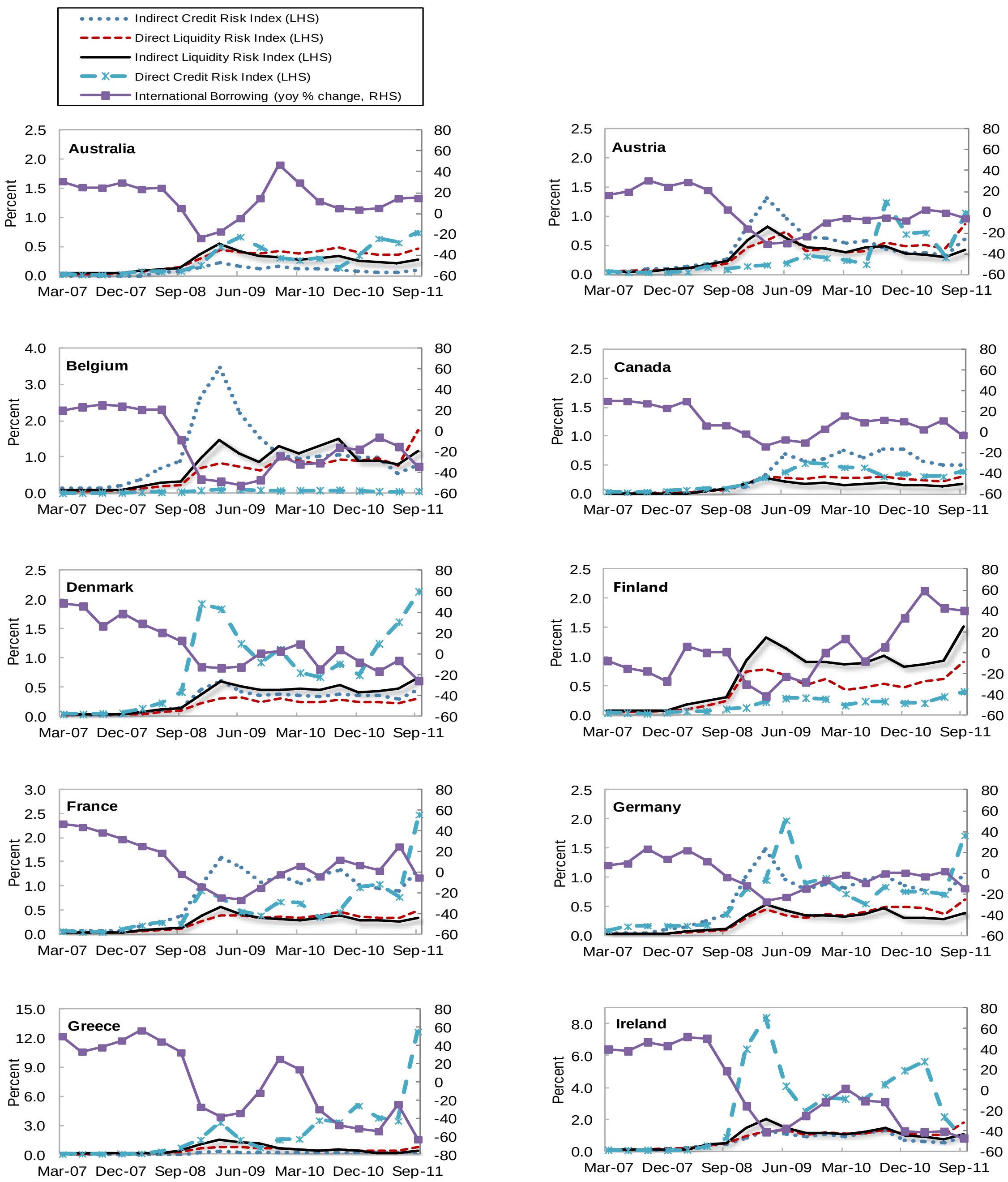


Figure 7. Cross-Border Counterparty Risk Indexes (continued)

(a) Advanced Banking Systems (Concluded)

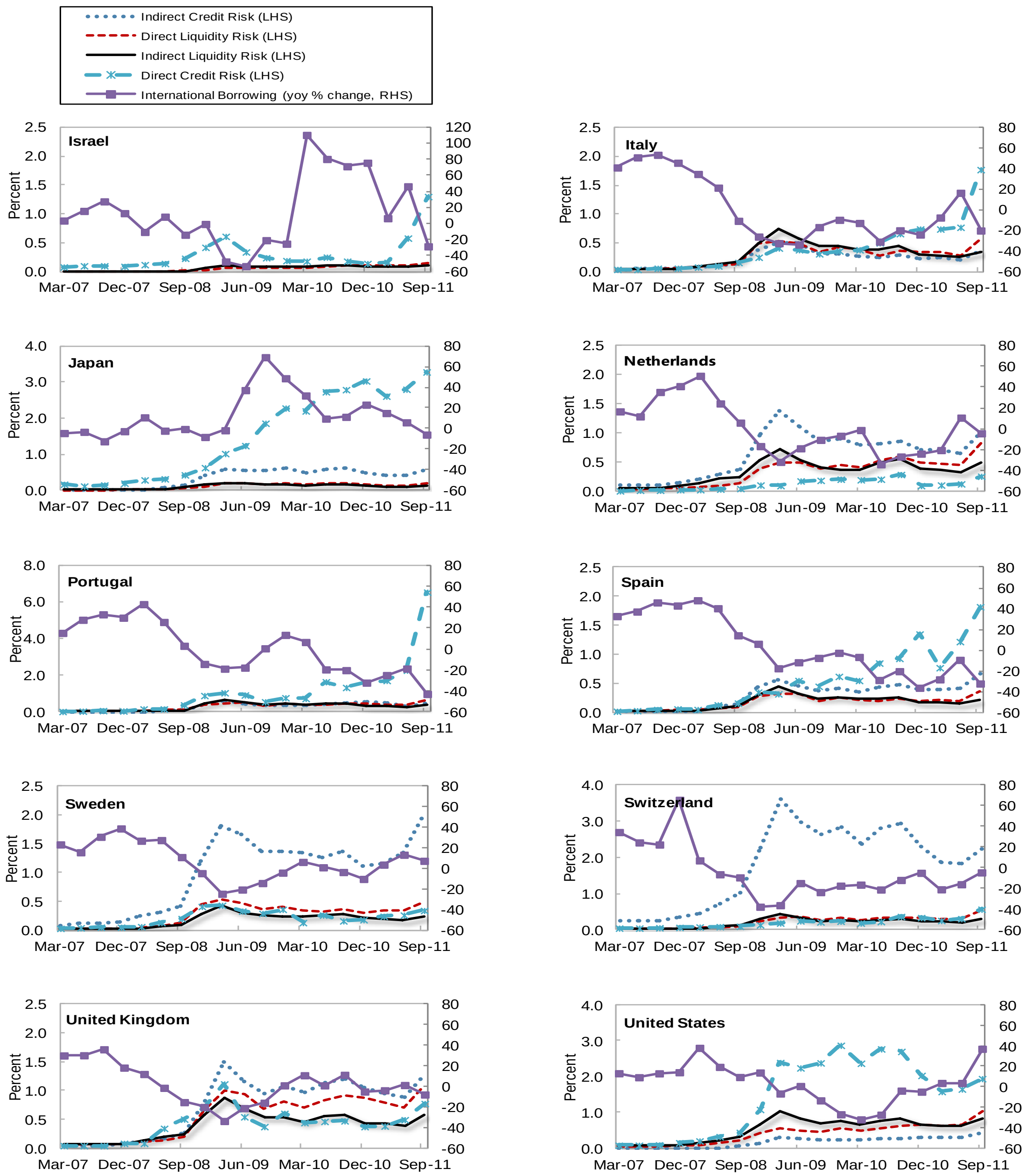


Figure 7. Cross-Border Counterparty Risk Indexes (continued)

(b) Emerging Banking Systems

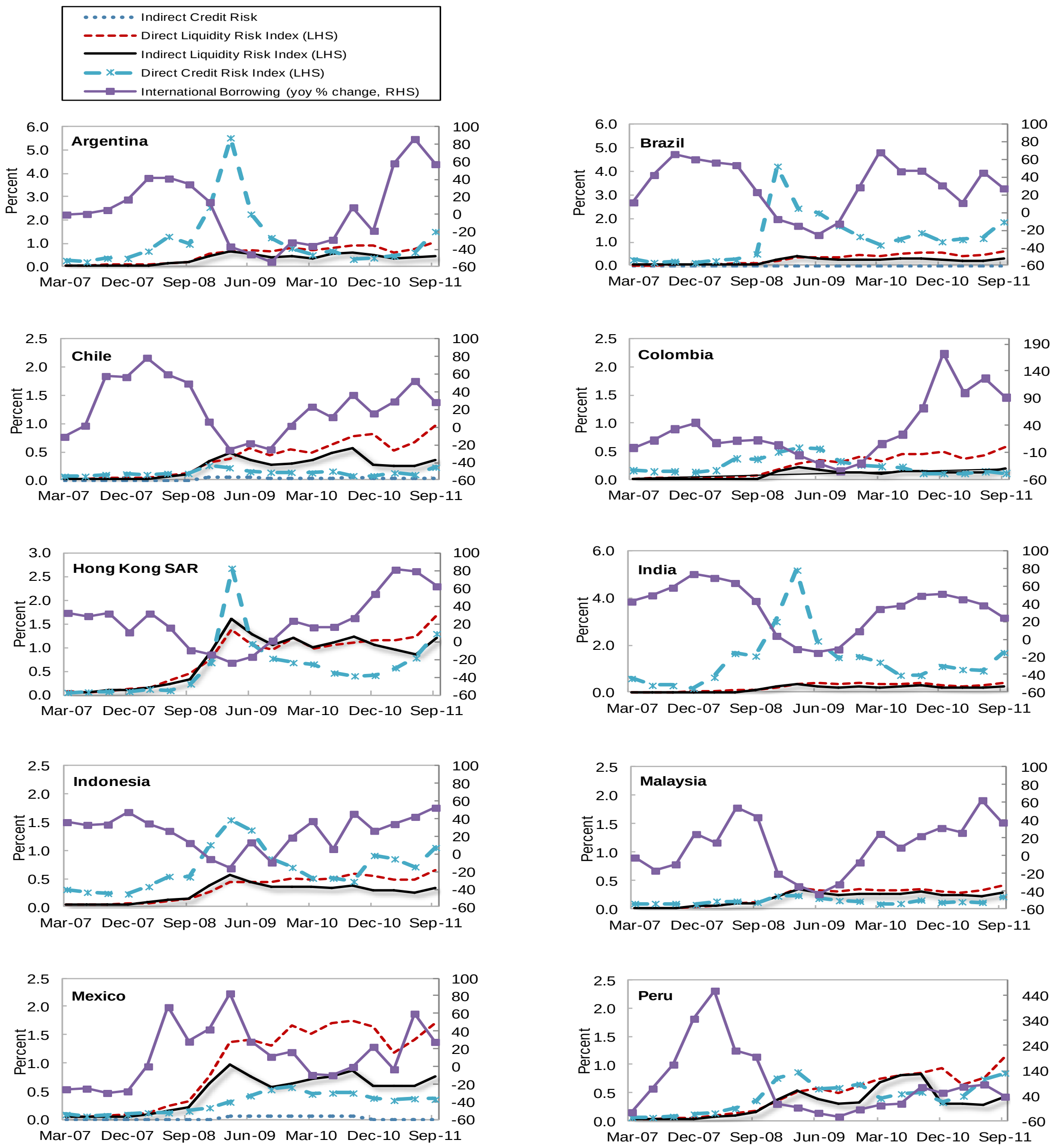
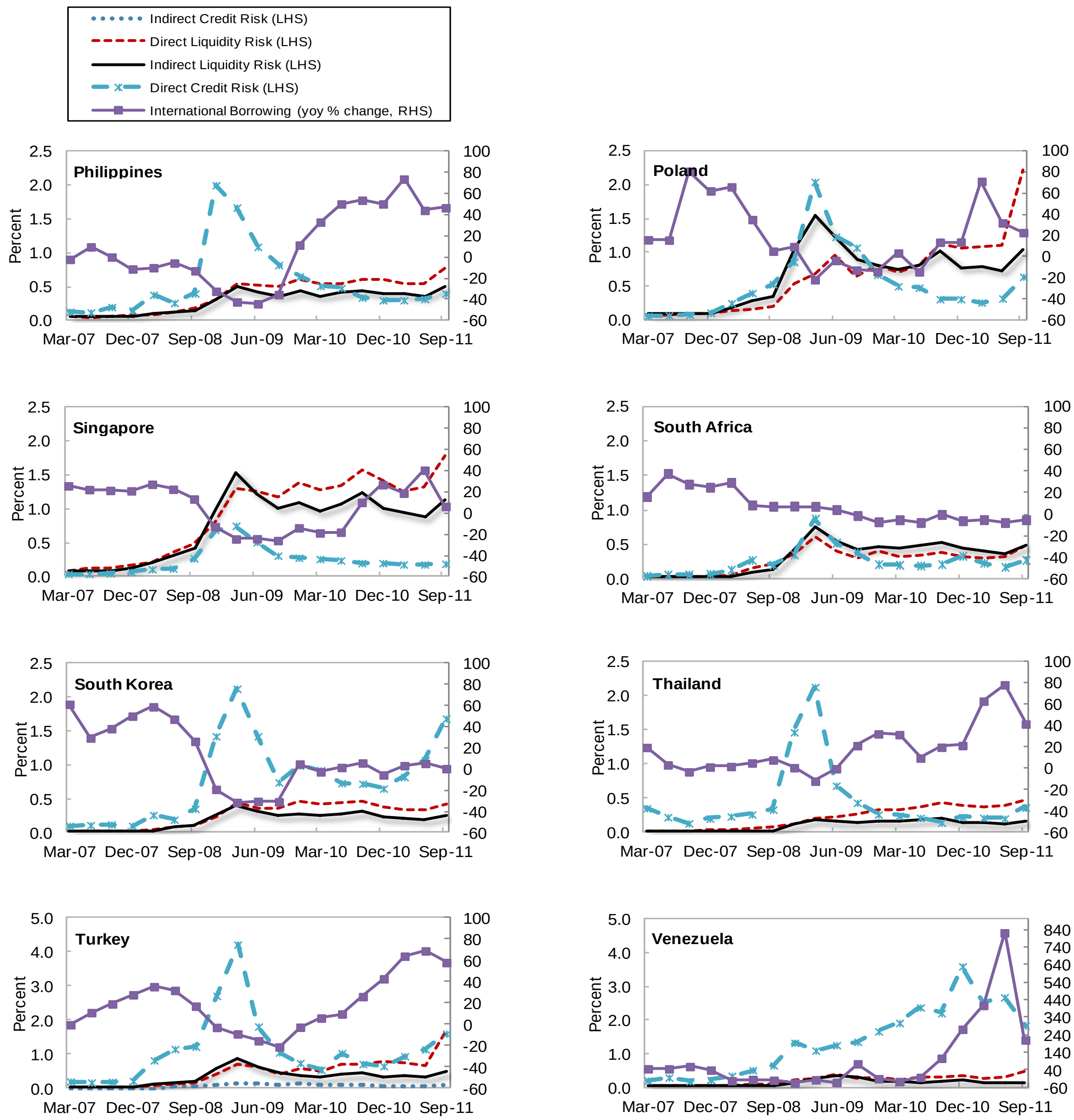


Figure 7. Cross-Border Counterparty Risk Indexes (continued)

(b) Emerging Banking Systems (Concluded)



Source: Bank for International Settlements Consolidated International Banking Statistics (immediate borrower basis).

Appendix IV. Diagnostic Tests

Figure 8. Residual Diagnostic Plot

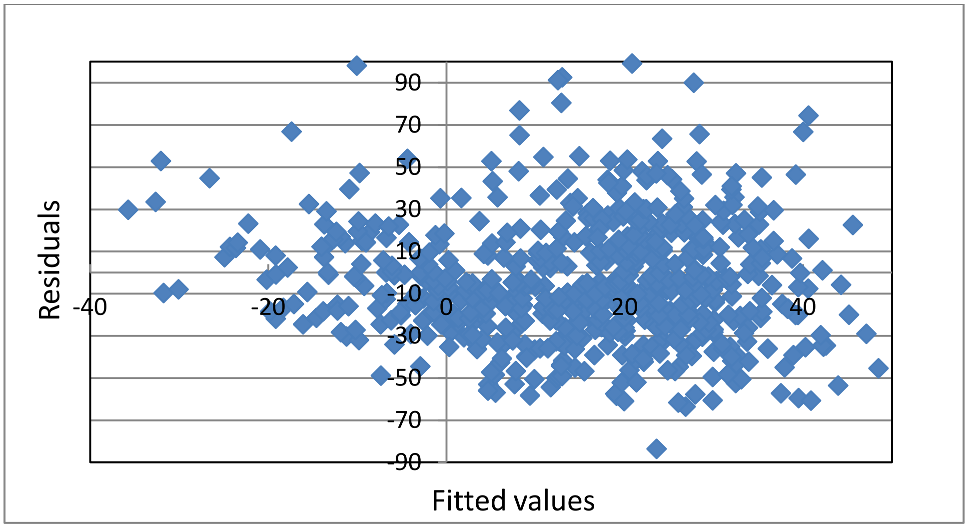


Table 6. Multicollinearity Tests

Variable	Variance inflation factor (VIF)	Sqrt (VIF)	Tolerance	Condition index
Credit risk index	1.56	1.25	0.64	1.00
Liquidity risk index	4.16	2.04	0.24	1.80
Indirect credit risk index	1.43	1.19	0.70	2.14
Indirect liquidity risk index	5.18	2.28	0.19	2.45
Foreign bank presence	1.45	1.20	0.69	2.96
Depreciation	1.10	1.05	0.91	3.21
GDP growth	1.70	1.30	0.59	4.50
Fiscal balance to GDP	1.52	1.23	0.66	4.82
Mean VIF	2.26			
Condition number	8.08			

Table 7. Hausman Test: Fixed versus Random Effects

Null hypothesis: Difference in coefficients is not systematic

	Coefficients			sqrt
	(b)	(B)	(b-B)	(diag (V_b-V_B))
	fixed	.	Difference	S.E.
Immediate crisis period				
Credit risk index	-8.40	-5.28	-3.12	1.08
Liquidity risk index	-31.01	-25.12	-5.88	3.56
Depreciation	0.57	0.69	-0.11	0.04
GDP growth	1.41	1.86	-0.45	0.25
Fiscal balance to GDP	0.23	0.15	0.08	0.15
		chi2(5) = 15.23		
		Prob>chi2 = 0.0094		
Extended period				
Credit risk index	-10.23	-7.99	-2.23	0.59
Liquidity risk index	-16.88	-13.60	-3.28	2.41
Depreciation	0.57	0.61	-0.03	0.02
GDP growth	1.19	1.49	-0.29	0.08
Fiscal balance to GDP	0.66	0.57	0.09	0.14
		chi2(5) = 25.87		
		Prob>chi2 = 0.0001		

Table 8. Heteroskedasticity and Autocorrelation-Robust Estimates 1/

(Estimation period: September 2007-September 2011, quarterly data)
Dependent variable: year-on-year percentage change in total bank borrowing

Variables [2/]	Full Sample	Advanced Economies	Advanced Europe	Emerging Economies
Cross-border counterparty risk				
Credit risk index (t)	-10.565***	-7.252***	-6.904***	-13.319***
	(1.562)	(1.296)	(1.186)	(1.874)
Indirect credit risk index (t-1)		-7.511**	-7.161**	
		(3.030)	(3.551)	
Liquidity risk index (t-1)	-17.777***	-31.502***	-33.422***	-10.124
	(5.129)	(7.720)	(8.706)	(7.768)
Control variables				
Depreciation (t-1) [3/]	0.752***	0.892***	0.971***	0.056
	(0.227)	(0.250)	(0.297)	(0.147)
GDP growth (t-1)	0.652	-0.114	-0.194	1.514***
	(0.490)	(0.223)	(0.212)	(0.356)
Fiscal balance to GDP (t-1)	0.584*	0.136	0.159	0.900***
	(0.355)	(0.183)	(0.201)	(0.342)
Constant	24.700***	20.662***	19.709***	26.227***
	(4.505)	(6.662)	(6.945)	(4.432)
Number of observations	609	289	238	303
R-squared	0.246	0.573	0.608	0.244

Note: Standard errors in parenthesis. ***p<0.01, **p<0.05, *p<0.1.

1/ Panel with fixed country effects and Driscoll-Kraay standard errors, which correct for heteroskedasticity and autocorrelation.

2/ All variables are expressed as percentages.

3/ Quarterly percentage change in nominal exchange rate (U.S. dollars per unit of domestic currency).

Table 9. Heteroskedasticity and Autocorrelation-Robust Estimates with Time Fixed Effects 1/

(Estimation period: September 2007-September 2011, quarterly data)
Dependent variable: year-on-year percentage change in total bank borrowing

Variables 2/	Full Sample	Advanced Economies	Advanced Europe	Emerging Economies
Cross-border counterparty risk				
Credit risk index (t)	-10.225***	-7.781***	-7.546***	-13.397***
	(1.885)	(1.503)	(1.559)	(4.839)
Indirect credit risk index (t-1)		-9.225***	-9.462***	
		(2.242)	(1.890)	
Liquidity risk index (t-1)	-16.879**	-38.827***	-42.191***	-4.936
	(7.361)	(9.266)	(9.515)	(9.043)
Control variables				
Depreciation (t-1) 3/	0.572**	0.924***	0.987***	-0.179
	(0.233)	(0.174)	(0.199)	(0.429)
GDP growth (t-1)	1.195**	-0.091	-0.177	2.437***
	(0.533)	(0.315)	(0.303)	(0.851)
Fiscal balance to GDP (t-1)	0.657**	0.187	0.194	0.900**
	(0.333)	(0.376)	(0.396)	(0.421)
Constant	22.458***	26.678***	27.320***	21.104***
	(3.456)	(2.713)	(3.189)	(6.311)
Number of observations	609	289	238	303
R-squared	0.185	0.473	0.478	0.142

Note: Standard errors in parenthesis. ***p<0.01, **p<0.05, *p<0.1.

1/ Panel with fixed country and time effects and Driscoll-Kraay standard errors, which correct for heteroskedasticity and autocorrelation.

2/ All variables are expressed as percentages.

3/ Quarterly percentage change in nominal exchange rate (U.S. dollars per unit of domestic currency).

Appendix V. Variable Definitions

Change in international bank borrowing: percentage change (y-o-y) in the quarterly international claims vis-à-vis banks. *Source:* BIS International Consolidated Banking Statistics on immediate borrower basis.

Credit risk index: Moody's KMV 1-year median Expected Default Frequency (EDF) for banking groups. *Source:* Moody's KMV Creditedge database. For some banking systems with missing data, the median EDF of the "financials" group was used instead.

Indirect credit risk index: sum of the banking system's foreign claims, weighted by borrowers' 1-year median EDFs, and divided by the banking system's total credit to the private sector. *Sources:* BIS Consolidated Banking Statistics on immediate borrower basis, Moody's KMV Creditedge database, and IMF International Financial Statistics.

Liquidity risk index: sum of the banking system's foreign liabilities, weighted by creditors' 1-year median EDFs, divided by the banking system's total credit to the private sector. *Sources:* BIS International Consolidated Banking Statistics on immediate borrower basis, Moody's KMV Creditedge, and IMF International Financial Statistics.

Indirect liquidity risk index: sum of the banking system's foreign liabilities, weighted by creditors' indirect credit risk index, and divided by the banking system's total credit to the private sector. *Sources:* author's calculations based on BIS International Consolidated Banking Statistics on immediate borrower basis, Moody's KMV Creditedge, and IMF International Financial Statistics.

Depreciation: quarterly percent change in the nominal exchange rate against the U.S. dollar, defined as U.S. dollars per unit of national currency. *Source:* IMF Global Data Source.

Real GDP growth: percent change in quarterly real GDP. *Source:* IMF Global Data Source.

Fiscal balance to GDP: quarterly fiscal balance as a percent of nominal GDP. Source: IMF Global Data Source. For Austria, Belgium, Greece and Portugal net operating balance since other data were not available. *Source:* IMF International Financial Statistics.

Statistical break dummy: the dummy variable identifies statistical breaks in the series based on a table published by BIS as an annex to the consolidated banking statistics. *Source:* BIS website.

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