Channels of Transmission of the 2007/09 Global Crisis to International Bank Lending in Developing Countries

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Abstract

During a financial crisis, credit provision by international banks may be stymied by three distinct, but related, channels: changes in lending standards as a result of increased economic uncertainty, changes in funding availability from interbank liquidity markets, and changes in solvency due to effects on bank balance sheets. This paper illuminates the manner by which each of these channels independently operated to affect developed-country bank lending in developing countries during

the global financial crisis of 2007/09. It quantifies how changes in banks' uncertainty about the value of their asset holdings, access to interbank liquidity, and internal balance sheet considerations altered their supply of credit in the run-up, during, and in the immediate aftermath of the financial crisis, both in terms of their relative magnitudes, as well as the sensitivity of these magnitudes to the crisis.

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1 Introduction

The economic environment that characterizes a financial crisis is one of fear, turmoil, and despair. For an international bank, these sentiments are experienced as changes in its lending standards as a result of heightened uncertainty over the value of its asset holdings, changes in its funding availability from interbank liquidity markets, and changes in its solvency due to balance sheet considerations. These three channels—of uncertainty, liquidity, and solvency—differentially affect the flow of credit provided by banks after the onset of a crisis. This paper seeks to illuminate the manner in which each of these channels independently operated to affect developed-country bank lending in developing countries in the run-up, during, and in the immediate aftermath of the global financial crisis of 2007/09.

Gaining a better understanding of how different bank credit channels function during a financial crisis is important, because the mitigation measures deployed by policymakers—whether before or after the fact—may differ according to the operative channel. For example, if liquidity access is the binding constraint, then the domestic central bank can relax its discount window, or engage in currency swap agreements with foreign central banks, in order to provide the necessary liquidity and alleviate the credit crunch. In contrast, if the problem is one of solvency, *ex ante* micro and macroprudential regulation may be more appropriate to limit the buildup of potentially nonperforming assets in the first place. Indeed, the issue of liquidity versus solvency is routinely discussed in the context of financial crisis management; however, relatively little of this debate has brought data to bear on the issue.

While the specific conditions that govern the contraction of credit in any given bank are undoubtedly unique, this does not mean that a more careful examination of the overall importance of the three distinct channels is unwarranted. After all, while the decision to wind down a bank does depend on its idiosyncratic circumstances, it is also valuable to identify the relative importance of the different transmission channels at the economywide level. This paper contributes to that discussion by providing a systematic decomposition of these different channels.

In a financial crisis, credit contraction occurs as a result of two distinct—but interrelated—factors. First, the crisis may bring about changes to the volatility of banks' asset holdings, their access to liquidity, and their balance sheets, inducing them to withhold credit to borrowers. But a second factor is that the *elasticity* of credit provision to each of these considerations may also be different during a crisis. Thus, a bank may be forced to limit its lending due to, say, the greater difficulty that it faces in obtaining liquidity in primary markets (a level effect), but also due to a heightened sensitivity to liquidity scarcity under crisis conditions (an elasticity effect).

Our findings suggest that during the crisis, bank liquidity problems and uncertainty were the main channels by which the crisis affected international lending from high income to developing countries, and that the solvency channel was relatively unimportant. Furthermore, the results suggest that banks' sensitivity to these factors did not tend to change during the crisis; that is, the effect of the crisis on lending was essentially a normal reaction to changes in interbank liquidity and economic uncertainty, and that the impact on lending was due to abnormally large

shocks to liquidity and uncertainty rather than to any change in banks' sensitivity to liquidity availability or change in risk. However, disaggregating lending into that by EU banks and that by U.S. banks yields a more nuanced message, with European banks becoming increasingly sensitive to market conditions during the most acute phase of the crisis, but this effect being offset, at least in part, by behavior of U.S. banks.

The work here speaks to several areas of active research. One important strand of literature is work related to the impact that foreign bank presence has on credit availability, especially in developing countries. Foreign bank presence has been found to affect both overall (Dages, Goldberg & Kinney 2000) and small business (Clarke, Cull, Martínez Pería & Sánchez 2005) lending in Latin America, as well as medium and large firms located in India (Gormley 2010). Across the developing world, the entry of foreign banks has had measurable influence on credit access by domestic firms, although the evidence favoring greater or lesser financing availability has been mixed (Clarke, Cull & Martínez Pería 2006; Detragiache, Tressel & Gupta 2008). While motivated by similar concerns, our work here focuses explicitly on crisis-related bank behavior, and explores the crisis effect in detail.

The findings are also related to the studies concerned with the role that foreign banks play in domestic credit provision during times of financial stress. Foreign banks were more successful than domestic banks in maintaining low interest margins during the financial crisis in Malaysia (Detragiache & Gupta 2006), while foreign banks demonstrated no significant difference in credit provision during the 1998 liquidity crunch in Pakistan (Khwaja & Mian 2008).¹ Greenfield foreign banks were also able to refrain from contracting their credit base during crises in Central and Eastern Europe (while domestic banks were not) (de Haas & van Lelyveld 2006), and for emerging markets more generally, foreign banks tend to be less responsive to monetary shocks in the host country (Wu, Luca & Jeon 2011).² Probably the paper closest in spirit to our work here is that of Cetorelli & Goldberg (2011). Like us, the authors are concerned with foreign liquidity provision during the recent crisis. However, given their focus on banks' internal financing markets, their concerns with liquidity and solvency deal with their role as bank-specific controls—rather than as channels of credit contraction—and they do not address the uncertainty channel at all. Nevertheless, we regard their findings as an important complement to those that we present here.³ Our contribution to this literature is a more careful documentation of how the different channels affect credit provision, rather than a study of lending activity *per se*.

A final group of papers is concerned with liquidity management by international banks,

¹Another notable feature of the Khwaja & Mian (2008) paper is that, in contrast to our work here, it decomposes bank liquidity shocks into a bank lending channel and a firm borrowing channel. While our focus is on alternate channels on the supply side of bank lending, we consider the demand side of the problem in greater detail in Section 5.

²In a slight twist, Peek & Rosengren (1997) examine the lending behavior of Japanese banks in the United States when a stock market crisis was experienced *in Japan*. They find an economically and statistically significant reduction in Japanese bank lending as a result of the shock.

³In a companion paper, Cetorelli & Goldberg (2011) also examine the liquidity channel in greater detail, decomposing it into direct cross-border lending by foreign banks and indirect local lending by foreign bank affiliates.

especially those based in the United States. One early study examined the determinants of the allocation of banking assets, and found that existing economic ties, level of development of the host economy, and domestic deposits were all correlated with greater asset holdings (Goldberg & Johnson 1990). However, asset holdings are not equivalent to liquidity exposures, and subsequent studies have attempted to make a more direct connection to credit provision. For example, Goldberg (2002) has found that U.S. bank lending to emerging markets is remarkably stable, and largely insulated from demand conditions in the host economies. While we are certainly interested in the factors affecting credit allocation by international banks, these are ultimately secondary to our central concern of the constraints such banks may face in different economic environments. Thus, non-crisis lending behavior in our study is mainly a benchmark against which to examine the more interesting (in our view) question of crisis lending behavior.

The rest of this paper is organized as follows. In Section 2, we walk through the theoretical literature on each of the three transmission channels for foreign bank lending. The next section goes on to describe our main dataset and variables of interest (Section 3.1), as well as the econometric model that we employ (Section 3.2). Section 4 reports our main results, along with robustness checks. Section 5 explicitly incorporates the demand side of the bank loan market into our analysis. A final section concludes with some thoughts on policy implications.

2 Channels of Transmission for Financial Shocks

There is a large literature that is concerned with alternative channels of monetary transmission in general, and effects of shocks on credit provision in particular. Credit frictions give rise to a wedge between the cost of funds raised externally and the opportunity cost of internal funds; this so-called “external finance premium” in turn operates either by shifting the supply of banks’ intermediated credit (a liquidity effect) (Bernanke 1983), or by impacting borrowers’ balance sheets (a solvency effect) (Bernanke & Gertler 1989).

Strictly speaking, the balance sheet channel of monetary transmission operates on the demand, rather than supply side, of the market for loanable funds. However, financial imperfections, not unlike those operating in the commercial credit market, may also lead to credit rationing in the wholesale credit market (Freixas & Jorge 2008). Thus, keeping in mind that foreign banks essentially operate in capital markets as both demanders (in the global interbank market) as well as suppliers (in the domestic commercial loan market), we consider both of these channels as relevant when considering the case of international banking activity.

Moreover, in the presence of informational asymmetries, interest rates alone may be insufficient as a mechanism for efficient allocation of credit, leading banks to engage in rationing behavior (Stiglitz & Weiss 1981). The increase in uncertainty due, in part, to such informational imperfections translates into increased variability in banks’ expected profits during a financial crisis.

To fix ideas, consider a simple (partial equilibrium) model of foreign bank activity in an

emerging market. In non-crisis periods, a given bank i will maximize expected profits at time t by allocating its liabilities (deposits and borrowings) d toward loans l and investible assets a ⁴:

$$\max E_t \sum_{t=0}^T \int_{\underline{a}}^{\bar{a}} \pi(l_{it}) f(a_{i,t+1}; l_{it}, \sigma_1) da_{i,t+1}, \quad (1)$$

where $f(a; \sigma_1)$ is the density function of the (continuous) random variable a with support $[\underline{a}, \bar{a}]$ and variance σ_1 . This density function captures the distribution of total returns from assets given the state of the world 1, where a captures both period returns (such as dividend payouts or coupon payments), as well as the current market valuation of the asset. The bank is subject to an intertemporal balance sheet constraint

$$a_{i,t+1} + m_{it} = B(a_{it}, m_{i,t-1}, -l_{it}, d_{it}), \quad (2)$$

where m is loanable cash, of which holdings are necessary for next-period loans in the form of a liquidity constraint

$$m_{i,t-1} \geq l_{it}. \quad (3)$$

For simplicity, we limit our solution to the circumstance where the bank will otherwise wish to hold no spare cash, that is, when the liquidity constraint is binding.⁵ This allows us to simplify the problem by substituting (3) into (2), and maximizing (1) subject to

$$a_{i,t+1} = B(a_{it}, l_{i,t+1}, d_{it}).$$

The Bellman value function for the problem is

$$V_0(a_{i,t+1}) = \max_{l_{it}} \left\{ \pi(a_{it}, l_{i,t+1}) + E_1 \int_{\underline{a}}^{\bar{a}} V_1(a_{i,t+1}) f(a_{i,t+1}; l_{i,t+2}, \sigma_1) da_{i,t+1} \right\}.$$

This yields an Euler that governs the allocation of loans between t and $t+1$ given by

$$\pi'(l_{it}) \cdot \frac{\partial B(a_{it}, l_{i,t+1}, d_{it})}{\partial a_{it}} = \pi'(l_{i,t+1}) \cdot \frac{\partial B(a_{i,t+1}, l_{i,t+2}, d_{i,t+1})}{\partial a_{it}}. \quad (4)$$

$$a_{i,t+1} \int_{\underline{a}}^{\bar{a}} f(a_{i,t+1}; \sigma_1) da_{i,t+1}.$$

As is standard in first order conditions of this nature, (4) essentially says that bank i will

⁴For the sake of simplicity, the model is stylized so that loans are regarded as nontradable assets with a fixed rate of return, whereas non-loan assets are tradable and thus subject to price and return volatility, and therefore subject to shocks to the variance of their return. In the context of the 2007/09 crisis, banks held a large portfolio of nontraditional investments, many in derivatives such as mortgage-backed securities (MBS) and collateralized debt obligations (CDO), often in special investment vehicles that the parent banks were ultimately liable for.

⁵This would be the case if the returns on investible assets exceed that of loans, since in that case agents will never choose to hold cash in advance of the next period's loans, as they would instead earn a higher return by placing the cash in assets. Whether this condition holds is, ultimately, an empirical question, which we abstract from in our very simple model of bank lending.

equate the marginal value of a loan made at time t to the expected value of the loan at time $t + 1$, taking into account the opportunity cost of making the loan as opposed to placing it in the investible assets (the relative price of which is given by $\frac{\partial B(a_{it}, l_{i,t+1}, d_{it})}{\partial a_{it}} / \frac{\partial B(a_{i,t+1}, l_{i,t+2}, d_{i,t+1})}{\partial a_{it}}$). Moreover, any given bank will face a transversality condition

$$\lim_{T \rightarrow \infty} \lambda_{T+1} a_{T+1} = 0, \quad (5)$$

where λ_{T+1} is the shadow price (multiplier) on the constraint (2).

Now, consider the behavior of the same bank during a financial crisis. While a financial crisis is likely to result in a first-moment shock to asset valuations, it is also likely to incorporate a second-moment element, where uncertainty becomes more pervasive. Following Bloom (2009), we call this crisis-induced change in the variance σ an uncertainty shock, which leads to a revised density function given by $f(a; \sigma_2)$, where the variance of the function is now given by $\sigma_2 > \sigma_1$.⁶ Repeating the exercise above yields the crisis-period analogue of (4):

$$\pi'(l_{it}) \cdot \frac{\partial B(a_{it}, l_{i,t+1}, d_{it})}{\partial a_{it}} = \pi'(l_{i,t+1}) \cdot \frac{\partial B(a_{i,t+1}, l_{i,t+2}, d_{i,t+1})}{\partial a_{it}} \cdot a_{i,t+1} \int_{\underline{a}}^{\bar{a}} f(a_{i,t+1}; \sigma_2) da_{i,t+1}. \quad (6)$$

Taken together, (4), (6), and (5) characterize the three channels that impact a bank's credit provision in and out of a financial crisis: its need for access to liquidity (the constraint (3) and the presence of next-period loans in the current-period derivative in the Euler, $\frac{\partial B(a_{it}, l_{i,t+1}, d_{it})}{\partial a_{it}}$); balance sheet solvency considerations (the constraints (2) and (5), and the inclusion of the function $B(\cdot)$); and the impact of uncertainty (the presence of σ_2 and σ_1).

The importance of the solvency channel has been empirically verified for periods of tight money (Bernanke, Gertler & Gilchrist 1996), as well as, more specifically, in the context of financial crises (Duchin, Ozbas & Sensoy 2010). Likewise, the liquidity channel is an important conduit for monetary policy (Kashyap & Stein 2000), and was important in the propagation of the Great Depression (Bernanke 1983), and appears to be relevant for the recent financial crisis as well (Ivashina & Scharfstein 2010). Finally, Bloom (2009) has found that uncertainty shocks are crucial for understanding the dynamics of crises; the uncertainty channel has also been explored in the context of financial contagion by Kannan & Koehler-Geib (2011).⁷

These three channels all appear to have been important in the 2007/09 financial crisis. Widespread concerns about the ability of counterparties to make good on unsecured loans dis-

⁶An alternative approach to capturing the role of risk is to directly introduce time-varying relative risk aversion into a utility function, as in Boschi & Goenka (2012). Crises are then modeled as shocks to the risk premia of portfolios held by international investors, which may give rise to contagion effects. Since this approach to modeling risk relies on *propensities* as opposed to asset *volatility*, it can have a material impact on the variables used to measure risk. We address this concern in our robustness section.

⁷Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez & Uribe (2011) also explore the real impacts of what they call a volatility shock on small open economies, arguing that emerging economies often face time-varying volatility of real interest rates.

rupted interbank credit markets, leading to sharp spikes in the spread between the interbank lending rate and the overnight index swap (LIBOR-OIS), especially in the aftermath of the Lehman collapse in September 2008 (Figure 1(a)). This led to widespread difficulties in obtaining basic rollover credit, and likely played a significant role in the contraction of credit. As the crisis wore on, moreover, spreads on credit default swaps (CDS) for bank bonds began to widen considerably, suggesting increasing concerns over (bank) credit impairment as a result of worsening balance sheets (Figure 1(b)). The degraded balance sheets, in turn, would likely have led banks to limit their lending to only the most creditworthy borrowers. Finally, the volatility of asset returns increased substantially during the crisis period; the implied volatility of the S&P 500, for example, rose in the first phase of the crisis, and jumped sharply in the second (Figure 1(c)).

(a) LIBOR-OIS spread, 2007–10

(b) CDS spreads on credit sector, 2007–10

(c) VIX market volatility index, 2007–10

Figure 1: Three-month LIBOR-OIS and TED spreads (top panel), five-year CDS spreads on U.S. banking sector index (middle panel), and VIX implied volatility of S&P 500 index options (bottom panel), January 2007 through December 2010. The charts show, for both the initial (light shaded area) and acute (dark shaded area) phases of the crisis, that there was severe difficulty in obtaining liquidity (interest rate spreads), significant concerns over bank solvency (credit default swap spreads), and that the volatility of returns on asset markets was elevated relative to non-crisis periods (market volatility index).

3 Data and Methodology

3.1 Data sources and description

The dataset used for this paper was compiled from a variety of sources, the full details of which are described in the technical annex. Here, we limit our discussion to the main variables of interest.

The main dependent variable that we consider is quarterly total foreign bank claims for BIS-reporting banks with lending to developing countries. The claims detail the foreign exposure, on a worldwide consolidated basis with inter-office positions netted out, of up to 5,615 BIS-reporting international banks with foreign exposure to as many as 138 developing economies per quarter. This coverage within the foreign claims universe is nearly 100 percent, and the foreign claims include cross-border claims in all currencies, along with local claims of foreign affiliates in both foreign currencies and local currency. In our robustness checks, we also consider the exposures of just the 150 U.S. banks with foreign exposure, along with those of the 4,488 BIS-reporting banks based in Europe.⁸ Overall, claims appear to have responded with some lag from the start of the crisis in 2007Q3 (peaks were attained about year later), and troughed at the start of 2009 (Figure 2).

Figure 2: Total cross-border foreign claims by BIS-reporting international banks to developing countries, disaggregated by exposure into EU, U.S., and other. Aggregate foreign claims rose steadily from the beginning of the sample period and peaked around 2008Q2, before assuming troughs in 2009Q1. Claims at the end of the sample period exceed the pre-crisis peaks.

Our main independent variables seek to capture the different channels of interest.

To capture liquidity effects, our benchmark analysis relies on the LIBOR-OIS spread.⁹ Since the spread represents the difference between (risky) interbank borrowing costs and a (low-risk)

⁸European countries with BIS-reporting banks are primarily, although neither exclusively nor exhaustively, members of the euro area: they comprise the EU-15 countries and Norway.

⁹We utilize a spread because rates alone—for example, the LIBOR overnight rate—are a reflection of not only liquidity availability but also the cost of capital, which is netted out when we take the spread between two rates of equivalent tenor.

derivative based on expectations of such costs, it captures the compensation demanded by investors to insure against default. However, the LIBOR-OIS spread also captures an element of liquidity. Since an OIS contract does not require the exchange of loan principal, but only the interest component, this premium can also be viewed as an inducement to forgo liquid assets; such premia may be especially important in the environment of a financial crisis, where liquidity is very scarce. Moreover, it appears that liquidity may in fact be the larger component of LIBOR-OIS spreads (Schwarz 2010).

Consequently, while the LIBOR-OIS rate does in fact comprise risk premia for both (inter-bank) credit risk and liquidity risk, in our application it nevertheless serves as a reasonable proxy for the *availability* of liquidity, as adjudged by the ability of a bank to secure short-term liquidity from the wholesale market. Another way to interpret this choice is that, when thinking about the liquidity channel, we are concerned not primarily with market liquidity—which is certainly well measured by more traditional spreads, such as those between LIBOR and certificates of deposit (CD), or that between bid and ask prices within a given securities market—but with funding liquidity for banks, which is well referenced by the LIBOR-OIS spread.

To measure solvency, our benchmark specification uses a synthetic global bank CDS, which is a foreign claims-weighted average of the 5-year (the most liquid term) banking sector CDS indexes for U.S. and European banks, which are in turn averages of the mid-spread CDS rate for each constituent bank in the respective index.¹⁰ Since contingent payment on a CDS is typically triggered by credit events such as, *inter alia*, bankruptcy and restructuring, CDS spreads for the banking sector serve as important indicators of market *expectations* of bank solvency. While the accuracy of such spreads in predicting the actual strength of banks' balance sheets has been certainly called into question by the financial crisis, they nevertheless remain valuable forward-looking signals of potential solvency issues (as opposed to accounting-based indicators, which are typically lagging).

For the uncertainty channel, we construct an index of asset price volatility by doing principal component analysis of the VIX (an index of the volatility of the S&P 500) and the GARCH(1,1) conditional variance of first differences in prices in 7 other asset markets, and averaging the first two components (since those two have eigenvalues greater than 1), weighted by their proportions of the cumulative variance of the components. The conditional variance of a return on an asset captures uncertainty of its future path, given past observations, and is thus an appropriate measure for testing the effect of volatility on forward looking lending behavior. The assets included in the index are debt (the TED spread), equity (the VIX), foreign exchange (the exchange rate of the dollar to the euro, Japanese yen, and pound sterling), and commodities (agricultural, energy, and industrial metals prices) (the complete list is reproduced in the data annex).

The working dataset for the benchmark is quarterly, beginning in 2004Q1 and ending 2011Q1, the last quarter where the European sovereign debt crisis remained largely contained

¹⁰Since banking sector CDS were only widely traded beginning in 2004, using this measure limits the sample coverage to begin in 2004Q1.

to Greece.¹¹ with the crisis period defined as encompassing 2007Q3 through 2009Q2, inclusive. This brackets the genesis of the crisis to the Quant event (Khandani & Lo 2011) and widespread central bank intervention starting in early August 2007, and the spread of the crisis to the real economy in the summer of 2009, accompanied by the significant easing in tensions in financial markets. The crisis period comprises about thirty percent of the sample, which offers sufficient variation for reasonable statistical inference.

3.2 Econometric approach

Our benchmark specification used to test the relative importance of (4), (6), and (5) is an econometric model that embeds the measures described in Section 3.1 for all three channels into a single equation for foreign claims by international banks:

$$FC_{it} = FC_{i,t-1} + \alpha_i + \beta_1 L_t + \beta_2 S_t + \beta_3 U_t + \gamma D_t + \mathbf{\Gamma}' \mathbf{X}_{it} + crisis_t + \epsilon_{it}, \quad (7)$$

where FC_{it} ($FC_{i,t-1}$) is total (nominal) foreign claims by all international banks in developing country i at time t ($t-1$), L_t , S_t , and U_t are measures of the liquidity, solvency, and uncertainty channels, respectively, D_t is a proxy variable for loan demand conditions in high income countries at time t , $\mathbf{X}$ is a vector of country-specific controls, and $crisis_t$ is an indicator variable that takes on unity during the crisis, and zero otherwise. α_i is a country fixed effect and $\epsilon_{it} \sim N(0, \sigma_\epsilon^2)$ is an i.i.d. disturbance term. The lagged dependent variable is included to account for possible persistence in the claims series, especially given the quarterly nature of the data.¹² In our benchmark, $\mathbf{X}$ includes, for country i , its output, output growth, and inflation rate.

Our benchmark relies on fixed effects estimators, with standard errors corrected for heteroskedasticity and autocorrelation.¹³ In the sections that follow, we explore alternative estimation methodologies, designed to address considerations about demand-side factors as well as possible endogeneity among the different channels.

4 Results and Findings

4.1 Baseline results

Our benchmark results are reported in Table 1. In column (*B2*), we regress foreign claims on its one-period lag, controls, a crisis dummy, and the three transmission channels as measured by the LIBOR-OIS spread (liquidity), global banking sector CDS (solvency), and the asset volatility

¹¹We also experimented with the sample period in two ways. First, we considered a restricted sample ending in 2010Q4. Second, we also included an additional crisis dummy for the European debt crisis that began in 2010Q1. Neither change affected the qualitative findings we report here in a significant fashion, and these additional results are available on request.

¹²A Fisher-type test for unit roots (Maddala & Wu 1999) fails to reject the null of stationarity for all series in the panel in levels ($\chi^2 = 240.9, p = 0.71$), but does so in first differences ($\chi^2 = 1288.2, p = 0.00$).

¹³A Hausman test further suggests that fixed, rather than random, effects should be applied ($\chi^2 = 470.06, p = 0.00$).

index (uncertainty). By way of comparison, the equivalent specification, which pools crisis and non-crisis periods, is repeated in column (B1), but without the indicator variable for the crisis period.

It is clear that controlling for the crisis period results in important differences. Interestingly, the coefficient for the crisis variable in column (B2) is positive and statistically significant, despite that lending to developing countries dipped during the crisis, while the coefficient on the LIBOR-OIS spread turns from positive to negative, suggesting that funding liquidity problems tend to be negatively associated with cross-border lending, but that the effect is partially offset during the crisis either by convexity in the negative relationship, or by countervailing effects of unobservables.

The results from this specification also suggest that lending to developing countries is affected by financial shocks primarily through the liquidity and uncertainty channels: the coefficients for the liquidity and uncertainty channels are both negative and statistically significant at the conventional levels. The economic effects of marginal changes in liquidity and uncertainty are economically insignificant: a 1 percent increase in the LIBOR-OIS spread is associated with about a 0.025 percent decrease in lending, and the decline associated with a 1 percent increase in volatility is about 0.06 percent. However, during the crisis these measures increased by several hundred percent, and changes of this magnitude are associated with economically significant reductions in cross-border lending. The solvency channel, on the other hand, does not appear to be important.

The ultimate impact of any single channel may not be contemporaneous, but rather unfold over time. To uncover the possible effects of delayed transmission, we specify an autoregressive distributed lag model in column (B3), with one-, two-, and three-quarter lags on the liquidity measure.¹⁴ Allowing for delayed effects of liquidity problems gives a statistically significant coefficient of about the same magnitude, -0.022, on the three-quarter lag. This specification may suffer in efficiency due to collinearity between the various lags, but it is nonetheless suggestive that the transmission of shocks to cross-border bank lending is not instantaneous.

In the final column, (B4), we explore the sensitivity of the coefficients $\beta_1 - \beta_3$ obtained from the earlier two specifications by interacting the contemporaneous measures of LIBOR-OIS, global bank CDS, and asset volatility with the crisis variable. This allows lending to not just react to changes in the levels of these variables—which did change markedly during the crisis period—but it also allows the elasticity of lending with respect to each of these variables to change under crisis conditions.

This specification yields a striking result. The coefficients on the liquidity and uncertainty measures are essentially unchanged, and the interaction terms appear to be insignificant. This suggests that the impact of liquidity problems and uncertainty on bank lending during the crisis was due entirely to changes in these variables during the crisis, and not to changes in sensitivity

¹⁴This specification was selected using the best-fit specification among $5^3 = 125$ models, for up to four lags per channel, according to Akaike and Bayesian information criteria. The relevant statistics are detailed in the technical annex.

Table 1: Benchmark regressions for transmission channels associated with foreign claims by international banks in developing countries, 2004Q1–2011Q1 [†]

	<i>B1</i>	<i>B2</i>	<i>B3</i>	<i>B4</i>
Lagged foreign claims	0.772 (0.03)***	0.772 (0.03)***	0.781 (0.03)***	0.771 (0.03)***
LIBOR-OIS	0.030 (0.01)***	-0.025 (0.01)*	-0.019 (0.02)	-0.030 (0.02)*
1st lag			0.010 (0.01)	
2nd lag			0.017 (0.01)	
3rd lag			-0.022 (0.01)**	
LIBOR-OIS $\times$ crisis				-0.000 (0.04)
Global bank CDS	-0.014 (0.01)**	-0.001 (0.01)	-0.004 (0.01)	0.002 (0.01)
Global bank CDS $\times$ crisis				-0.012 (0.01)
Asset volatility	-0.062 (0.02)**	-0.060 (0.02)**	-0.067 (0.02)***	-0.068 (0.04)*
Asset volatility $\times$ crisis				0.018 (0.06)
Loan demand	0.009 (0.03)	-0.002 (0.03)	-0.006 (0.04)	-0.017 (0.04)
Inflation	-0.019 (0.01)***	-0.022 (0.01)***	-0.022 (0.01)***	-0.022 (0.17)
Growth	-0.131 (0.15)	-0.168 (0.15)	-0.159 (0.15)	-0.173 (0.19)
GDP	0.308 (0.04)***	0.289 (0.04)***	0.289 (0.04)***	0.282 (0.04)***
Crisis		0.108 (0.02)***	0.078 (0.03)***	0.153 (0.12)
Adj. R^2	0.770	0.771	0.776	0.762
R^2 (within)	0.771	0.772	0.777	0.772
Estimator	FE	FE	FE	FE
N	3,435	3,435	3,429	3,435

[†] All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses, with the exception of specification (*B4*), where errors are bootstrapped. A constant term was included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

to these variables. In the case of the uncertainty measure, this result sheds light on the question of whether risk aversion itself changed during the crisis, or whether market participants, facing a shock to uncertainty and risk, took actions to reduce their risk exposure; our results support the latter of these two competing views.

Finally, the coefficients of some of the control variables appear to be consistent with *a priori* theory. Bank lending to developing countries is greater for larger economies, and smaller for economies with higher inflation rates, perhaps due to greater *ex ante* uncertainty of real returns on loans, or because inflation proxies for a less favorable policy environment more broadly.¹⁵ There does not appear to be a significant association of lending with growth, nor with loan demand from high income markets (as proxied by demand for loans faced by U.S. banks¹⁶).

4.2 Robustness of the benchmark

The results are generally robust to alternative measures of the three channels, as shown in Table 2. In column (*R1*), the LIBOR-CD spread is substituted for LIBOR-OIS as a measure of interbank liquidity; (*R2*) includes both LIBOR-CD and LIBOR-OIS. In (*R3*), loss allowances as a fraction of outstanding loans substitute for CDS as a measure of bank balance sheet problems. In (*R4*), the index of conditional volatility of asset prices used to capture the uncertainty channel in the benchmark is replaced with an index of the unconditional standard deviations of the same set of asset prices. In (*R5*), the volatility measure is replaced with measure of changes in risk aversion of bankers; in (*R6*), both this risk aversion measure and the volatility measure are included. In (*R7*), growth and inflation are measured on a quarter-on-quarter basis instead of year-on-year. Specification (*R8*) adds depreciation of the local currency against the U.S. dollar to the set of control variables.

As discussed in Section 3.1, the term “liquidity” can have more than one meaning. Since we are concerned with the availability of funding liquidity to banks, as opposed to the degree of liquidity of a market which is better captured by traditional measures such as the spread between on-the-run and off-the-run securities or the bid-ask spread, the LIBOR-OIS spread is our preferred measure. However, disentangling a pure liquidity component from a counterparty risk component is not straightforward, since availability of credit depends crucially on credit risk, and more than one approach is worth considering. One alternative measure in the literature has been the spread between LIBOR and the rate on CDs, since purchasers of CDs do not necessarily face the liquidity constraints that banks do during a financial crisis (Taylor & Williams 2009). Furthermore, since CDs are typically only insured up to a limit, CD rates may rise along with

¹⁵We use quarter-on-quarter (QoQ) inflation and growth data to better capture sharp, short-run changes that may be important during a crisis, as well as for consistency with the overall frequency of the dataset. However, QoQ data for inflation may result in extreme outliers, which we ameliorate by taking logarithms. Dropping these cases would potentially bias the results, since we lose valuable information from those observations. In any case, the results reported here remain robust to either artificially limiting the inflation rate in these cases to 1,000 percent, or dropping these observations entirely.

¹⁶The measure of loan demand is from the Fed’s Senior Loan Officer Survey. The ECB collects comparable data on loan demand faced by European banks, but we use the U.S. measure since U.S. banks lend less in developing countries.

Table 2: Robustness regressions for transmission channels associated with foreign claims by international banks in developing countries, 2004Q1–2011Q1 [†]

	$R1$	$R2$	$R3$	$R4$	$R5$	$R6$	$R7$	$R8$
Lagged foreign claims	0.772 (0.03)***	0.771 (0.03)***	0.772 (0.03)***	0.772 (0.03)***	0.770 (0.03)***	0.771 (0.03)***	0.769 (0.03)***	0.772 (0.03)***
LIBOR-OIS		-0.027 (0.01)*	-0.019 (0.02)	-0.026 (0.01)**	-0.047 (0.01)***	-0.028 (0.01)*	-0.023 (0.01)*	-0.028 (0.01)**
LIBOR-CD	-0.003 (0.01)	-0.006 (0.01)						
Global bank CDS	-0.007 (0.01)	-0.000 (0.01)		0.002 (0.01)	0.002 (0.01)	-0.004 (0.01)	-0.001 (0.01)	-0.000 (0.01)
Loss allowances			-0.012 (0.01)					
Asset volatility	-0.082 (0.03)**	-0.071 (0.03)**	-0.062 (0.02)***			-0.083 (0.03)***	-0.057 (0.02)**	-0.061 (0.02)**
Asset volatility (unconditional)				-0.085 (0.03)**				
Risk aversion					0.025 (0.07)	0.154 (0.09)*		
Loan demand	0.003 (0.04)	-0.015 (0.04)	-0.005 (0.03)	0.004 (0.03)	0.015 (0.04)	0.025 (0.04)	0.004 (0.03)	-0.001 (0.03)
Inflation	-0.021 (0.01)***	-0.022 (0.01)***	-0.021 (0.01)***	-0.022 (0.01)***	-0.022 (0.01)***	-0.023 (0.01)***		-0.056 (0.01)***
Inflation, YoY							-0.033 (0.01)***	
Growth	-0.154 (0.15)	-0.168 (0.15)	-0.176 (0.15)	-0.158 (0.15)	-0.137 (0.15)	-0.177 (0.16)		-0.184 (0.16)
Growth, YoY							-0.224 (0.37)	
GDP	0.298 (0.03)***	0.286 (0.03)***	0.295 (0.03)***	0.284 (0.04)***	0.282 (0.04)***	0.279 (0.04)***	0.289 (0.04)***	0.290 (0.04)***
Depreciation								0.020 (0.00)***
Crisis	0.077 (0.02)***	0.113 (0.03)***	0.095 (0.03)***	0.113 (0.02)***	0.108 (0.02)***	0.097 (0.02)***	0.105 (0.02)***	0.113 (0.02)***
Adj. R^2	0.771	0.771	0.771	0.771	0.771	0.771	0.770	0.772
R^2 (within)	0.772	0.772	0.772	0.772	0.771	0.772	0.771	0.773
Estimator	FE	FE	FE	FE	FE	FE	FE	FE
N	3,435	3,435	3,435	3,435	3,435	3,435	3,401	3,399

[†] All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A constant term was included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

LIBOR due to concerns about the credit worthiness of banks, so the LIBOR-CD spread is viewed by some as a measure of pure liquidity scarcity. We view the premise that purchasers of CDs are not liquidity constrained during a crisis as questionable, but LIBOR-CD is nonetheless a clear candidate for a robustness check of our main liquidity variable. When LIBOR-CD is included in lieu of LIBOR-OIS (column *R1*), the coefficient is close to zero and statistically insignificant. When both LIBOR-CD and LIBOR-OIS are included (column *R2*), LIBOR-OIS retains its sign, magnitude, and significance.

Our preferred measure of balance sheet problems is an index of CDS spreads, which has the advantages of being forward-looking, and of being based on rates faced by a wide sample of banks in both the U.S. and Europe. However, more direct measures of solvency issues can be found in bank financial data. As a robustness check, loss allowances as a fraction of outstanding loans, as reported by U.S. banks to the FDIC, are included in place of the CDS index (column *R3*). The coefficient is insignificant, as is that on CDS in the benchmark estimates that do not include lagged channel variables. Although not reported, similar results are found for other variables reported to the FDIC: measures of noncurrent loans and net charge-offs as fractions of outstanding loans, and the fraction of lenders which are unprofitable. These results are broadly supportive of the idea that balance sheet problems have little, if any, contemporaneous impact on cross-border bank lending.

In the benchmark estimates, we rely on a GARCH (1,1) conditional volatility index as a measure of uncertainty, for reasons given above. Here, we consider the robustness of this measure by instead using an unconditional measure of volatility: an index of the rolling standard deviations of prices in the same 7 asset markets, along with VIX, used to compute the conditional volatility measure.¹⁷ Results with this alternative measure of volatility are reported in column (*R4*), and mirror the benchmark results, with a significant negative coefficient on the alternative volatility measure.

As discussed in Section 2, the uncertainty channel variable is intended to measure shocks to uncertainty, as distinct from shocks to risk aversion. However, the two concepts are interrelated, as the effect of uncertainty on behavior depends on the degree of risk aversion; and the degree of perceived risk aversion, as well as the effect of a given degree of risk aversion on behavior, may depend on the level of uncertainty. Furthermore, there is a question of whether risk aversion itself changed during the crisis, or whether behavior to reduce risk exposure during the crisis was predominantly a reaction to heightened risk and uncertainty for a given degree of risk aversion. Results with a variable measuring U.S. loan officers' risk aversion are reported in columns (*R5*) and (*R6*).¹⁸ While the coefficient is insignificant when risk aversion is included in place of

¹⁷The results are robust to the method of aggregation. While we report here the weighted average of the first two principal components, using a simple average of the 8 series yields qualitatively similar results.

¹⁸The risk aversion variable is constructed from a question on the Fed's Senior Loan Officer Survey that asks loan officers who reported that they tightened or eased credit standards or terms on C&I loans what factors were relevant to that decision, with reduced or increased tolerance for risk given as an option for the reason for tightening or easing, respectively. Banks' responses are averaged, with each response that a change in risk tolerance was "very important" given twice the weight of a response that it was "important."

volatility, it is notable that it is positive and significant when volatility is also included in the specification. One explanation is that, while heightened uncertainty may cause banks to reduce their lending both at home and abroad, shocks to risk aversion for a given level of uncertainty cause banks to substitute towards lending in relatively stable markets. During the crisis, which is mainly when increases in risk aversion were reported, this means lending more in developing countries, *ceteris paribus*. It is also worth noting that when both volatility and risk aversion are included, the coefficient on volatility remains negative and highly significant, suggesting that the two variables' relationships with lending are distinct and that our benchmark measure is not primarily picking up shocks to risk aversion as opposed to uncertainty.

While we prefer quarter-on-quarter measures of growth and inflation because they capture sharp short-term shocks to output and prices during a crisis, they are also sensitive to seasonal variation, so we consider year-on-year measures as alternate controls, with the results reported in column (*R7*). Also, it has been argued that investment can be sensitive to exchange rate variations (Campa & Goldberg 1999), and so loan demand by banks may fluctuate accordingly. We allow for this possibility in column (*R8*), where we include the depreciation of the local currency vis-à-vis the U.S. dollar as an additional control. The main results are robust to these checks.

4.3 Does foreign bank lending differ by source and destination?

Foreign claims by high income country banks on counterparties in developing countries consist mainly of loans by European banks, but the U.S. was at the center of the crisis, and there is no reason to think that the benchmark results apply equally well to European and U.S. banks. Separating foreign claims into those by U.S. banks and those by EU banks yields a number of insights; the results are given in Table 3. Columns (*S1*) and (*S5*) replicate the benchmark regression (*B2*) for U.S. and EU banks' claims, respectively, but with two crisis dummies for each, with the crisis divided into pre- and post-Lehman Brothers collapse for the U.S., and pre- and post-Vienna Initiative for the EU, since these events are widely regarded to mark relevant shifts in the crisis for these two markets. Due to small period length for both the latter periods, we regress the interaction terms for each channel separately; these are reported in columns (*S2*)–(*S4*) for U.S. banks, and (*S6*)–(*S8*) for EU banks.

One key result is that the solvency channel is significant, but with a positive coefficient for U.S. banks, and negative for EU banks, which helps to explain why it is insignificant for total foreign claims in the benchmark estimates. One possible explanation for why solvency considerations seem to have afflicted European bank lending (insofar as exposures to developing countries are concerned), but not U.S. lending, is that the Federal Reserve intervened far more aggressively than the European Central Bank (ECB). Indeed, anecdotal evidence is generally supportive of this difference: While the U.S. Federal Reserve introduced the Troubled Asset Relief Program (TARP) to shore up bank balance sheets, along with a large number of new credit lines—such as the Term Auction Facility (TAF) and the Commercial Paper Lending

Table 3: Regressions for transmission channels associated with foreign claims by EU and US banks in developing countries, 2004Q1–2011Q1 [†]

	<i>S1</i>	<i>S2</i>	<i>S3</i>	<i>S4</i>	<i>S5</i>	<i>S6</i>	<i>S7</i>	<i>S8</i>
	<i>US Banks</i>				<i>EU Banks</i>			
Lagged foreign claims	0.600 (0.04)***	0.600 (0.04)***	0.600 (0.04)***	0.599 (0.04)***	0.752 (0.03)***	0.751 (0.03)***	0.751 (0.03)***	0.751 (0.03)***
LIBOR-OIS/ EURIBOR-EONIA	-0.110 (0.04)***	-0.080 (0.05)*	-0.058 (0.05)	-0.073 (0.05)	0.042 (0.02)**	0.072 (0.03)***	0.072 (0.03)**	0.072 (0.03)**
LIBOR-OIS × pre-Lehman		-0.180 (0.20)	-0.196 (0.19)	-0.187 (0.19)				
LIBOR-OIS × post-Lehman		-0.153 (0.12)						
EURIBOR-EONIA × pre-Vienna						-0.014 (0.05)	-0.014 (0.05)	-0.014 (0.05)
EURIBOR-EONIA × post-Vienna						-0.142 (0.05)***		
US/EU bank CDS	0.066 (0.03)**	0.056 (0.03)**	0.046 (0.03)*	0.053 (0.03)**	-0.017 (0.01)*	-0.031 (0.01)***	-0.031 (0.01)**	-0.031 (0.01)**
US bank CDS × pre-Lehman		-0.340 (0.12)	-0.420 (0.12)	-0.364 (0.12)				
US bank CDS × post-Lehman			1.101 (0.56)*					
EU bank CDS × pre-Vienna						0.098 (0.04)**	0.098 (0.04)***	0.098 (0.04)**
EU bank CDS × post-Vienna							-0.706 (0.26)***	
Asset volatility	-0.003 (0.06)	0.114 (0.12)	0.191 (0.10)*	0.137 (0.11)	-0.113 (0.03)***	-0.134 (0.06)**	-0.134 (0.06)**	-0.134 (0.05)**
Asset volatility × pre-Lehman		-0.340 (0.20)*	-0.420 (0.18)**	-0.364 (0.20)*				
Asset volatility × post-Lehman				-0.219 (0.14)				
Asset volatility × pre-Vienna						-0.067 (0.11)	-0.067 (0.10)	-0.067 (0.11)
Asset volatility × post-Vienna								-0.214 (0.07)***
Loan demand, US/EU banks	-0.174 (0.12)	-0.140 (0.12)	-0.094 (0.12)	-0.131 (0.14)	0.159 (0.06)***	0.219 (0.08)***	0.219 (0.08)***	0.219 (0.09)**
Inflation	0.109 (0.01)***	0.109 (0.20)	0.109 (0.25)	0.109 (0.22)	-0.025 (0.00)***	-0.028 (0.10)	-0.028 (0.10)	-0.028 (0.12)
Growth	-0.237 (0.40)	-0.308 (0.51)	-0.267 (0.44)	-0.306 (0.51)	-0.404 (0.20)*	-0.443 (0.26)*	-0.443 (0.26)*	-0.443 (0.27)
GDP	0.275 (0.09)***	0.269 (0.09)***	0.275 (0.10)***	0.269 (0.10)***	0.214 (0.04)***	0.187 (0.05)***	0.187 (0.05)***	0.187 (0.05)***
pre-Lehman	0.121 (0.06)*	0.474 (0.45)	0.511 (0.43)	0.488 (0.43)				
post-Lehman	0.153 (0.10)	0.744 (0.48)	-5.969 (3.12)*	0.255 (0.14)*				
pre-Vienna					0.085 (0.03)***	-0.226 (0.18)	-0.226 (0.17)	-0.226 (0.17)
post-Vienna					0.044 (0.03)*	0.651 (0.20)***	3.842 (1.38)***	0.229 (0.06)***
Adj. R^2	0.437	0.416	0.416	0.416	0.702	0.691	0.691	0.691
R^2 (within)	0.439	0.439	0.440	0.440	0.703	0.704	0.704	0.704
Estimator	FE	FE	FE	FE	FE	FE	FE	FE
N	3,435	3,435	3,435	3,435	3,435	3,435	3,435	3,435

[†] All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A constant term was included in the regressions, but not reported. Indicator variables for Lehman and Vienna separate the crisis variable at 2008Q4 and 2009Q1, respectively. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

Facility (CPLF)—to enhance liquidity during the height of the crisis, European banks only had the standard discount window of the ECB (along with currency swap agreements, although these likewise had to be intermediated by the ECB). For the U.S., CDS interacted with the second phase of the crisis is also positive and significant, meaning that the positive association increased during this phase, which is consistent with the policy response explanation. For the EU, the analogous interaction term is negative and significant, meaning that EU bank lending became more sensitive to solvency problems during the acute second phase of the crisis as well.

The results on liquidity also add some nuance to the benchmark estimates. For U.S. banks, LIBOR-OIS is associated with decreased lending to developing countries (in specifications (*S1*) and (*S2*)), and the sensitivity to LIBOR-OIS does not change during either phase of the crisis. For EU banks, on the other hand, the EURIBOR-EONIA spread is associated with increased lending during normal times, but decreased lending during the second phase of the crisis. This can be seen in the overall foreign claims patterns in Figure 2.

As for the uncertainty channel, U.S. lending appears to have been negatively associated with volatility during the first phase of the crisis only, and insensitive to it at other times. EU lending is negatively associated with volatility in good times and bad, but was especially so during the second phase of the crisis, despite the efforts of the Vienna Initiative to prop up credit provision to Eastern Europe.

5 What is the Role of the Interest Rate?

Up till this stage, our examination of the three main transmission channels has taken the form of Equation (7), which deliberately suppresses any discussion of internal demand conditions in developing countries. To the extent that we incorporated demand considerations, this was through a measure—changes in demand conditions reported by the Federal Reserve—which proxies for external demand conditions, mainly from high-income countries. While we certainly recognize that (7) does not fully account for internal loan demand, our preference for this approach—at least at the outset—was conditioned by a desire to focus which transmission channels affect the supply side, along with the desire to introduce interaction effects between the crisis and the main coefficients of interest (β_1 , β_2 , and β_3).

In this section, we substitute the generic measure of demand conditions with country-specific interest rates. Accordingly, (7) can be re-expressed as

$$FC_{it} = FC_{i,t-1} + \alpha_i + \beta_1 L_t + \beta_2 S_t + \beta_3 U_t + \gamma' r_{it} + \mathbf{\Gamma}' \mathbf{X}_{it} + crisis_t + \epsilon_{it}, \quad (8)$$

where r_{it} is the domestic lending rate in country i at time t , which now more fully approximates the potential effect of local demand for bank loans. Of course, since interest rates are codetermined by bank lending as well as saver deposits, r is endogenous. Consequently, we require an instrument to identify the loan demand function, and (8) is estimated via instrumental variables (IV). For this purpose, we rely on country demographics; in particular, we exploit the

(plausibly) exogenous variation offered by the aged dependency ratio. Increases in this ratio are associated with reduced saving, as domestic agents draw down on the stock of national saving. Since local banks typically have access to only the domestic deposit base, the interest rates they charge will rise, which in turn reduces the demand for their loans as firms substitute toward foreign lenders with lower interest rates on offer. In equilibrium, the observed domestic lending rate will, *mutatis mutandis*, increase in tandem with the dependency ratio.

There are two additional empirical issues that we need to consider in our estimation of (8). First, what does a national-level interest rate mean in the context of multiple distinct foreign banks? Arguably, interest rates should be bank- and borrower-specific, but this is precluded by the aggregate nature of the data. Fortunately, even if our measure of interest rates does turn out to be noisy, one of the advantages of IV estimates is that, conditional on a reliable instrument, the approach corrects for measurement error in the instrumented variable. We accordingly proceed with the use of the quarterly average national lending rate as a measure of our domestic lending rate.

A second issue concerns the inclusion (or not) of our original measure of demand conditions, D . In theory, these two demand forces are distinct, and should both be included in (8). However, since our proxy measure of loan demand in high-income countries may also contain a component of developing-country loan demand,¹⁹ we limit any conflation between the two by specifying (8) with only the interest rate variable.

The estimation results are reported in Table 4. In column ($I1$), we replicate the fixed-effects model in ($B2$), but replace loan demand with the lending rate. The coefficient on the interest rate is positive (as expected *a priori*), but statistically indistinguishable from zero; this is also the case for the IV specifications that follow. The coefficients on the three channels are also the same as before (negative), but again are statistically insignificant. Due to the endogeneity problems inherent in the estimate, however, we regard these results as merely illustrative, and proceed to a discussion of the IV estimates.

Columns ($I2$)–($I4$) report IV estimates that correspond to the benchmark specifications ($B2$)–($B4$). The instruments satisfy the relevance condition—Kleibergen-Papp LM tests are statistically significant—and the (insignificant) Hansen J statistic indicates that the instruments are valid. While F statistics (not reported) imply that the first-stage fit is reasonable, the corresponding Kleibergen-Papp F statistics are relatively low ($F \in [4.41, 4.94]$, equivalent Stock-Yogo critical values place this range at around 25 percent relative bias), which suggests that the specifications could be weakly identified. We recognize this possible weak instrument problem, and, consequently, our interpretation of the results here proceed with greater caution.

While the results are largely similar to those in Table 1, the asset volatility channel does not appear to be operative any longer in any of our specifications. We conjecture that the inclusion of the interest rate could dilute the impact of the asset volatility channel, since interest rates

¹⁹The question on changes in demand conditions posed in Senior Loan Officer Survey does not distinguish between borrower nationality. While cross-border exposures of U.S. banks are mainly to high-income countries, the response may nevertheless incorporate some consideration of demand conditions in developing countries.

Table 4: Regressions for transmission channels associated with foreign claims by EU and US banks in developing countries, 2004Q1–2011Q1 [†]

	$I1$	$I2$	$I3$	$I4$
Lagged foreign claims	0.788 (0.03)***	0.796 (0.03)***	0.797 (0.03)***	0.799 (0.02)***
LIBOR-OIS	-0.040 (0.01)***	-0.035 (0.01)**	-0.027 (0.02)	-0.029 (0.02)
1st lag			0.005 (0.01)	
2nd lag			0.015 (0.02)	
3Rd lag			-0.017 (0.01)	
LIBOR-OIS $\times$ crisis				-0.006 (0.05)
Global bank CDS	0.007 (0.01)	-0.000 (0.01)	-0.003 (0.01)	0.008 (0.01)
Global bank CDS $\times$ crisis				-0.008 (0.02)
Asset volatility	-0.024 (0.02)	-0.029 (0.03)	-0.039 (0.03)	0.029 (0.06)
Asset volatility $\times$ crisis				-0.048 (0.07)
Lending rate	0.110 (0.11)	0.641 (1.82)	0.873 (1.73)	-1.520 (2.44)
Inflation	-0.007 (0.02)	-0.061 (0.19)	-0.085 (0.18)	0.157 (0.31)
Growth	-0.075 (0.15)	-0.045 (0.13)	-0.044 (0.14)	-0.140 (0.19)
GDP	0.261 (0.04)***	0.286 (0.11)***	0.301 (0.10)***	0.174 (0.12)
Crisis	0.106 (0.02)***	0.104 (0.03)***	0.081 (0.03)***	0.175 (0.14)
Adj. R^2	0.801	0.793	0.792	0.788
Kleibergen-Papp rk		12.915**	11.812**	11.917**
Hansen J		2.343	1.999	0.209
Estimator	FE	IV	IV	IV
Instruments		13	19	16
N	2,849	2,713	2,713	2,782

[†] All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses, with the exception of specification ($I4$), where errors are bootstrapped. A constant term was included in the regressions, but not reported. The excluded instruments are the aged dependency ratio and its lags for four quarters. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

are themselves subject to significant variation, especially during periods of crisis.

The coefficient on the liquidity channel retains its sign and statistical significance in the first two of the four specifications, and approaches statistical significance in the final two ($p = 0.134$ and $p = 0.159$, respectively). Its magnitude is of the same order of significance as the benchmark: the range of coefficients is between -0.02 and -0.04 . Overall, we regard the findings reported in this section as broadly corroborative of the benchmark results. More importantly, given the insignificance of the interest rate even when it is instrumented, we conclude that concerns about endogeneity arising from its omission from the benchmark specifications are not generally well founded.

6 Conclusion

In this paper, we have examined the transmission channels for financial shocks that affect international bank lending to developing countries, using the 2007/09 crisis as a case study. Our main finding is that cross-border lending by international banks contracted primarily due to liquidity difficulties faced by these banks, and to heightened uncertainty. Another key message is that the reduction in aggregate lending to developing countries by high income banks during the crisis was not the result of changes in their sensitivity to liquidity shortages or changes in their tolerance of risk, but instead was a normal reaction to an abnormally large shock to liquidity and uncertainty.

The main shortcomings of our work here stem from our reliance on aggregate cross-border lending data. While such data encompasses much greater coverage of the total volume of lending to the developing world, our inferences were largely limited to broad averages—and, in Subsection 4.3, U.S. and EU exposures—which limits our ability to tease out idiosyncratic elements that may be of interest, such as whether solvency considerations were altogether unimportant, or whether they were more important for certain classes of financial institutions, such as those facing more severe balance-sheet difficulties. Future research along the lines of the work considered here can attempt to explore these distinctions in greater detail.

Our work here suggests that, during a financial crisis, policymakers in developing countries that host international banks may wish to supplement liquidity provision by these banks' home nations with additional monetary support, rather than limiting their credit window to domestic banks alone. This will limit the deleterious effects of credit contraction during the crisis, especially if such international banks play a significant role in their economies. Even though such banks are ultimately foreign-owned, policymakers are nevertheless invested in their success, insofar as their countries' continued viability may be directly related to those of the banks.

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Technical Appendix

Table A.1: Summary statistics for main variables in benchmark specification, by crisis period[†]

	N	Mean	Std. Dev.	Min	Max
<i>Non-crisis</i>					
Foreign claims	2,445	17,629	52,040	3	593,879
Libor-OIS	2,445	11.2	4.6	6.8	22.6
Global banking CDS	2,445	66.0	83.4	8.9	279.4
Asset volatility	2,445	-0.1	0.2	-0.4	0.4
Loan demand	2,445	0.1	0.2	-0.3	0.4
Inflation*	2,438	7.8	22.8	-35.9	941.1
Growth	2,445	5.7	5.4	-37.5	63.8
GDP	2,445	51,824	126,587	106.8	1,148,256
<i>Crisis</i>					
Foreign claims	990	22,263	58,476	4	377,268
Libor-OIS	990	88.7	49.7	42.7	211.5
Global banking CDS	990	128.9	64.9	33.7	229.7
Asset volatility	990	1.4	1.1	0.3	4.0
Loan demand	990	-0.3	0.2	-0.6	-0.1
Inflation*	986	9.9	13.3	-29.4	122.9
Growth	990	3.1	6.3	-40.5	67.5
GDP	990	58,897	137,326	157.2	1,197,708

[†] Summary statistics are provided for the sample between 2001Q4 and 2011Q1. The crisis period was defined as the period between 2007Q3 and 2009Q2.

* The inflation statistics reported here suppress the outlier cases where QoQ inflation exceeds 1,000 percent.

Table A.2: Definitions and sources of variables

Variable	Definition and construction	Data source(s)
Foreign claims	Total consolidated foreign claims of BIS reporting banks on up to 138 developing countries	BIS
LIBOR-OIS spread	Quarterly average of daily 3-month LIBOR and overnight index swap rate differential	Bloomberg
EURIBOR-EONIA spread	Quarterly average of daily 3-month EURIBOR and Euro overnight index swap rate differential	Bloomberg
LIBOR-CD spread	Quarterly average of daily 3-month LIBOR and certificate of deposit rate differential	Thomson Datastream
Global bank CDS	Synthetic claims-weighted index of U.S. and European bank CDS credit default swap indices	Thomson Datastream
Loss allowances	Allowances for losses as fraction of outstanding loans, banks with foreign offices	FDIC Qtr Bank Profile
Asset volatility	Predicted common factor of 1-month GARCH(1,1) conditional volatility of 8 assets [†]	Datastream and GEM
Asset volatility (uncond)	Predicted common factor of 1-month rolling coefficient of variation of 8 assets [†]	Datastream and GEM
Risk aversion	Net tightening of lending due to change in risk aversion (range: -1 to 1)	Fed SLOS/ECB BLS
Loan demand	Strength of demand change for C&I loans by borrowers from U.S./EU banks (range: -1 to 1)	Fed SLOS/ECB BLS
GDP	Gross domestic product, in current U.S. dollars	World Bank GEM & WDI
GDP growth	Year-on-year percentage change of real gross domestic product	World Bank GEM & WDI
Inflation	Year-on-year percentage change of CPI	IMF IFS
Depreciation	Quarterly average of change in market rate of local currency to U.S. dollars	IMF IFS
Lending rate	Quarterly average of national lending rate	IMF IFS

[†] These comprised the VIX and the computed volatility for 7 additional constituent assets: exchange rates for the USD/EUR, USD/JPY, USD/GBP, price indexes for agriculture, energy, and industrial metals, and the TED spread.

Table A.3: Information criterion statistics for autoregressive distributed lag model[†]

AIC						BIC					
L_t						L_t					
U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}		U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}	
S_t	146.73	146.73	133.07	38.86**	43.51	220.01	220.01	212.45	124.34**	135.08	S_t
S_{t-1}	146.73	146.73	133.07	38.86**	43.51	220.01	220.01	212.45	124.34**	135.08	S_{t-1}
S_{t-2}	175.63	175.63	177.48	88.72	93.44	254.55	254.55	262.47	179.76	190.54	S_{t-2}
S_{t-3}	100.71	100.71	102.53	102.35	107.15	185.15	185.15	193.01	198.86	209.68	S_{t-3}
S_{t-4}	82.19	82.19	82.86	82.56	84.55	172.05	172.05	178.72	184.41	192.39	S_{t-4}
L_{t-1}						L_{t-1}					
U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}		U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}	
S_t	146.73	146.73	133.07	38.86**	43.51	220.01	220.01	212.45	124.34**	135.08	S_t
S_{t-1}	146.73	146.73	133.07	38.86**	43.51	220.01	220.01	212.45	124.34**	135.08	S_{t-1}
S_{t-2}	175.63	175.63	177.48	88.72	93.44	254.55	254.55	262.47	179.76	190.54	S_{t-2}
S_{t-3}	100.71	100.71	102.53	102.35	107.15	185.15	185.15	193.01	198.86	209.68	S_{t-3}
S_{t-4}	82.19	82.19	82.86	82.56	84.55	172.05	172.05	178.72	184.41	192.39	S_{t-4}
L_{t-2}						L_{t-2}					
U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}		U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}	
S_t	126.56	126.56	126.43	35.36	40.03	205.95	205.95	211.92	126.94	137.70	S_t
S_{t-1}	126.56	126.56	126.43	35.36	40.03	205.95	205.95	211.92	126.94	137.70	S_{t-1}
S_{t-2}	172.37	172.37	173.16	86.22	90.97	257.36	257.36	264.22	183.33	194.14	S_{t-2}
S_{t-3}	96.75	96.75	97.30	99.20	102.99	187.23	187.23	193.81	201.74	211.55	S_{t-3}
S_{t-4}	77.62	77.62	74.83	76.43	75.86	173.48	173.48	176.68	184.28	189.69	S_{t-4}
L_{t-3}						L_{t-3}					
U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}		U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}	
S_t	33.41***	33.41***	33.64*	34.63	36.00	118.89***	118.89***	125.23*	132.32	139.78	S_t
S_{t-1}	33.41***	33.41***	33.64*	34.63	36.00	118.89***	118.89***	125.23*	132.32	139.78	S_{t-1}
S_{t-2}	80.55	80.55	82.48	82.71	84.68	171.59	171.59	179.59	185.88	193.91	S_{t-2}
S_{t-3}	96.68	96.68	98.26	99.15	99.57	193.19	193.19	200.80	207.72	214.16	S_{t-3}
S_{t-4}	78.81	78.81	76.81	78.38	76.22	180.67	180.67	184.65	192.21	196.05	S_{t-4}
L_{t-4}						L_{t-4}					
U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}		U_t	U_{t-1}	U_{t-2}	U_{t-3}	U_{t-4}	
S_t	35.54	35.54	34.13	36.05	25.53	127.11	127.11	131.81	139.83	135.41	S_t
S_{t-1}	35.54	35.54	34.13	36.05	25.53	127.11	127.11	131.81	139.83	135.41	S_{t-1}
S_{t-2}	77.10	77.10	78.89	80.78	69.22	174.19	174.19	182.05	190.01	184.52	S_{t-2}
S_{t-3}	96.93	96.93	98.55	100.47	89.14	199.45	199.45	207.10	215.06	209.75	S_{t-3}
S_{t-4}	79.18	79.18	78.15	80.10	72.43	187.02	187.02	191.98	199.93	198.24	S_{t-4}

[†] Notes: Akaike (AIC) and Bayesian (BIC) information criteria reported for models with up to four lags for the liquidity (L), solvency (S), and uncertainty (U) channels for the benchmark model. * indicates third-lowest statistic, ** indicates second-lowest statistic, and *** indicates lowest statistic, for the corresponding criterion. Multiple asterisks indicate ties.

The following tables report, without comment, additional robustness regressions for the autoregressive distributed lag (Table A.4) and interaction (Table A.5) specifications analogous to the robustness checks reported in the main text (Table 2). Note that the ADL(3,0,0) specification reported in these additional robustness checks were chosen for comparability with the benchmark, and may not reflect the best model selected according to information criteria.

The qualitative results are, in the main, unaffected by the alternative specifications, although in some cases (notably for the CDS variable), additional coefficients were rendered significant. The total effect in these cases yielded results that were consistent with those reported in the text.

Table A.4: Additional robustness regressions for transmission channels associated with foreign claims by international banks in developing countries, 2004Q1–2011Q1 †

	AR1	AR2	AR3	AR4	AR5	AR6	AR7	AR8
Lagged foreign claims	0.780 (0.03)***	0.781 (0.03)***		0.782 (0.03)***	0.779 (0.03)***	0.780 (0.03)***		0.782 (0.03)***
LIBOR-OIS		-0.017 (0.02)	-0.018 (0.02)	-0.022 (0.02)	-0.052 (0.02)***	-0.012 (0.02)	-0.018 (0.02)	-0.022 (0.02)
1st lag		0.006 (0.01)	0.013 (0.01)	0.016 (0.01)	0.018 (0.01)	-0.004 (0.02)	0.013 (0.01)	0.011 (0.01)
2nd lag		0.032 (0.01)**	0.014 (0.01)	0.013 (0.01)	0.002 (0.01)	0.028 (0.01)*	0.012 (0.01)	0.017 (0.01)
3rd lag		-0.034 (0.01)***	-0.017 (0.01)	-0.022 (0.01)**	-0.018 (0.01)	-0.039 (0.01)***	-0.017 (0.01)	-0.023 (0.01)**
LIBOR-CD	-0.051 (0.02)**	-0.009 (0.02)						
1st lag	0.012 (0.01)							
2nd lag	0.013 (0.01)							
3rd lag	-0.003 (0.01)							
Global bank CDS	(0.01)	(0.01)						
Loss allowances	-0.007 (0.01)	-0.001 (0.01)		-0.001 (0.01)	0.004 (0.01)	-0.002 (0.01)	-0.001 (0.01)	-0.003 (0.01)
Asset volatility			-0.002 (0.02)					
Asset volatility (unconditional)	-0.053 (0.04)	-0.116 (0.04)***	-0.061 (0.02)**	-0.096 (0.04)***		-0.118 (0.03)***	-0.055 (0.03)**	-0.068 (0.02)***
Risk aversion								
Loan demand	-0.016 (0.04)	-0.062 (0.06)	0.015 (0.04)	0.005 (0.04)	0.072 (0.09)	0.304 (0.11)***		-0.004 (0.04)
Inflation	-0.023 (0.01)***	-0.022 (0.01)***	-0.023 (0.01)***	-0.024 (0.01)***	-0.024 (0.01)***	-0.025 (0.01)***	0.021 (0.05)	-0.059 (0.01)***
Inflation, YoY							-0.034 (0.01)***	
Growth	-0.180 (0.15)	-0.162 (0.15)	-0.235 (0.16)	-0.148 (0.15)	-0.128 (0.15)	-0.191 (0.16)		-0.176 (0.16)
Growth, YoY							-0.403 (0.40)	
GDP	0.278 (0.04)***	0.276 (0.04)***	0.321 (0.04)***	0.285 (0.04)***	0.269 (0.04)***	0.248 (0.04)***	0.324 (0.05)	0.289 (0.04)***
Depreciation								0.022 (0.00)***
Crisis	0.075 (0.02)***	0.080 (0.03)***	0.074 (0.03)**	0.083 (0.03)***	0.083 (0.03)***	0.041 (0.03)	0.075 (0.03)***	0.082 (0.03)***
Adj. R^2	0.776	0.776	0.715	0.776	0.775	0.776	0.714	0.777
R^2 (within)	0.776	0.777	0.716	0.777	0.776	0.777	0.716	0.778
Estimator	FE	FE	FE	FE	FE	FE	FE	FE
N	3,429	3,429	3,054	3,429	3,429	3,429	3,054	3,393

† All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A constant term was included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

Table A.5: Additional robustness regressions for transmission channels associated with foreign claims by international banks in developing countries, 2004Q1–2011Q1 [†]

	BR1	BR2	BR3	BR4	BR5	BR6	BR7	BR8
Lagged foreign claims	0.772 (0.03)***	0.771 (0.03)***	0.772 (0.03)***	0.771 (0.03)***	0.769 (0.03)***	0.770 (0.03)***	0.769 (0.03)***	0.772 (0.03)***
LIBOR-OIS	-0.036 (0.02)	-0.036 (0.02)	-0.022 (0.02)	-0.028 (0.02)	-0.024 (0.02)	-0.043 (0.02)**	-0.027 (0.02)	-0.030 (0.02)*
LIBOR-OIS × crisis	0.011 (0.05)	0.011 (0.05)	0.005 (0.04)	-0.003 (0.04)	-0.075 (0.04)*	0.036 (0.04)	-0.001 (0.04)	-0.004 (0.04)
LIBOR-CD	0.015 (0.06)	0.042 (0.08)						
LIBOR-CD × crisis	-0.020 (0.06)	-0.048 (0.07)						
Global bank CDS	-0.007 (0.01)	0.003 (0.01)		0.004 (0.01)	0.005 (0.01)	0.001 (0.01)	0.002 (0.01)	0.002 (0.01)
Global bank CDS × crisis	-0.002 (0.02)	-0.010 (0.01)		-0.010 (0.01)	-0.035 (0.02)	-0.016 (0.01)	-0.013 (0.01)	-0.010 (0.01)
Loss allowances			-0.006 (0.01)					
Loss allowances × crisis			-0.024 (0.03)					
Asset volatility	-0.058 (0.04)	-0.067 (0.05)	-0.069 (0.04)*			-0.104 (0.05)**	-0.062 (0.04)	-0.063 (0.05)
Asset volatility × crisis	-0.035 (0.04)	-0.002 (0.07)	0.014 (0.06)			0.004 (0.06)	0.016 (0.07)	0.013 (0.06)
Asset volatility (unconditional)				-0.089 (0.07)				
Asset vol (uncond) × crisis				0.017 (0.10)				
Risk aversion					-0.092 (0.11)	0.187 (0.10)*		
Risk aversion × crisis					0.380 (0.32)			
Loan demand	0.001 (0.05)	-0.013 (0.06)	-0.021 (0.04)	-0.009 (0.04)	-0.091 (0.08)	0.027 (0.05)	-0.012 (0.04)	-0.015 (0.04)
Inflation	-0.021 (0.16)	-0.022 (0.15)	-0.022 (0.16)	-0.022 (0.16)	-0.024 (0.16)	-0.023 (0.18)	-0.057 (0.15)	-0.057 (0.15)
Inflation, YoY							-0.034 (0.30)	
Growth	-0.166 (0.18)	-0.176 (0.19)	-0.179 (0.16)	-0.165 (0.18)	-0.159 (0.20)	-0.179 (0.15)		-0.190 (0.18)
Growth, YoY							-0.241 (0.38)	
GDP	0.294 (0.04)***	0.287 (0.05)***	0.288 (0.04)***	0.277 (0.05)***	0.260 (0.04)***	0.274 (0.04)***	0.281 (0.05)***	0.283 (0.04)***
Depreciation								0.020 (0.09)
Crisis	0.167 (0.16)	0.267 (0.19)	0.081 (0.12)	0.155 (0.10)	0.390 (0.12)***	0.042 (0.15)	0.159 (0.14)	0.168 (0.14)
Adj. R^2	0.762	0.762	0.762	0.762	0.762	0.763	0.761	0.763
R^2 (within)	0.772	0.772	0.772	0.772	0.772	0.772	0.771	0.773
Estimator	FE	FE	FE	FE	FE	FE	FE	FE
N	3,435	3,435	3,435	3,435	3,435	3,435	3,401	3,399

[†] All variables are in log form. Bootstrapped standard errors are reported in parentheses. A constant term was included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.