Discussion Paper

International banking and liquidity risk transmission: lessons from across countries

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Non-technical summary

Research Question
In the past decades, banking has become global and the ratio of credit over GDP has surged. Banking systems are much larger than they used to be and have a greater exposure to international shocks. Yet, we know relatively little about the actual transmission of balance sheet shocks through international banks, about which banks are affected most, and about the effectiveness of interventions by governments and central banks in domestic and international contexts. Many of these questions cannot be answered using data that are aggregated or semi-aggregated across all banks participating in an economy. Careful analysis of the transmission of shocks through internationally active banks requires micro-data on individual bank.

Contribution
For these reasons, the International Banking Research Network (IRBN) was conceptualized and then established in 2012 by central bank researchers and academics from Austria, Germany, the United Kingdom, and the United States. In 2013, the IRBN expanded to include researchers from Australia, Canada, France, Hong Kong, Ireland, Italy, Poland, and Spain, with representatives of the BIS and the IMF engaged in IBRN discussions. The network brings together researchers with access to their country´s bank-level data to analyse issues pertaining to global banks. This paper summarizes cross country empirial results focusing on one specific theme, namely the exposure of banks to liquidity shocks and the resulting impact of liquidity shocks on bank lending, both domestically and abroad. More specifically, 11 country studies use data for the period from 2006 through 2013 and focus on the question of how liquidity shocks transmit into bank lending and which balance sheet characteristics shape this transmission. We set up a meta analysis in order to summarize the results of the 11 studies. The studies show that the lending responses of domestic bank (those without foreign affiliates) to liquidity risk do not depend on banks' balance sheet characteristics in a consistent way across countries. By contrast, the studies find interesting distinctions across global banks (those with foreign affiliates) in transmission of liquidity risk into lending.

Results
The paper provides valuable insights into how liquidity shocks affect national and international lending. The selected approaches are better suited to explain national than international lending. Amongst others, banks' balance sheet structure and the possibility of liquidity management between parent enterprises and their international subsidiaries appear to be important for the transmission of shocks. However, there is no consistent picture with regard to the relevance of different balance sheet metrics across borders. Another finding is that government support measures, which the banks could draw upon when faced with such liquidity shocks, were important for lending. They often replaced funding sources which were available to the banks under "normal" circumstances, and have thus stabilised lending.

Nicht-technische Zusammenfassung

Fragestellung
International tätige Banken haben in der Finanzkrise eine wichtige Rolle gespielt. Welche Eigenschaften international tätiger Banken eher stabilisierend, welche eher destabilisierend gewirkt haben, ist aber eine offene Frage. Dieses Papier geht daher der Frage nach, über welche Mechanismen und wie stark Liquiditätsschocks die nationale und die grenzüberschreitende Kreditgewährung von Banken beeinflusst haben.

Beitrag
Das Papier untersucht diese Fragen mithilfe von empirischen Daten einzelner Banken. Entsprechende Ansätze beschränkten sich bisher auf Daten für jeweils ein Land. Erstmals werden hier die Daten für 11 Länder zu Grunde gelegt, darunter so wichtige wie die USA, Deutschland und Großbritannien. Dies wurde durch die Zusammenarbeit von Volkswirten aus den betreffenden Notenbanken im Rahmen eines Forschungsnetzwerkes ermöglicht (Internationales Bankennetzwerk, IBRN). Zwar konnten die Daten aus Vertraulichkeitsgründen nicht zusammengeführt werden. Sie wurden aber mithilfe des Netzwerkes mit einem einheitlichen Ansatz analysiert.

Ergebnisse
Das Papier zeigt, wie Liquiditätsschocks die nationale und internationale Kreditgewährung beeinflussen. Dabei sind die gewählten Ansätze besser geeignet, die nationale als die internationale Kreditgewährung zu erklären. Unter anderem scheint die Bilanzstruktur der Banken und die Möglichkeit des Liquiditätsmanagements zwischen Müttern und ihren internationalen Niederlassungen für die Übertragung der Schocks wichtig zu sein. Allerdings zeigt sich kein einheitliches Bild bezüglich der Relevanz der verschiedenen Bilanzkennzahlen für die Transmission von Schocks. Eine andere Erkenntnis ist, dass staatliche Unterstützungsmaßnahmen die Kreditgewährung beeinflusst haben.

International Banking and Liquidity Risk Transmission:

Lessons from Across Countries[*]

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Abstract

Activities of international banks have been at the core of discussions on the causes and effects of the international financial crisis. Yet, we know little about the actual magnitudes and mechanisms for transmission of liquidity shocks through international banks, including the reasons for heterogeneity in transmission across banks. The International Banking Research Network (IBRN), established in 2012, brings together researchers from around the world with access to micro-data on individual banks to analyze issues pertaining to global banks. This paper summarizes the common methodology and results of empirical studies conducted in 11 countries to explore liquidity risk transmission. Among the main results is, first, that explanatory power of the empirical model is higher for domestic lending than for international lending. Second, how liquidity risk affects bank lending depends on the whether the banks are drawing on official sector liquidity facilities. Third, liquidity management across global banks can be important for liquidity risk transmission into lending. Fourth, there is substantial heterogeneity in the balance sheet characteristics that affect banks' responses to liquidity risk. Overall, bank balance sheet characteristics matter for differentiating lending responses across banks mainly in the realm of cross-border lending.

1 Background and Motivation

In the past decades, banking has become global and the ratio of credit over GDP has surged. Banking systems are much larger than they used to be and have a greater exposure to international shocks. Internationally active banks have thus been at the core of discussions on the causes and effects of the international financial crisis. Policymakers have stated their intention "to manage capital flows in order to deal with the risks and reap the benefits of cross-border capital flows", recognizing that "central banks play a major role in addressing global liquidity shocks".[1] Yet, we know relatively little about the actual transmission of balance sheet shocks through international banks, about which banks are affected most, and about the effectiveness of interventions by governments and central banks in domestic and international contexts.

The papers compiled in this symposium thus address four main questions: First, how do liquidity conditions affecting the parent bank transmit into domestic and foreign lending for different types of banks? Second, how does the ex-ante balance sheet composition of banks (for example, capitalization, liquid asset shares, deposit funding) influence cross-sectional responses to liquidity risk? Third, what role does internal liquidity management in banks, achieved through borrowing and lending across affiliated domestic and foreign offices, play in magnifying or damping lending effects of liquidity risk? Fourth, did the use of official sector liquidity provision influence the cross-sectional differences across banks in domestic and foreign lending?

Many of these questions cannot be answered using data that are aggregated or semi-aggregated across all banks participating in an economy. Careful analysis of the transmission of shocks through internationally active banks requires micro-data on individual banks and perhaps markets. While the corresponding bank-level micro data are aggregated and used as an input to the International Banking Statistics of the Bank for International Settlements (BIS), the bank-level data are confidential and cannot be merged together across countries for analytical work.

For these reasons, the International Banking Research Network (IBRN) was conceptualized and then established in 2012 by central bank researchers and academics from

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[1] See Communiqué of the G20 Finance Ministers and Central Bank Governors, Paris, October 15, 2011. On the role of public sector liquidity provision during crises, see also Committee on the Global Financial System (2011).

Austria, Germany, the United Kingdom, and the United States. In 2013, the IBRN expanded to include researchers from Australia, Canada, France, Hong Kong, Ireland, Italy, Poland, and Spain, with representatives of the BIS and the IMF engaged in IBRN discussions. The network brings together researchers with access to their country's bank-level data to analyze issues pertaining to global banks. The participants analyze bank-level datasets by country and share empirical results and insights (not data). The resulting research yields comparable cross-country evidence on a topic from different banking system perspectives and with the benefits of delving into the reasons for heterogeneity within and across countries.

The papers included in this symposium focus on one specific theme, namely the *exposure of banks to liquidity shocks* and the resulting *impact of liquidity shocks on bank lending*, both domestically and abroad. More specifically, 11 country studies use data for the period from 2006 through 2013[2] and focus on the question of how liquidity shocks transmit into bank lending and which balance sheet characteristics shape this transmission. All papers use a common research methodology wherein changes in different types of lending are regressed on balance sheet characteristics, measures of liquidity risk, and information on public interventions. If relevant data are available, IBRN researchers explore the effects of official sector policy interventions, such as bank-specific use of special lending facilities. The datasets available at the national level differ with regard to their granularity, but they allow the researchers to combine information on flows of funds through banks with balance sheet characteristics of banks. Beyond applying a common analytical framework, each country contribution provides a narrative which is specific to its national experience. Some examples are the importance of the Vienna Initiative for Austrian banks (Segalla 2014), the distinction between foreign branches and subsidiaries for German banks (Kerl and Koch 2014), or the importance of foreign exchange loans for Poland (Pawlowska et al. 2014). Countries have banks also play different roles in international financial markets. For example, Ireland (Everett et al. 2014) and Poland are largely hosts to foreign-owned banks while the United States (Correa et al. 2014), Germany, and the United Kingdom (Hills et al. 2014) are the homes of many banks with foreign affiliates.

We set up a meta analysis in order to summarize the results of the 11 studies. Meta analyses characterize the results across empirical studies by asking which features of the regression sample affect an outcome or the explanatory power of a particular empirical model (Boockmann 2010, Card and Krueger 1995, Doucouliagos and Stanley 2008). The empirical

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[2] Countries providing research contributions to the initiative in 2013 are: Australia, Austria, Canada, France, Germany, Hong Kong, Ireland, Italy, Poland, the United Kingdom, and the United States.

studies we summarize are very homogenous across countries because all teams used the same baseline regression model, even if the variable definitions and samples of banks can differ along specific dimensions. Hence, we do not have to deal with issues such as publication bias which affect meta analyses that draw on published research only. Within our meta analysis, we use the probability that the effect of a particular variable has a significant impact on lending as a function of variables such as the number of banks included, the type of banking activity (domestic versus cross-border lending versus lending internal to the organization), or the type of banks (those with versus without foreign affiliates).

The studies show that the lending responses of domestic banks (those without foreign affiliates) to liquidity risk do not depend on banks' balance sheet characteristics in a consistent way across countries. By contrast, the studies find interesting distinctions across global banks (those with foreign affiliates) in transmission of liquidity risk into lending.[3] The meta analysis identifies the following tendencies in liquidity risk transmission:

- Across regression specification, explanatory power is higher when the dependent variable is domestic loan growth, compared with specifications focussed on intra-bank net lending or cross-border lending.

- How liquidity risk affects lending of banks with different balance sheet structures depends on the time period considered. Responses in more "normal" periods, when banks are not accessing official liquidity facilities, differ from those in periods when banks access these facilities. Bank use of official liquidity facilities tends to replace funding support drawn from affiliated offices.

- Internal capital market activity within banks matters for lending stability. Banks operating within host markets support lending to a greater degree in times of increased liquidity risk if the banks have higher net borrowing from (or lower net lending to) the rest of their organizations.

- While balance sheets factors sometimes drive cross-sectional differences in domestic lending growth by banks, balance sheet factors matter most consistently for cross-border lending growth changes in response to liquidity risk conditions. It is noteworthy, however, that no single balance sheet factor drives lending results in the same way across all countries.

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[3] Depending on the country, these banks can be domestically-owned with affiliates located outside of their country, or they can be foreign-owned banks operating in a country that is largely a host for the global banks.

In Section 2, we provide descriptive statistics on the evolution of international banking during the crisis. Section 3 briefly summarizes previous literature in the field and lays out the common empirical methodology. Section 4 summarizes the main results from meta-analysis study. Section 5 concludes, also stressing that the meta analysis is a complement to, but not a substitute for, the rich insights include in the individual country analyses contained within the papers of the symposium.

2   The Big Picture

The past decades have witnessed a significant increase in bank credit, both domestically and across borders. This expansion of international credit has come to an abrupt halt since the outbreak of the financial crisis in 2007/2008. Between 2000 and 2007, the ratio of credit over GDP expanded from close to 100% to an average of 120% in the countries under study; at the end of 2012, it stood at an even higher 125% of GDP. Cross-border credit, in contrast, doubled from about 30% to 66% of GDP before the crisis but declined to 55% subsequently.[4] These findings are consistent with observations that global liquidity fell more than domestic liquidity in the wake of the crisis (BIS CGFS 2011), but also has not fully recovered.

Data on cross-border banking activities as provided by the Bank for International Settlements (BIS) are particularly useful for illustrating some of the dynamics of the crises (Figure 1). While lending to bank and nonbank counterparties sharply contracted initially, bank-to-bank lending has remained at lower levels while the lending to private non-bank customers rebounded more quickly. The build up of cross-border assets before the crisis and the subsequent withdrawal from foreign markets, as also reflected in stocks of outstanding claims (Figure 2), look very similar for all BIS reporting countries and the IBRN countries represented in this symposium.

However, looking behind the aggregate patterns reveals quite distinct trends across countries (not shown). Cross-border bank flows for Germany, Ireland, and the United Kingdom show patterns roughly in line with those seen in the aggregate data. France and the United States exhibit similar general patterns, but the data are somewhat more volatile. Some smaller countries in our sample look quite distinct: Australian banks, for instance, did not

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[4] Data on annual net domestic credit (IFS line 32) and GDP are taken from the IMF and The World Bank. To convert net domestic credit from local currency to US-Dollar, we construct the annual exchange rate as implied by the conversion of GDP in local currency to GDP in US-Dollar. Data on cross-border credit are taken from the BIS Locational Banking Statistics. The corresponding numbers using the Consolidated Banking Statistics increased from 30% to 61% of GDP before the crisis and declined subsequently to 56%.

build up foreign assets before the crisis, while the country experienced quite significant in- and outflows of bank assets during the crisis. Also, Canadian banks did not increase their exposure to foreign countries before the crisis, but these banks invested abroad at a fairly large scale during the crisis (Chapman and Damar 2014). Italian banks moderately invested abroad before the crisis, while in- and outflows of the Italian banking system became more volatile after the outbreak of the crisis.

It is important to understand the driving forces and dynamics of both domestic and international lending. If banks withdraw from international markets at a large scale, this may reduce their ability to hedge domestic country idiosyncratic risk, but it may also increase their resilience against global shocks. Adjustment of domestic lending ultimately affects the financing conditions for domestic firms. Analyzing the relative adjustment of domestic and international lending and the bank-specific features that drive this adjustment requires bank-level data.

Figure 3 compares the evolution of loans to different counterparties, using some of the data from the country-specific regressions in this symposium. In order to compare data across countries, all (nominal) series in US-dollar are indexed to 100 for the beginning of the period (2006). In terms of domestic loans, the time series are relatively flat for Germany and rose before dropping back and recovering in late 2008 into 2009 for the United States. Data for Ireland, in contrast, show a longer and deeper boom-bust-cycle as domestic lending increased before the crisis, to be followed by a contraction through 2011. In Canada and, even more pronounced, in Poland, domestic lending has increased throughout.

Foreign loans by banks follow different patterns than domestic loans. The boom-bust-cycle is again quite pronounced for Ireland's banks. Canadian banks increased foreign loans during the period when US foreign loans contract, with a common growth trajectory afterwards. German and Polish banks have contracted their foreign loans. In this sense, the withdrawal from foreign markets during the crisis has been a European phenomenon. This increasing "home bias" is stressed by the country studies for British and German banks (Hills et al. 2014, Kerl and Koch 2014).

Finally, two panels show the pattern of net lending between banks and their affiliates, separately displayed due to the differences in scales of change for the U.S. and German banks as compared with the Ireland and Canada banks. First, observe that banks in all four countries were net debtors relative to their affiliates at least through 2010. These affiliates served as net funding sources, not for all banks within each country, but for all these countries overall

during the early sample period. Net volumes through internal capital markets varied considerably over time, particularly for Canada and Ireland, and even reversed direction on balance for the U.S. and Irish banks.

3 Theoretical Background and Empirical Method

The papers in this symposium ask two main research questions: First, how does liquidity risk affect banking lending, both at home and abroad? Second, how does this response differ across banks and countries? These questions are not new – they are, in fact, at the heart of studies analyzing the impact of the banking system on the real economy – but previous literature could not answer these questions from a comparative cross-country perspective. In this section, we thus explain how research in the IBRN adds to previous literature and how we tackle the issue of identifying shock transmission through internationally active banks.

3.1 Previous Literature

Until recently, research on international banking has been a relatively underdeveloped field in international economics and international business. This reflects the lack of a consistent theoretical framework to analyze international banking activities. But it also reflects a lack of access to relevant bank-level data. In recent years, theoretical and empirical research on international banking has made significant progress.

Two strands of theoretical literature are particularly relevant for the research conducted in the IBRN. The first deals with the effects of the integration of banking markets for financial stability. In their seminal work on the contagious effects of liquidity shocks, Allen and Gale (2000) show that the link between financial integration and the risk of financial contagion is highly non-linear: the risk of contagion is greatest in partially integrated banking markets with an incomplete network of interbank linkages. Subsequent research has enriched the baseline model by including asset price shocks, by analyzing the role of publicly provided liquidity, or by examining the impact of systemic shocks. Generally, this literature shows that the risk of financial contagion is greatest when banks' liquidity buffers are depleted and the stronger the common (liquidity) shock.

This literature on financial contagion takes the degree of integration of international banking markets as given or does not address this dimension at all. Issues relevant for the transmission of shocks such as the decision of banks to lend across borders or to set up affiliates abroad are not studied. For these reasons, a new research field has developed which

successfully applies insights from international economics to international banking (Goldberg 2007). The essence of this literature is that internationalization choices of banks are strongly driven by bank size and productivity, and that only the large and productive banks can afford the fixed costs of entering foreign markets.[5] Size effects also feature prominently in applications of gravity models to international banking (Brueggemann et al. 2012, Niepmann 2013, Okawa and van Wincoop 2012).

Empirical studies have shifted focus to the transmission of shocks through internationally active banks.[6] Peek and Rosengren (1997, 2000) documented the transmission of asset price shocks originating in Japan to the United States, exploiting the fact that these shocks were exogenous to the banks affected and that the presence of Japanese banks in the United States varied across regions. In terms of the bank-level characteristics that affect shock transmission, recent literature has provided at least two main insights. First, balance sheet strength matters. Several studies show that access to a stable funding base of (local) deposits and the strength of the capital buffer of the (foreign) parent bank can affect the stability of local lending.

Second, domestic and international banks behave differently. Multinational banks actively use internal capital markets to manage liquidity (Cetorelli and Goldberg 2012a). In the financial crisis, foreign banks with a high exposure to the subprime crisis reduced internal funds available for their affiliates in the US, leading to relative weaker lending by these affiliates (Cetorelli and Goldberg 2012b). Purely domestic banks were more isolated from the crisis and showed more stable lending patterns than multinational banks (Claessens and van Horen 2012, De Haas and van Lelyveld 2011), reflecting different business models and different customer bases. Hale et al. (2013), using data on international syndicated bank lending to analyze the transmission of financial shocks through international banking networks, show that these networks tend to support international trade between countries.

The structure of host country markets and the bank relationship with that market matters as well for the transmission of shocks. Foreign banks remained more committed to countries hosting an affiliated subsidiary, that are geographically close, and that have developed relationships with local banks (De Haas and van Horen 2011). The shock transmission to affiliate locations through the parent bank is weaker for those affiliate locations considered as

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[5] See De Blas and Russ (2013) for a theoretical analysis of banks' internationalization choices; Buch et al. (2011) for an empirical analysis using German data. Buch and DeLong (2012) provide a comprehensive survey of literature on cross-border bank mergers.

[6] See also Acharya et al. (2013) or Dietrich and Vollmer (2010).

important investment locations and stronger for important funding locations (Cetorelli and Goldberg 2012c). International shock transmission also was influenced by government interventions in recent crises (Buch et al. 2014, Rose and Wieladek 2011).

In sum, empirical research on the impact of liquidity shocks on bank lending should take into account the nature of the shock (bank-specific versus global), the balance sheet structure, the degree of internationalization of the bank under study, and the role of public sector liquidity support. In exploring the effects of liquidity shocks, the key challenge is the identification of loan demand and supply effects across banks. The approach that papers in this volume follow is to explain heterogeneity across banks (and countries) in order to identify a loan supply effect. In the following, we describe our approach towards "identification through heterogeneity" (Gilchrist and Zakrajsek 1995).

3.2 Theoretical Justification of Loan Specification

The country studies in this volume show changes in lending by banks in response to changes in liquidity risk as a function of bank-specific characteristics and the pricing and availability of official sector liquidity. In this section, we provide theoretical justification for the specifications. We begin with the Khwaja and Mian (2008, KM2008) two-period model of bank lending, provide extensions of this framework to map to the Cornett, McNutt, Strahan and Tehranian (2011, CMST2011) empirical specification, and we then show how use of official sector liquidity matters.

3.2.1 *Baseline Model*

In period t, a representative bank i and firm j negotiate a loan of size L_t^{ij}. The bank receives funding through deposits, D_t^{ij} which are costless (or priced at a low fixed rate) up to some given level. The implicit assumption is that bank deposits are insured through a deposit insurance system. The bank can fund its activities through costless deposits until a certain scale of activity is reached. Thereafter, additional external financing B_t^i is available to bank i with the marginal cost of funds given by $\alpha_B B_t^i$ with $\alpha_B > 0$. Credit demand is such that marginal returns on loans are decreasing in loan size with every counterparty $\bar{r}_t^j - \alpha_L L_t^{ij}$.

At the end of period t, two types of shocks hit the economy. Available funds beyond the *ex ante* level of deposits vary with an aggregate credit supply shock $\bar{\delta}_t$ and a bank-specific or idiosyncratic shock δ_t^i. Credit demand shocks work through the marginal returns

on loans, which increase with aggregate and idiosyncratic productivity shocks $\bar{\eta}_t$ and η_t^j.

Jointly solving the first order conditions for loan supply and demand in each period, KM 2008 solve for the single first-differenced equation (1), here amended with time subscripts:

$$\Delta L_{t+1,t}^{ij} = \frac{1}{(\alpha_L + \alpha_B)}\left(\alpha_B \cdot \bar{\delta}_{t+1} + \bar{\eta}_{t+1}\right) + \frac{\alpha_B}{(\alpha_L + \alpha_B)}\delta_{t+1}^i + \frac{1}{(\alpha_L + \alpha_B)}\eta_{t+1}^j \tag{1}$$

The first term on the right hand side of (1) is a constant and thus the common shock affecting all transactions. This common effect is captured by a time fixed effect (or a country-time fixed effect if the data span several countries). The second term is idiosyncratic to the bank but transmitted to all borrowers of that specific bank. KM2008 interpret δ_t^i as the bank-specific change in access to deposits. While KM2008 exclusively focus on the cross-sectional adjustment at a point in time, we exploit the time series variation in lending as well. δ_t^i could broadly be interpreted as market liquidity risk. Moreover, we follow Cetorelli and Goldberg (2011) and reinterpret "firm j" as corresponding to the aggregate of firms from country c as reported by the banks in their country exposures. [7]

Liquidity risk has two dimensions. On the asset side, it refers to the structure of a bank's assets and thus captures the share of assets that can be converted into cash quickly. On the liability side, liquidity risk refers to rollover risk, i.e. the risk of not being able to refinance short-term debt as it becomes due. Our examination starts with a liquidity risk time series r_t^c that is common across all banks i within some country c and that is proxied by the LIBOR-OIS spread.[8] The exposure of a specific bank to liquidity risk thus depends on the strength of its balance sheet (CMST2011). We capture balance sheet strength through a vector χ_t^i, which could include the proportion of deposits in bank funding, the share of assets that are illiquid, or outstanding credit commitments.

We substitute $\delta_t^i \equiv \chi_t^i \cdot \Delta r_t^c$ and re-write (1) to yield a time-series panel specification where ex-ante balance sheet composition influences the adjustment of lending (and other variables within L_t^{ij}) to changes in the market price of liquidity risk Δr_t^c:

$$\Delta L_{t+1,t}^{ij} = \frac{1}{(\alpha_L + \alpha_B)}\left(\alpha_B \cdot \bar{\delta}_{t+1} + \bar{\eta}_{t+1}\right) + \frac{\alpha_B}{(\alpha_L + \alpha_B)}\chi_t^i \cdot \Delta r_t^c + \frac{1}{(\alpha_L + \alpha_B)}\eta_{t+1}^j \tag{2}$$

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[7] Brueggemann, Kleinert and Prieto (2011) provide a gravity model for banks and show how bank-firm level relationships can be aggregated up at the country-level.

[8] See Drehmann and Nikolaou (2010) on the definition and measurement of funding risk.

The interactions between $\chi_t^i \cdot \Delta r_t^c$ show which balance sheet characteristics of banks drive responses of lending to liquidity risk.

3.2.2 *The Role of Official Sector Liquidity*

While specification (2) holds in "normal" periods, it may yield biased estimates of the effects of liquidity risks in periods when banks access liquidity provided by central banks (or other public sector sources). The availability and use of official liquidity at a price below r_t^c renders the market price as being less relevant to the banks.

To illustrate this point, Figure 4a Panel I shows how banks' external cost of finance relate to bank characteristics, and how these cost frontier curves are shifted upward across time t_0, t_1, t_2 for all banks as a result of exogenous shocks. Banks with different characteristics χ_t^i are denoted across the horizontal axis. The line at the bottom reflects the effective funding costs facing banks at time t_0: costs of market liquidity are proportionately higher for banks with weaker fundamentals (lower χ_t^i) than for banks with stronger fundamentals. The market price of liquidity risk can evolve over time, generating pricing frontiers at different dates, and different types of banks $i = 1, 2, …, k$ may be affected differently. The resulting time series of liquidity costs for specific types of banks are re-mapped in Figure 4a Panel II, appearing as the graphical visualization of regression treatments.

Missing from this visualization is the role for publically-provided liquidity, for example through lender of last resort facilities available through central banks. Such emergency lending is typically available through facilities such as the discount window of the Federal Reserve. However, the pricing of this liquidity and perceived stigma associated with its use (Armantier et al. 2011) generally leaves the cost of funding above the market prices of external finance. This is illustrated in Figure 4b Panel I, wherein t_0 has the interpretation of "normal" market conditions, and the public sector price of liquidity for country c is $r_0^{c,pub}$.

Now suppose there is an exogenous shift in private sector liquidity costs to a higher frontier at time t_1. As shown in Figure 4b Panel I, as long as public sector (central bank) liquidity $r_{t=0}^{c,pub}$ is above the market rate, the effective cost of liquidity still corresponds to the funding costs on the private market. At the initial pricing of public sector funds, large and potentially disruptive changes in the private cost of funds are mitigated by public sector provision only for the weakest banks at t_2.

Alternatively, suppose public sector funding is offered at $r_1^{c,pub} < r_0^{c,pub}$. In this case, when private sector liquidity costs rise in t_1, banks with weak fundamentals will find it cost-effective to access public sector liquidity mechanisms. The strong banks will continue to acquire funding in private markets. The effective price of liquidity for the weak banks is no longer a transformation of the private price, introducing a kink into the time series profile shown in Figure 4b Panel II. Assuming the same market price over time while, in reality, the public cost of liquidity has been below the private cost of liquidity, will yield to biased regression results for all firms for which χ_t^i is lower than some threshold value. For these banks and at these dates, elasticities of balance sheet response to changes in liquidity provision need to be measured relative to the public cost of funds, not the private cost of funds.

Now suppose that the jump in the private cost of funds from period t_0 to t_1 raises systemic concerns arising from large potential changes in L_t^{ij} that generate a credit crunch, a lack of capital in the system, or a downward spiral of asset prices across banks. Figure 4c Panel I demonstrates the case when emergency liquidity facilities are introduced and the price of public funding is lowered to $r_1^{c,pub\prime} < r_1^{c,pub}$. As shown in Figure 4c Panel II, weak banks experience a discrete drop in the effective cost of liquidity (denoted by the red arrow). Additionally, a larger group of χ_t^i banks (with characteristics between $i = 1$ and $i = 2$) are subject to the kinked effective cost of funds due to the availability of attractively priced public funding at date t_1. The bias in empirical specifications becomes even more pronounced in models which assume linearities and ignore the role of public sector funding and emergency lending in crises episodes.

3.3 Translation to an IBRN Empirical Specification

The framework described above maps into an IBRN empirical specification which has two basic methodological antecedents. The first is CMST2011 who examined the role of ex-ante bank balance sheet composition in explaining the ex-post differences across large and small U.S. banks in terms of balance sheet adjustment to liquidity risk conditions. The second is the work by Cetorelli and Goldberg (2012c) who focus on global banks, which are those with foreign affiliates.

Within the IBRN initiative, the respective country teams delineate types of banks that are particularly relevant for their economies. For example, IBRN countries distinguish across

three characteristics: bank size (small versus large), banks with or without foreign affiliates, and bank type. Some countries also contrast the responses of domestic lending versus funding, and lending with related and unrelated counterparties at home and abroad. Where data availability permits, some IBRN studies are able to explicitly test for the kinked response to liquidity risk under the presence of an official sector liquidity facility.

The main regression specification appears as:

$$\Delta Y_{it} = \gamma_i + \mu_t + \left(\beta^0 + \beta^1 LIB\_OIS_t \right) \chi_{i,t-1} + \left(\alpha^0 + \alpha^1 LIB\_OIS_t \cdot \chi_{i,t-1} \right) F_{it} + \varepsilon_{it} \qquad (3)$$

where Y_{it} corresponds to bank i balance sheet items that could affect the response of lending to liquidity risk exposures. Most countries, given our focus on lending and credit, explore loans to domestic counterparties and loans to foreign counterparties, all scaled by bank assets. Some countries have data on domestic banks with foreign affiliates, and can also consider local claims extended by these affiliates and net due to balances (which capture the net internal borrowing of the parent bank from its foreign affiliates).[9] Some countries also follow the CMST2011 specification more closely by including liquid assets and credit extension.

$\chi_{i,t-1}$ is a vector of lagged control variables that captures the degree to which a bank is exposed to liquidity risk through ex ante balance sheet composition and market access. Balance sheet composition is captured through bank-specific data on lagged illiquid asset share, the share of deposits in bank funding, the size of outstanding unused commitments, and bank capital. Because some of the banks have affiliates with which they can borrow and lend through internal capital markets, some specifications include related net due to shares in funding. As in CMST2011, we refrain from interpreting the role of bank size in the specifications given its multiple potential implications. The impact of size on exposure to liquidity risk is, in fact, not clear a priori. Large banks, for example, might have better opportunities to diversify risk but may, at the same time, be exposed to systemic risk to a greater degree.

To proxy liquidity risk r_t^c, each country team includes a relevant measure like a LIBOR over OIS spread $\left(LIB\_OIS_t \right)$.[10] The associated data are provided in Figure 5. The

[9] The country teams introducing "Net Due To" positions in their specifications are Australia, Austria, Canada, Germany, Ireland, Poland, and the United States.

[10] Some alternative series include the 3-month LIBOR-OIS spreads (along with its components) of the European Euro (EUR), Pound Sterling (GBP), Hong Kong Dollar (HKD), Japanese Yen (JPY), Singapore Dollar (SGD), Swiss Franc (CHF), the US dollar (USD), Australian dollar (AUD), Canadian Dollar (CAD). For Hong Kong

interaction between the balance-sheet composition terms and the LIBOR over OIS spread shows whether banks' credit extension changes with funding risks depending on ex-ante balance sheet features. The baseline regression model includes bank (γ_i) and time (μ_t) fixed effects so that β reflect the importance of cross-sectional differences in balance sheet compositions on the liquidity risk effects.

Data for some countries allow testing whether the use of official liquidity facilities affects how banks respond to liquidity risks.[11] For this purpose, interaction terms between the $\chi_{i,t-1}$ variables and a measure of central bank interventions are introduced, for example by having a F_{it} (Facility), an indicator variable equaling 1 if a bank accessed an official liquidity facility at time t. During periods with official support, the overall sensitivity of the balance sheet to liquidity risk in periods of central bank facility use is captured by $\beta^1 + \alpha^1$.

The second methodological building block exploits information by bank and by specific foreign lending locations, following Cetorelli and Goldberg (2012c). The idea is that the business models of global banks and the characteristics of destination countries, as investment or funding locations for individual banks, drive the relative adjustment in banks' lending and internal capital markets adjustment to liquidity risk. If appropriate data are available, country studies include estimation of a modified version of (3) wherein each bank adjusts its claims on different countries in accordance with the strategic importance of those locations to that bank. Formally, the following equation applies:

$$\Delta Y_{it}^c = \gamma^i + \mu_t^c + \left(\beta^0 + \beta^1 LIB\_OIS_t + \beta^2 \chi_{i,t-1}^c + \beta^3 LIB\_OIS_t \cdot \chi_{i,t-1}^c \right) \chi_{i,t-1}$$
$$+ \left(\alpha^1 LIB\_OIS_t + \alpha^3 LIB\_OIS_t \cdot \chi_{i,t-1}^c \right) \chi_{i,t-1} \cdot F_{it} + \varepsilon_{it} \tag{4}$$

where the dependent variable is a claim of bank i on a resident of country c at time t, which can take the form of cross-border lending (claims), local claims extended through overseas branches or subsidiaries, or internal borrowing and lending of the affiliate location. Strategic importance variables are measures of whether countries are core investment or funding

and Singapore, the interbank rates are Hong Kong Interbank Offered Rate (HIBOR) and Singapore interbank offered rate (SIBOR), respectively.

[11] The countries with specification that can control for bank use of official liquidity facilities are Austria, Canada, France, Germany, Ireland, Italy, the United Kingdom, and the United States.

location for each parent bank i $\left(\chi_{i,t-1}^c \right)$.[12] The estimating equation includes location-time fixed effects to absorb changes in demand conditions $\left(\mu_t^c \right)$.

4   Overview of Key Cross-Country Results

The 11 country studies included in this symposium apply the common methodology to a time frame of approximately 2006 through 2013, generally using quarterly data. The liquidity shock variables are country specific, and explanatory variables are defined in similar but not identical ways due to local reporting conventions. Some countries have banks that are purely domestically focused alongside banks with global affiliates. Other countries primarily serve as the host countries for domestic subsidiaries of foreign parents. The studies account for differences in business models of banks, differences in national banking systems, and differences in access to official liquidity support.

In this section, we summarize the results of the country studies on banks' responses to liquidity risk during the crisis. We focus on a subset of empirical specifications, leaving the details, the rich idiosyncratic narratives, and additional specifications to each of the individual papers. We describe results that cover two main groupings of banks – banks with foreign affiliates, and banks without foreign affiliates – and four key dependent variables – changes in domestic loans, cross-border loans, local claims, and net due to parents, reflecting the net borrowing from the domestic location vis-à-vis the rest of the organization.

4.1   Descriptive Statistics

Table 1 shows the number of countries providing regression specifications and the total number of specifications across these countries for each dependent variable such as changes in domestic loans, in cross-border loans, in local claims, and in net due to of the parent bank. [13] For example, 10 countries report specifications using a sample of banks with foreign affiliates to study domestic loan sensitivity, with 20 regression specifications of the form of equation (1), differing in the particular samples of included banks. For example some countries have separate specifications for larger banks versus smaller banks, or foreign-

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[12] A <u>core funding location</u> for bank i is a location where the local foreign offices fund their operations largely through local borrowing; <u>a core investment location</u> for bank i is a location that represents a large share of overall foreign investments (claims) of bank i.

[13] Hong Kong is excluded from the meta analysis due to a difference regression format from the main specifications we analyze. For the purpose of the meta analysis, we define Net Due To for the bank in the reporting country to be the net borrowing of that bank from the rest of its organization outside of that country.

ownership versus domestic-ownership, or branches versus subsidiaries of respective owners. 9 of the 10 countries provide specifications covering cross-border or foreign lending, in addition to domestic lending, while 7 of the 10 countries are able to examine the effects of liquidity risk on internal capital market flows through banks as reflected in their Net Due To balances.

We next provide an overview of the pattern of statistical significance of the interactions between the different balance sheet characteristics of banks (deposits, capital, or ex ante net due to) and the Libor-OIS spreads across the regression specifications already profiled in Table 1. We take a 10 percent level of statistical significance on the estimated regression coefficients β, which measure whether the response of bank lending to a liquidity shock runs through a particular balance sheet variable. We also consider the incidence of statistical significance of these same balance sheet characteristics in periods when banks access official sector liquidity support, as reflected in the $\beta^1 + \alpha^1$ coefficients described in equation (3).[14] It is important to note that the type of official liquidity support the studies look at differs across countries. For example, in the study of banks in Germany the authors use information on guarantees and capital injections provided for distress banks (Kerl and Koch 2014), while the study of banks in the United States uses information on draws on the discount window and the term auction facility.

There are two parts to Table 2. First, Table 2a takes the full group of specifications across all studies (10 are included in the meta-analysis) and considers how many of the regression specifications generate a particular β or $\beta^1 + \alpha^1$ that is positive and statistically significant, negative and statistically significant, not statistically significant, or missing from this group of regression specifications. These results are depicted within the cells of the table provided under headings (a), (b), (c) and (d) respectively.

For example, recall from Table 1 that there are 7 regression specifications from 5countries that explore domestic loan growth for banks without foreign affiliates. Consider patterns under with the columns of Table 2a, under banks without foreign affiliates, and then under changes in domestic loans. Looking down column(s) we observe that deposit shares are the only non-zero entry, so are the only variable interacted with LIBOR-OIS that are associated with higher cross-sectional growth of domestic loans, and this occurs in 3 of the 7 regression specifications. This channel of support for cross-sectional differences in domestic loan growth disappears during periods when banks access official liquidity, and from

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comparing columns (a) and (b), it even turns negative and significant in one case. Particularly striking from these first columns of Table 2a are how seldom these balance-sheet variables explain cross-sectional differences in loan growth as liquidity conditions change, and in the sample of banks without foreign affiliates. Also striking is that features that tend to support more domestic loan growth can have the opposite effect in explaining cross-sectional differences in cross-border lending growth. Generally, the results of Table 2a show that the balance sheet differences across banks generally are typically not very important for explaining variation in lending of banks *without* foreign affiliates as liquidity risk conditions evolve. For these banks, most of the cross-sectional variation in lending growth is absorbed by bank fixed effects.

The picture of statistical significance is very different when countries explore the micro-data on banks *with* foreign affiliates. The corresponding results are provided under the heading of banks with foreign affiliates for the rightmost columns of results in Table 2a. Looking down the respective columns it is clear from the non-zero entries that cross-sectional variation across banks in growth of domestic loans, cross-border loans, and "net due to" are in fact associated with bank balance sheet compositions within some of the 10 countries. At the same time, different balance sheet characteristics matter in different countries, and for the different forms of loan growth.

Local claims of bank with foreign affiliates, which are the claims extended by subsidiaries in other locations, are not well explained by the parent bank balance sheet interacting with liquidity risk. Like the domestically-owned banks, the banks with foreign activities have thus isolated differences in their local lending in the host country from parent funding shocks.

Particularly interesting are the patterns of significance of balance sheet variables in differentiating across banks the transmission of liquidity risk into cross-border lending growth. For this dependent variable, cross-sectional variation in response to liquidity risk conditions is often tied to the types of bank balance sheet characteristics such as deposit shares, unused credit commitment balances, and net borrowing positions of the reporting bank vis-à-vis affiliates, as demonstrated by the frequency of non-zero entries in columns (a) and (b) under the cross-border loan column section. Also interesting, but less prevalent, is the finding that cross-sectional differences in internal capital market borrowing by banks, often conducted with its foreign affiliates, also are sensitive to bank balance sheet characteristics.[15]

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[15] Recall also that a smaller group of countries have analyzed the internal capital market flows by their banks.

Table 2b considers whether the patterns of findings just profiled occur across a group of countries, or whether they are concentrated within specific country regressions among the 10 countries included. In this alternative table variant, we focus only on providing a counterpart to columns (a) and (b) of Table 2a, but now also introducing the names of the countries that find positive or negative statistical significance of a liquidity risk transmission "channel". Next to the names of the countries, we indicate in parentheses the number of specifications for that country associated with this statistical significance.

For example, consider the specifications under the column headings of banks with foreign affiliates (which are either domestic banks with external affiliates, or foreign banks operating within a country, depending on the reporting country). Numerous country names are represented in these columns, showing the incidence of statistical significance of particular balance sheet characteristics in the country specifications captured by our meta-analysis.

Cross-sectional differences in domestic lending growth in response to changing liquidity risk are linked to different factors in respective countries. In periods without official liquidity use, net due balances matter for banks in the U.S., Ireland, and Germany, although these balances cease to drive cross-sectional differences across banks in domestic lending when banks are accessing official liquidity. Ex ante differences across banks in deposit shares are correlated with domestic lending growth responses to liquidity risk for banks in Ireland and the United Kingdom, but in different directions. Turning to columns under cross-border loan growth, the studies show that variability across banks in response to liquidity risk is tied to a broader set of balance sheet variables, whether illiquid asset shares, deposit funding, commitment ratios, tier 1 capital holdings, or use of internal capital markets.

4.2   Results of the Meta Regressions

To analyze the regression results in a more systemic fashion that accounts for differences across countries and regression specifications, we next turn to a meta analysis, following the approach of previous applications such as in labor economics (Boockmann 2010, Card and Krueger 1995, Doucouliagos and Stanley 2008). We first examine the sample and specification features that are associated with the explanatory power for regressions. We then focus more specifically on the features associated with significant roles for deposit funding, internal capital markets, and official liquidity support in loan growth response to liquidity risk.

The result of the meta analysis are reported in Tables 3 and 4. Table 3 uses the regression R^2 as the dependent variable. Because the range of the R^2 across countries is

relatively large, we include country fixed effects in all regressions. Given that the R^2 is bound between 0 and 1, we run a censored Tobit model with robust standard errors. Next, in Table 4, we explore through which balance sheet variables liquidity shocks affect bank lending. We use a probit model with robust standard errors. Country fixed effects are not included because of their colinearity with the number of banks. The dependent variable in these regressions is a 0/1-dummy which is set equal to one if the interaction between liquidity shocks and bank balance sheet characteristics is significant at least at the 10%-level. We run these regressions for three explanatory variables: deposit funding, net due to, and official support.

Consider first the explanatory power of regression specifications, as presented in Table 3. Columns (1) through (7) of this table provide results for specification R^2 statistics, while column (8) used adjusted R^2 as the dependent variable. A waterfall structure across columns (1) through (5) separately considers different regression dependent variables in the country specifications. Generally, increasing the number of banks (for a given time series dimension of the data) lowers the explanatory power of our model. This shows the impact of bank-level heterogeneity for our results. Also, regression specifications have higher R^2 for countries when domestic loans is the dependent variable, indicating the relative stability of growth these loans compared to the alternative forms of lending considered across countries. Net due to, cross-border loans or foreign office loans tend to be more volatile over time and cross-sectionally within countries, which tends to lower the R^2 in these regressions. Regression specifications with bank fixed effects have marginally higher fits, but tend to not change the overall pattern of results of the specifications.

Table 4 compares the regression sample features associated with significant roles of internal capital market balances, deposit shares, and use of official support in the cross-sectional distinctions among banks in liquidity risk transmission into lending. 85 of the total of 127 specifications contain the net due measure. All 127 specifications contain a measure of deposit share in funding. 103 of the regression specifications contain a measure of official support utilized by banks and facilitating a distinction of results across "normal" and "stress" periods when official sector liquidity is substituting for private liquidity on bank balance sheets. Table 4 is set up with a waterfall structure, so we are able to determine if there are particular types of lending which tend to be more sensitive to these three features.

From Column 1, we observe that net due balances are more likely to be significant for liquidity risk transmission within specifications that have a larger number of banks reporting. Column 2 shows that the country specifications on adjustments of internal capital market

positions in response to liquidity risk are significantly less likely to be sensitive to ex ante positions of net borrowing in the organization, when contrasted with specifications covering other forms of lending. Specification (4) shows that internal capital market positions are more likely to matter for cross-sectional differences in domestic lending compared with the other types of bank lending.

Table 4 columns (6) through (10) explore the importance of deposit funding in explaining cross-sectional differences across banks in loan responses to liquidity risk. The "number of banks" in the sample is not important for the probability of role for deposit funding. The main driver tends to be whether specifications cover the banks without foreign affiliates, as it is this group in which deposit funding matters the most, regardless of type of lending conducted. The French study argues that, rather than proxying for the specific funding strategy of a given bank, the share of deposit funding rather proxies for the business model and the degree of risk aversion of banks (Bussiere et al. 2014). Similarly, the UK study finds that banks which rely on deposits cut back external lending and raise domestic lending by more (Hills et al. 2014). In general, the mixed and relatively weak role of deposits in driving liquidity risk effects across countries might be a result of conflating more stable bank funding balances with more domestically-oriented loan portfolios as core businesses of banks.

Finally, columns (1) through (15) explore which types of regression specifications are more likely to demonstrate a role for bank use of official liquidity support in changing the pattern of transmission of liquidity risk. The main result is that the probability of a role for official liquidity support is significantly lower for banks without foreign affiliates. This finding does not imply that official support did not matter for these banks. Rather, it implies that these banks were not differentially transmitting liquidity risk in line with receiving the support. An alternative interpretation is that official support was utilized more by internationally active banks, and therefore played a larger role in changing the balance sheet characteristics that mattered for observed transmission of liquidity risk into bank lending.

5   Conclusions

Research conducted in the International Banking Research Network shows a large degree of heterogeneity across banks and countries in terms of adjustment to liquidity shocks. Nonetheless, we observe several common patterns in explaining the heterogeneity in bank lending response to liquidity risk.

First, the regression specifications explain more of the cross-sectional and time-series variation in domestic lending compared with explaining the variation observed in lending to related affiliates (i.e. net due to or intrabank lending) or cross-border lending. In general, patterns of domestic lending growth by banks are more stable over time and across institutions compared with other forms of bank lending.

Second, the pattern of balance sheet drivers of lending adjustment to liquidity risk across banks changes when banks access official liquidity support. This changing set of drivers of effects during access to official liquidity support is stronger for the banks with foreign affiliates than for the banks that do not have foreign affiliates. Some of the use of official liquidity support displaced cross-sectional differences in banks in their use of internal capital markets in relation to balance sheet structure. Given the diverse country experiences represented by papers in this symposium, we cannot draw strong conclusions on the design of the liquidity facilities or the conditions associated with use of these liquidity facilities.

Third, internationally active banks have access to and have used an additional channel of adjustment to liquidity risk, both during normal times and during the crisis. Banks that increased net borrowing affiliates as liquidity risk rose supported domestic and cross-border lending in some instances, but this result did not always hold.

Fourth, a stronger general result is that cross-border lending growth is more sensitive to liquidity risk in relation to the balance sheet characteristics of the banks. One interpretation is that banks may subordinate cross-border lending relative to domestic lending activity as stress conditions change. This same pattern of results did not in general show up in the changes in bank lending conducted through the foreign branches and subsidiaries of these same banks. In general though, no single balance sheet factor affects banks' exposure to liquidity risk in a consistent way across time and across countries (or banks).

Generally, the explanatory power of the empirical model is weaker the larger the number of banks. In other words, banks are heterogeneous in their lending patterns, and specifications with larger numbers of banks – regardless of being domestic or global banks – have more unexplained heterogeneity. Heterogeneity which reflects differences in bank business models may contribute to an enhanced resilience of the system. At the same time, a large degree of heterogeneity in which balance sheet characteristics are associated with more volatile responses by banks also complicates finding appropriate regulatory responses.

In conclusion, the formation of the IBRN and the studies of this symposium represent the first systemic cross-country work using individual bank micro-data using a common

methodology that is comparable across countries. This work provides an important example of the benefits of international collaboration and communications between researchers in academia and central banks from around the world. Such collaboration helps support the common goals of macroeconomic stability and financial stability. These efforts also provide lessons that inform appropriate regulatory responses to liquidity risks and other shocks by providing comparable cross country evidence from the recent crisis.

While the IBRN will move forward with tackling research questions, there are still broad agendas that all countries face on issues regarding data. One big advantage of the IBRN network is the ability to access similar and very detailed datasets across countries. At the same time, our analysis has been constrained by gaps in the collection and availability of data within and across countries on banks and on policy interventions. The successful and ongoing cross-country research efforts in this symposium highlight the benefits of continuing efforts to collaborate across countries and to improve the availability, coverage, and granularity of micro-banking data for academic research and policy analysis.

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Table 1: Counts of Regressions Included in the Meta-Analysis

This Table summarizes the number of countries reporting regression results for each combination of dependent variable (columns) and specification feature (rows), followed by the number of regressions reported in total by all countries. Countries included are Australia, Austria, Canada, France, Germany, Ireland, Italy, Poland, the United Kingdom, and the United States.

Dependent variable Regression sample	Δ domestic loans		Δ x-border loans		Δ foreign office claims		Δ net due to parent	
Specifications including bank fixed effects								
Banks with foreign affiliates	10	19	9	19	4	8	7	13
Banks without foreign affiliates	5	7	4	6	0	0	1	1
Specifications excluding bank fixed effects								
Banks with foreign affiliates	10	14	9	14	4	6	7	10
Banks without foreign affiliates	5	5	4	4	0	0	1	1

Table 2a: Patterns of Significance on Liquidity Risk Across Regressions

This Table shows the significance of the interaction terms with Libor-OIS for the bank fixed effect models only. It gives the number of specifications with positive significant coefficients and negative and significant coefficients, both at the 10%-level. The following countries have specifications with Net Due To (LHS) (with Bank FEs): Canada, Austria, Germany, US, Ireland, Australia, and Poland. The following countries do not have specifications with Net Due To (LHS) (with Bank FEs): Italy, UK, France. The following countries have information on official support: Canada, France, Italy, Austria, Germany, US, Ireland, UK. The following countries are missing information on official support: Poland, Australia (no official support information for Australia aside from one of their tabs called "Locational Table", whose specifications were not included in the meta analysis).

	Period with official support?	Banks without foreign affiliates								Banks with foreign affilates															
		Δ domestic loans				Δ x-border loans				Δ domestic loans				Δ x-border loans				Δ foreign office claims				Δ net due			
		a = positive significant at the 10%-level, b = negative significant at the 10% level, c = insignificant, d = missing																							
		a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Illiquid assets	No	0	1	6	0	0	0	6	0	0	0	17	2	2	1	14	2	0	1	7	0	0	1	10	2
	Yes	0	0	5	2	0	0	5	1	0	3	11	5	2	1	12	4	0	1	7	0	0	2	6	5
Commitment ratio	No	0	2	4	1	0	0	5	1	1	0	14	4	5	0	10	4	1	0	5	2	1	1	7	4
	Yes	0	0	5	2	1	0	4	1	1	1	12	5	1	2	12	4	0	0	6	2	0	2	6	5
Deposits	No	3	0	4	0	0	3	3	0	1	1	17	0	3	0	16	0	1	0	7	0	0	0	13	0
	Yes	0	1	4	2	0	1	4	1	0	1	15	3	0	5	12	2	0	2	6	0	1	0	9	3
Tier 1	No	0	0	6	1	0	0	5	1	0	0	13	6	2	1	10	6	0	0	6	2	0	0	8	5
	Yes	0	0	4	3	0	0	4	2	2	0	9	8	0	0	12	7	0	0	6	2	1	1	4	7
Net Due To	No	0	0	1	6	0	0	0	6	2	3	10	4	3	1	11	4	0	0	7	1	0	1	12	0
	Yes	0	0	0	7	0	0	0	6	0	0	12	7	1	1	10	7	0	0	7	1	0	2	8	3

Table 2b: Country Names of Regressions with Significant Coefficients

This table identifies the countries corresponding to nonzero counts in the positive significant and negative significant (10% level) columns. For example, the table shows that for the regressions using the change in domestic loans as the dependent variable conducted on the "Banks without foreign affiliates" subsample, three such regressions reported positive significant (10% level) coefficient estimates for the Deposits*Libor_OIS interaction term. The corresponding cell in this table identifies these to be from the Austria, US, and Poland results. Canada, Austria, Germany, US, Ireland, Australia, and Poland reported specifications with the Net Due dependent variable, while Italy, UK, and France did not. Canada, France, Italy, Austria, Germany, US, Ireland, and UK report information on official support (through triple interaction terms), while Poland and Australia did not. Abbreviations: AU = Austria, AUS = Australia, CN = Canada, US = United States, FR = France, GER = Germany, IRE = Ireland, IT = Italy, PO = Poland, UK = United Kingdom. Number in parenthesis next denotes the number of regressions from each country, only specifications with bank fixed effects reported.

Explanatory variable	Period with official support?	Banks without foreign affiliates				Banks with foreign affiliates							
		Δ domestic loans		Δ x-border loans		Δ domestic loans		Δ x-border loans		Δ foreign office claims		Δ net due	
Illiquid assets	No	0	AUS(1)	0	0	0	0	CN(1), US(1)	GER(1)	0	CN(1)	0	AU(1)
	Yes	0	0	0	0	0	CN(2), GER(1)	GER(2)	CN(1)	0	CN(1)	0	US(1), CN(1)
Commitment ratio	No	0	AU(2)	0	0	UK(1)	0	AU(1), US(1), IRE(2), UK(1)	0	FR(1)	0	US(1)	PO(1)
	Yes	0	0	AU(1)	0	AU(1)	GER(1)	US(1)	GER(2)	0	0	0	GER(2)
Deposits	No	AU(1), US(1), PO(1)	0	0	AU(2), US(1)	IRE(1)	UK(1)	CN(1), GER(1), AUS(1)	0	CN(1)	0	0	0
	Yes	0	AU(1)	0	US(1)	0	CN(1)	0	CN(1), AU(2), GER(2)	0	CN(1), AU(1)	US(1)	0
Tier 1	No	0	0	0	0	0	0	GER(2)	UK(1)	0	0	0	0
	Yes	0	0	0	0	GER(1), US(1)	0	0	0	0	0	GER(1)	US(1)
Net Due	No	0	0	0	0	US(1), IRE(1)	GER(3)	US(2), AUS(1)	AU(1)	0	0	0	AUS(1)
	Yes	0	0	0	0	0	0	US(1)	GER(1)	0	0	0	CN(1), GER(1)

Table 3: Determinants of the Regression R^2

This Table reports the results of Tobit regressions, using the regression R^2 as the dependent variable (columns (1)-(7)). The regressions account for the fact that the dependent variable has an upper (1) and a lower bound (0). Column (8) used the adjusted R^2 as the dependent variable. Robust standard errors are reported in brackets. ***, **, * indicates significance at the 1%, 5%, 10%-level.

Dependent variable	(1) R^2	(2) R^2	(3) R^2	(4) R^2	(5) R^2	(6) R^2	(7) R^2	(8) adjusted R^2
Bank fixed effects included	0.033*	0.032*	0.033*	0.033*	0.032*	0.032*	0.014	0.033
	(0.018)	(0.018)	(0.018)	(0.018)	(0.017)	(0.017)	(0.022)	(0.024)
log banks	-0.087***	-0.086***	-0.086***	-0.089***	-0.091***	-0.090***	-0.134***	-0.046**
	(0.013)	(0.014)	(0.012)	(0.013)	(0.014)	(0.014)	(0.012)	(0.019)
Banks without foreign affiliates	0.005	-0.004	0.010	0.002	-0.007	-0.008	-0.023	-0.107***
	(0.019)	(0.021)	(0.018)	(0.019)	(0.021)	(0.021)	(0.025)	(0.028)
Dependent variable net due		-0.052**				-0.013	-0.024	-0.038
		(0.024)				(0.023)	(0.024)	(0.035)
Dependent variable cross-border loans			-0.044***					
			(0.014)					
Dependent variable foreign office claims				-0.021		0.005	0.002	-0.073*
				(0.033)		(0.029)	(0.039)	(0.037)
Dependent variable domestic loans					0.081***	0.078***	0.080***	0.116***
					(0.018)	(0.017)	(0.028)	(0.025)
Constant	0.495***	0.502***	0.506***	0.506***	0.489***	0.488***	0.641***	0.299***
	(0.056)	(0.058)	(0.054)	(0.058)	(0.052)	(0.052)	(0.047)	(0.076)
Country fixed effects included	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Sigma	0.094***	0.092***	0.092***	0.094***	0.086***	0.086***	0.121***	0.108***
	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)	(0.010)
Observations	127	127	127	127	127	127	127	87

**Table 4: Determinants of Banks' Responses to Liquidity Shocks**

This Table reports the results of Probit regressions, using a 0/1-dummy indicating whether the interaction between liquidity risk and the respective variable is significant at least at the 10%-level. For example, the first column should be read as follows: The interaction term between "net due" and liquidity risk is more likely to be significant in regressions with a larger number of banks (log banks) and less likely to be significant in regressions using the change on "net due to" as the dependent variable. Not all variables are included in all models due to colinearity. Robust standard errors are reported in brackets. ***, **, * indicates significance at the 1%, 5%, 10%-level.

| Explanatory variable / Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Net due					Deposits					Official support				
Bank fixed effects included	-0.124 (0.340)	-0.138 (0.352)	-0.132 (0.343)	-0.129 (0.349)	-0.143 (0.371)	0.106 (0.281)	0.102 (0.281)	0.105 (0.281)	0.111 (0.281)	0.111 (0.296)	-0.100 (0.256)	-0.100 (0.256)	-0.098 (0.257)	-0.106 (0.257)	-0.100 (0.258)
log banks	0.630*** (0.170)	0.710*** (0.190)	0.629*** (0.182)	0.641*** (0.150)	0.641*** (0.179)	-0.162 (0.156)	-0.167 (0.160)	-0.157 (0.157)	-0.172 (0.152)	-0.199 (0.164)	0.066 (0.128)	0.065 (0.128)	0.057 (0.128)	0.100 (0.132)	0.083 (0.128)
Banks without foreign affiliates						1.062*** (0.332)	1.046*** (0.337)	1.076*** (0.339)	1.041*** (0.336)	1.032*** (0.370)	-0.804** (0.395)	-0.831** (0.401)	-0.838** (0.392)	-0.780** (0.396)	-0.776** (0.394)
Dependent variable net due		-1.213** (0.587)			-1.464** (0.601)							-0.142 (0.342)			
Dependent variable cross-border loans			0.401 (0.355)		-0.233 (0.388)		0.286 (0.294)			0.060 (0.318)			0.218 (0.267)		
Dependent variable foreign office claims								0.121 (0.448)		-0.058 (0.476)				0.447 (0.389)	
Dependent variable domestic loans				0.767** (0.343)					0.190 (0.288)						-0.363 (0.271)
Constant	-2.802*** (0.553)	-2.833*** (0.588)	-2.929*** (0.618)	-3.101*** (0.511)	-2.327*** (0.603)	-0.830 (0.530)	-0.916* (0.523)	-0.864 (0.544)	-0.869 (0.541)	-0.586 (0.562)	-0.107 (0.437)	-0.076 (0.444)	-0.152 (0.439)	-0.281 (0.466)	-0.045 (0.438)
Observations	85	85	85	85	73	127	127	127	127	102	103	103	103	103	103
Pseudo R²	0.108	0.190	0.124	0.165	0.211	0.094	0.102	0.094	0.098	0.091	0.031	0.032	0.036	0.041	0.044

Figure 1: Changes in Cross-Border Claims of BIS Reporting Banks (2000-2013)

This graph shows the changes in cross-border claims on banks and non-banks during the period from the first quarter of 2000 through the third quarter of 2013. The sample covers 50 reporting countries. The data is obtained from the BIS locational banking statistics. The IBRN countries are Australia, Austria, Canada, France, Germany, Ireland, Italy, the United Kingdom, and the United States.
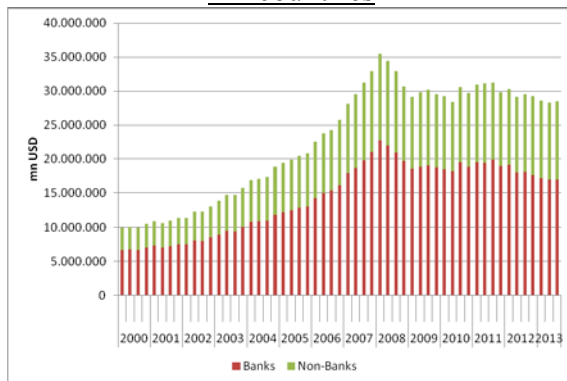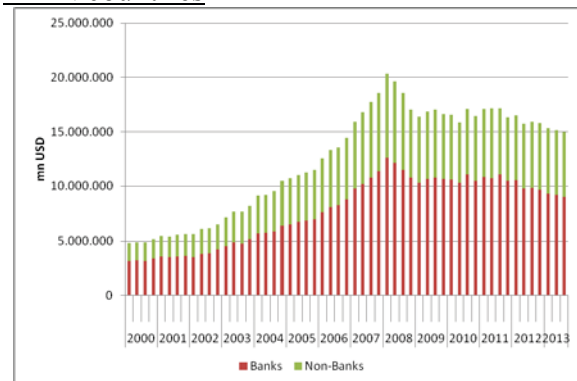
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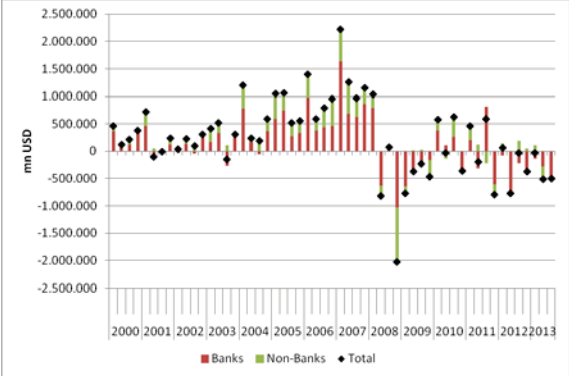
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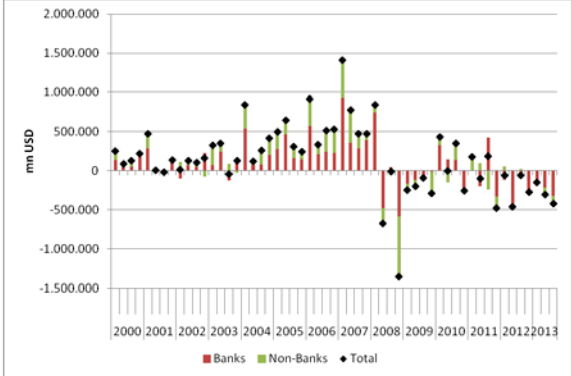
Figure 2: Stocks of Banks' Foreign Assets

This graph shows cross-border claims on banks and non-banks during the period from the first quarter of 2000 through the third quarter of 2013. The sample covers 50 reporting countries. The data is obtained from the BIS locational banking statistics. The IBRN countries are Australia, Austria, Canada, France, Germany, Ireland, Italy, the United Kingdom, and the United States.
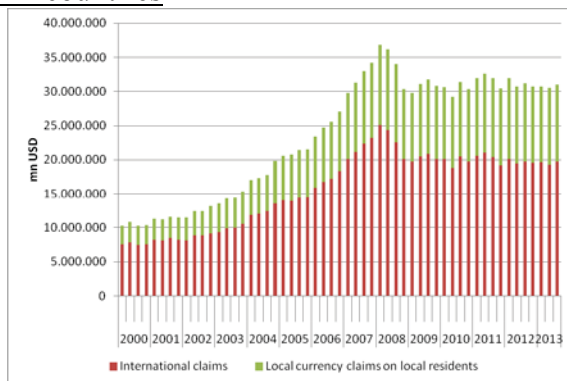
Locational Banking Statistics

All countries

IBRN countries

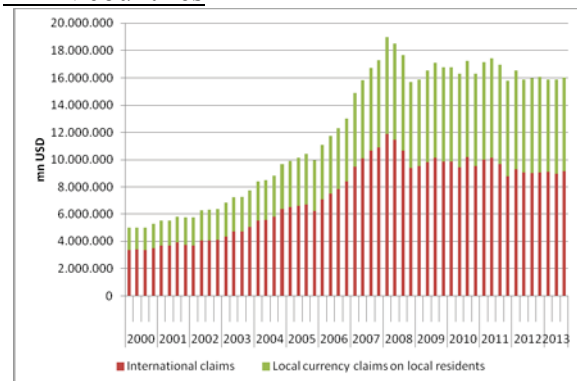### Consolidated Banking Statistics

All countries

IBRN countries

Figure 3: Lending by Selected IBRN Countries

These graphs show *domestic loans* (Figure a), *foreign loans* (Figure b) and net intra-bank lending (*net due*) positions (Figure c) for selected countries and first quarter of 2006 through the fourth quarter of 2012. All series are based on data in national currency and indexed to data of the first quarter of 2006. *Net due* is positive if a domestic bank is a net debtor to its foreign affiliates. *Domestic loans* in the first quarter of 2006: USA 8,320,683 Million USD; Canada 783,000 Million CAD; Germany 1,809,324 Million EUR; Ireland 313,332 Million EUR; and Poland 359,114 Million PLN. *Foreign loans* in the first quarter of 2006: USA 1,414,507 Million USD; Canada 154,000 Million CAD; Germany 630,432 Million EUR; Ireland 73,957 Million EUR; and Poland 77,717 Million PLN. *Net due* in the first quarter of 2006: USA 219,765 Million USD; Canada 14,600 Million CAD; Germany 121,260 Million EUR; and Ireland 7,099 Million EUR. For Canada, the series refer to all banks including foreign. For Germany, the series refer to German parent banks. For Ireland, the series refer to all residing retail banks including parent and foreign-owned branches and subsidiaries. For Poland, the series refer to banks located in Poland. For the USA, the data series refer to banks with foreign affiliates. Index defined as 100 at 2006Q1. Source: Data provided by country teams.

Domestic Lending

Foreign Lending

Net Due
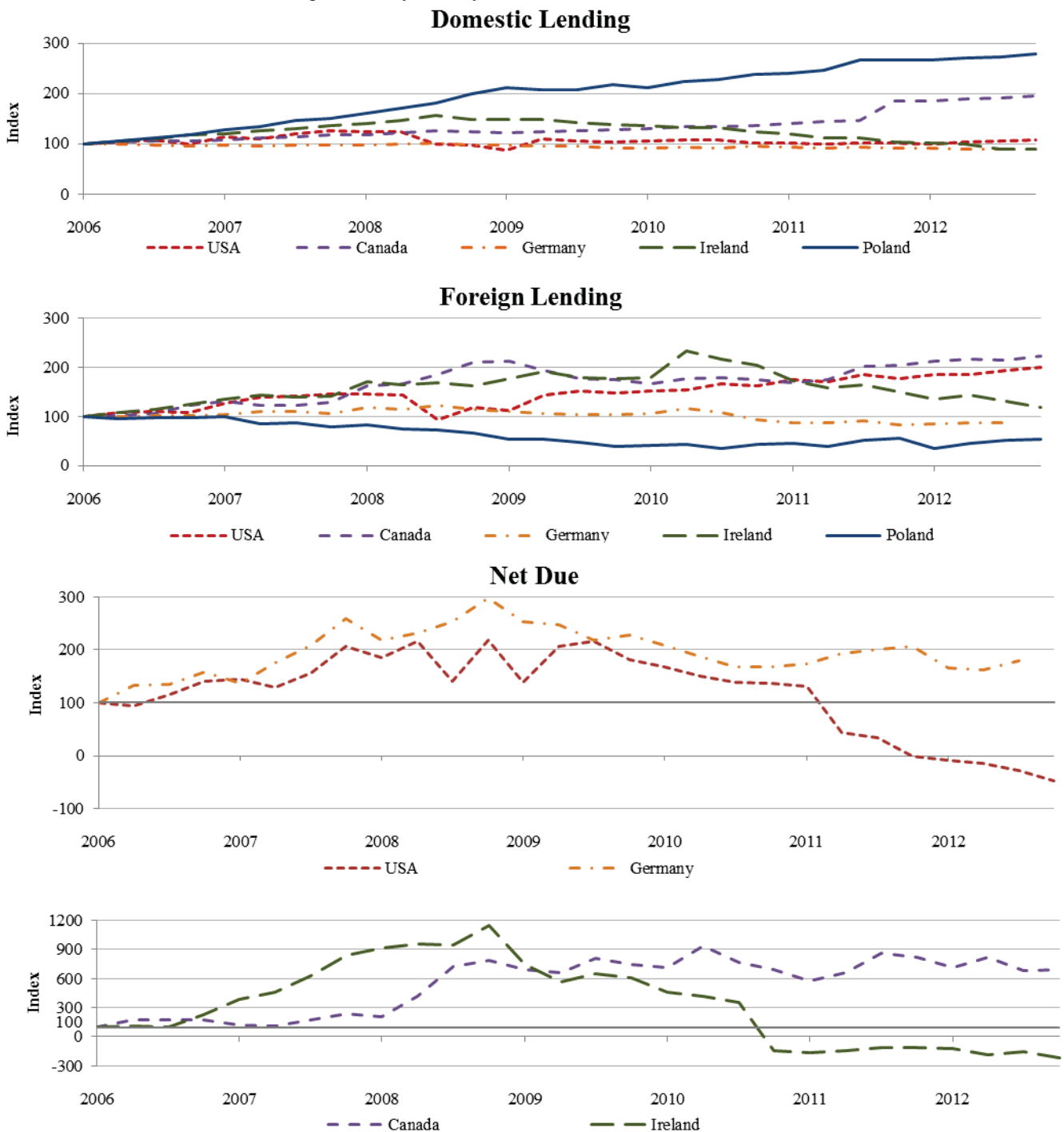
Figure 4: Liquidity Risk Pricing and Bank Characteristics

Row (a) shows how the external funding costs evolve for banks with different balance sheet strength (Panel I). In Panel II, the evolution of funding costs is plotted over time. Row (b) shows the same information but accounting for public liquidity provision in normal times, Row (c) additionally introduces emergency lending.

Panel I	Panel II

(a) Baseline scenario

(b) With public liquidity provision

(c) With emergency lending

33
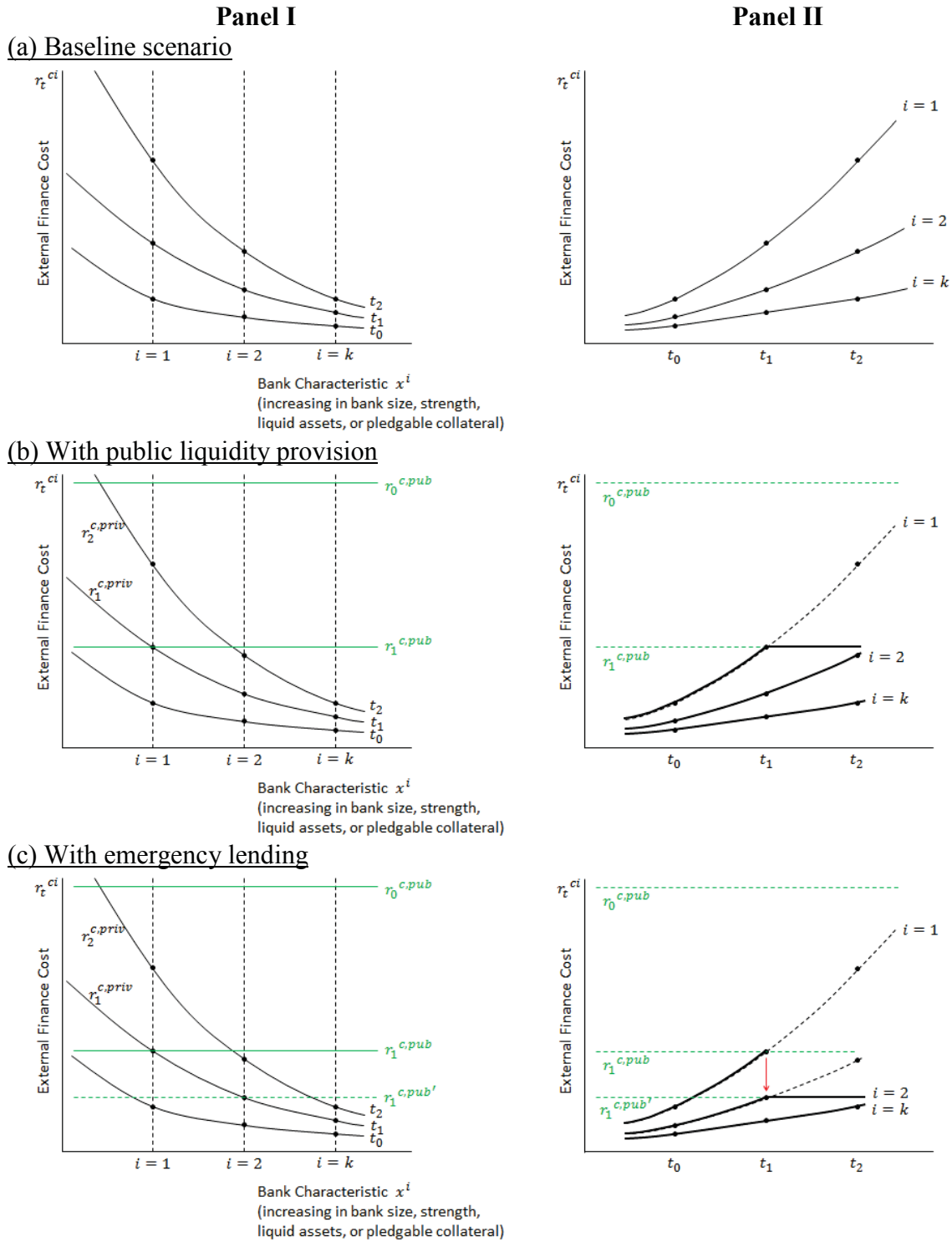
Figure 5: Libor-OIS Spread

This graph shows the 3-month LIBOR-OIS spreads of the Euro (EUR), Pound Sterling (GBP), Hong Kong Dollar (HKD), Japanese Yen (JPY), Singapore Dollar (SGD), Swiss Franc (CHF), the US dollar (USD), Australian dollar (AUD), Canadian Dollar (CAD). For Hong Kong and Singapore, the interbank rates are Hong Kong Interbank Offered Rate (HIBOR) and Singapore interbank offered rate (SIBOR), respectively. Source: Data from January 2006 through September 2013 provided by country teams.