HONG KONG INSTITUTE FOR MONETARY RESEARCH

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HKIMR Working Paper No.21/2014

August 2014

Hong Kong Institute for Monetary Research
香港金融研究中心
(a company incorporated with limited liability)

Implications of Liquidity Management of Global Banks for Host Countries — Evidence from Foreign Bank Branches in Hong Kong*

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August 2014

Abstract

Using a regulatory dataset of foreign bank branches in Hong Kong, this study finds evidence of the international transmission of funding shocks from home countries of global banks through their internal capital markets during the 2007-08 financial crisis. Global banks are found to buffer parent-bank liquidity shocks by repatriating cross-border internal funding, leading to reductions in loan supply by branches in Hong Kong. Branches with a higher loan-to-asset ratio are estimated to cut loan supply sharper than their counterparts. More liquid assets held by parent banks and central bank liquidity are found to reduce the extent of shock transmission significantly.

Keywords: Global Banks, Internal Capital Market, Liquidity Management, Shock Transmission
JEL Classification: E44, F36, G32

* The authors would like to thank Linda Goldberg, Dong He, Cho-hoi Hui and Dewitt D. Marston for their comments. All remaining errors are the authors' own.

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1. Introduction

Global banks played a key role in transmitting financial shocks internationally thereby contributing to the 2007-08 global financial crisis (GFC). The strong presence of global banks in Hong Kong implies that the domestic banking sector is not immune to inward spillovers[1] of shocks from global banks' home countries. Indeed, 44 of the 50 largest global banks operated in Hong Kong in the form of bank branches (Figure 1) at the end of 2013.[2] Many of these branches played a significant funding role before the GFC, and their cross-border intragroup funding activities (i.e. internal capital markets) are one major channel through which financial shocks are propagated.

Cross-border banking flows of the Hong Kong banking sector before the GFC were driven largely by global banks' funding activities. Specifically, reflecting mainly global banks' strong demand for US-dollar liquidity, the total supply of cross-border banking funds by the sector, on a net basis, increased rapidly and reached its peak at US$222 billion in October 2007 (Figure 2). To provide a perspective on the scale of this flow, the peak amount of US$222 billion is comparable to 40% of the peak outstanding amount of central bank liquidity swap lines by the Federal Reserve recorded in 2008Q4. Importantly, more than half of these cross-border flows were channelled by global bank branches in Hong Kong through their internal capital markets (detailed analysis can be found in Section 2).

In view of the large scale of cross-border funding flows and their potential implications for financial stability, this paper quantifies how funding shocks to global banks' parents during the GFC affected the loan supply of their branches in Hong Kong through this internal capital market channel.

Our empirical study is carried out using a confidential panel dataset reported by foreign bank branches in Hong Kong to the Hong Kong Monetary Authority (HKMA), with supplementary data for their parent bank from *Bankscope*. In light of the rich balance-sheet information both for branches and parent banks, our estimations can properly control for huge heterogeneity of the asset-and-liability structure arising from different business models, and thus should provide clean estimation results.

The empirical results of this paper confirm the findings of recent studies that internal capital markets of global banks do operate in response to a parent-bank funding shock.[3] Specifically, we find that global banks react to a parent-bank funding shock by repatriating net internal funding from their Hong Kong branches, with the intensity being more pronounced for those parent banks that *ex ante* hold less liquid assets. In addition, we find that those global banks that gained access to the Federal Reserve's Discount Window (DW) and Term Auction Facility (TAF) relied less on internal funding

[1] Inward spillover of shocks refers to a situation that the Hong Kong banking sector is a receiver of external financial shocks emerging from home countries of global banks.

[2] If global banks refer to global systemically important banks (G-SIBs) by the Financial Stability Board (2013), 27 of 29 G-SIBs operated in Hong Kong as banks.

[3] See Cetorelli and Goldberg (2010, 2012b), Jeon et al. (2013) and Reinhardt and Riddiough (2014).

support from their Hong Kong branches, suggesting that central bank liquidity measures during the crisis effectively alleviated funding pressures on global banks. The estimation results also indicate that more internal funding in support of the parent bank leads to a significant reduction in loan supply by global bank branches in Hong Kong, particularly for those branches that have a high loan-to-asset ratio. The impact on foreign loans is found to be larger than that on domestic loans. Taken together, this study provides clear host-country evidence of the international transmission of both funding stress and central bank policy from global banks' home countries through an internal capital market channel.

The remainder of this paper is organised as follows. Section 2 provides an overview of the internal capital markets of global bank branches in Hong Kong. Section 3 discusses the empirical model and data. Section 4 presents the estimation results, and Section 5 concludes by providing policy implications of the empirical findings.

2. An Overview of Internal Capital Markets of Global Bank Branches in Hong Kong

To provide perspective on the scale of the internal capital markets of global bank branches in Hong Kong, Figure 3 shows the cyclical movement of foreign-currency "net due from overseas offices" (*NDF*) for foreign bank branches in Hong Kong (i.e. overseas-incorporated authorized institutions (AIs)[4] in Hong Kong). *NDF* is defined as "due from overseas offices" (i.e. assets of Hong Kong branches) minus "due to overseas offices" (i.e. liabilities of Hong Kong branches). By definition, a positive *NDF* means that Hong Kong branches are net lenders to the rest of their respective banking groups. The aggregate *NDF* is further broken down by country group based on branches' headquarters locations. The figure shows that in the run-up to the GFC, European banks (i.e. the blue bars) and to a less extent US banks (i.e. the red bars) increasingly channelled funds from Hong Kong through their internal capital markets to support their parent banks. Importantly, an increase in *NDF* was broadly associated with the first spike in funding stress in home countries in 2007H2 as measured by the spread between interbank rate and overnight indexed swap rate (Libor-OIS spread). This observation is consistent with the view that global banks buffered parent-bank liquidity shocks by channelling internal funding from their foreign affiliates, including branches in Hong Kong.

The scale of internal funding support from Hong Kong branches, however, has dropped since 2007Q4. The timing is in line with the launch of the TAF by the Federal Reserve in December 2007. As global banks gained access to the Federal Reserve's liquidity measures, their Hong Kong branches played a much less important funding role, partly contributing to the reversal of their funding pattern as early as mid-2010. Since then, many foreign bank branches in Hong Kong have become net recipients of internal funding (i.e. negative *NDF*).

[4] Institutions authorized under the Banking Ordinance in Hong Kong to carry on the business of taking deposits.

The change in the funding pattern is particularly clear for European and Japanese banks since late 2010, which is consistent with Shin's (2011) hypothesis that non-US banks (especially European and Japanese banks), by taking advantage of liquidity measures during the crisis by the Federal Reserve, channelled US-dollar liquidity to emerging market economies. Indeed, published data by the Federal Reserve on individual banks' access to the TAF and DW show that many global banks with branches in Hong Kong drew significantly on the US central bank liquidity (Figure 4; see also Shin, 2011).

To investigate the implications for host countries, we examine the relationship between *NDF* of global bank branches in Hong Kong and their lending. There is evidence that the change in the funding pattern since 2010 is one contributing factor to the sharp rise in branch lending (Figure 5), although strong loan demand in the Asia-Pacific region may also play a role.[5] At the end of 2013, foreign bank branches accounted for around 40% of outstanding loans in Hong Kong[6], which are mainly denominated in foreign currency. The high loan-to-deposit ratio implies that loans are supported by funds from the banks' internal capital market. The evidence suggests that central bank liquidity, while easing the funding stress of global banks during the GFC, could spillover to host countries through banks' internal capital markets.

3. The Econometric Model and Data

A two-stage econometric approach similar to that in Cetorelli and Goldberg's (2012a) study is adopted to quantify the impact of parent-bank funding shocks on global bank branches in Hong Kong. In the first-stage regression, we estimate how the parent bank's funding need and central bank liquidity, which are exogenous from a branch's perspective, drive the change in the "net due from overseas offices" of Hong Kong branches (ΔNDF). We then use the predicted value of ΔNDF, which by construction ties internal funding flows of Hong Kong branches to these two exogenous factors, as an instrumental variable in the second-stage estimation to explain the branch operation, including the adjustment for (foreign and domestic) loans, credit (i.e. the sum of loans and credit commitments) and liquid assets. This approach by design avoids the potential endogeneity problem that exists between ΔNDF and loans of branches.[7]

The model specification can be described as follows: funding stress of a global bank's parent is assumed to be triggered by a liquidity shock in the home country measured by the Libor-OIS spread (*libois*), which is exogenous from the perspective of its Hong Kong branch. The extent to which the

[5] Funding patterns tend to vary among banks of different countries. For instance, the funding source of US banks and European banks mainly comes from their internal capital market, while this is not the case for the Chinese banks.

[6] KPMG (2014).

[7] In particular, ΔNDF can be driven merely by changes in the funding needs of branches in Hong Kong to finance their loan business. So, a strong negative empirical relationship between these two variables obtained from a simple single-stage model that regresses loans directly by ΔNDF cannot be regarded as evidence to support the hypothesis that parent-bank funding shocks affect global bank branches in Hong Kong. The two-stage approach, in theory, identifies the part of ΔNDF that is exogenous to Hong Kong branches, and thus is conducive to a clean estimation result.

shock affects ΔNDF is conjectured to be dependent on the liquidity condition of the parent bank, which is proxied by four parent-level indicators. These indicators are selected based primarily on Cornett and others (2011): (1) the share of liquid assets in total assets, (2) the share of core liabilities (= the sum of deposits from non-bank customers and equity) in total assets, (3) the ratio of credit commitments to total credit, and (4) size (in real terms and logarithmic form).

We further assume that the parent bank takes into account the business model of its Hong Kong branch when adjusting ΔNDF. To capture this, three proxies are included. On the funding side, we include the share of gross due from overseas offices (*GDF*) of the Hong Kong branch in total interbank borrowing of the whole banking group. On the asset side, the contribution of investment of the Hong Kong branch to that of the whole organisation is considered. Finally, we postulate that the parent bank tends to commit more stable internal funding to its Hong Kong branch if the spread between the average loan price (*pri*) in Hong Kong and that of the whole banking group widens. Apart from these business model considerations, central bank liquidity (*cbl*), which is proxied by the sum of drawdowns from the DW and TAF by the banking group, is posited to reduce internal funding support from the Hong Kong branch.

Finally, two market-based indicators are added as control variables. First, the credit default swap spread (*cds*) of the parent bank is included to measure the ability to raise external funding. Second, the spread between the implied US-dollar funding rate by swapping home-country currency into the US dollar and the US-dollar Libor (*cip*) is included[8], as the parent bank may be more reliant on branch funding (particularly for US-dollar liquidity) if the cross-currency swapping funding strategy is not economically viable. The first-stage equation is therefore specified as follows:

$$\Delta NDF_{k,t} = (\beta_0 + \beta_1 libois_{c,t})X + \beta_2 cds_{i,t} + \beta_3 cip_{c,t} + \beta_4 t_t + \beta_5 b_k + \varepsilon_{k,t} \quad (1)$$

where *k* denotes Hong Kong branch of global bank *i* with the headquarter in country *c*. *t* denotes time. $\Delta NDF_{k,t}$ is expressed as a ratio of total assets of *k* in *t-1*. *X* is a vector of variables {liquid assets/assets$_{i,t-1}$, core liabilities/assets$_{i,t-1}$, commitments/credit$_{i,t-1}$, log real assets$_{i,t-1}$, $GDF_{k,t-1}$/interbank borrowing$_{i,t-1}$, invest$_{k,t-1}$/invest$_{i,t-1}$, $pri_{k,t}$ -$pri_{i,t}$, *cbl/assets*$_{i,t}$}. *X* is interacted with $libois_{c,t}$ to determine the extent to which the parent-funding shock drives internal funding support from the Hong Kong branch. t_t and b_k are time and bank dummies respectively. The appendix details the definition of the variables.

To the extent that the first-stage estimates adequately capture the part of net internal funding flows of the Hong Kong branch that are solely driven by the parent bank's funding need to buffer the home-country funding shock, the empirical relationship between the instrumental variable for $\Delta NDF_{k,t}$ and branch variables should identify the extent to which a parent-bank funding shock affects the operation of the Hong Kong branch through the internal capital market channel. The second-stage model essentially captures this idea and is specified as follows:

[8] See Baba and Packer (2009).

$$\Delta y_{k,t} = (\alpha_0 + \alpha_1 loans/assets_{k,t-1})\Delta NDF(IV)_{k,t-1} + \alpha_2 Z_{k,t-1} + \alpha_3 t_t + \alpha_4 b_k + \eta_{k,t} \quad (2)$$

where $\Delta y_{k,t}$ is vector of variables for the Hong Kong branch {Δliquid assets$_{k,t}$/assets$_{k,t-1}$, Δloans$_{k,t}$/assets$_{k,t-1}$, Δdomestic loans$_{k,t}$/assets$_{k,t-1}$, Δforeign loans$_{k,t}$/assets$_{k,t-1}$, Δcredit$_{k,t}$/ (commitments + assets)$_{k,t-1}$}. $\Delta NDF(IV)_{k,t}$ is the instrumental variable for $\Delta NDF_{k,t}$ derived from the first-stage regression. $Z_{k,t-1}$ is a set of branch indicators serving as control variables, including liquid assets/assets$_{k,t-1}$, deposits/non-related liabilities$_{k,t-1}$[9], commitments/credit$_{k,t-1}$, log real assets$_{k,t-1}$ and loans/assets$_{k,t-1}$. The time and bank dummies intend to capture changes in conditions in Hong Kong (e.g. loan demand) and unobservable heterogeneity across banks respectively.

The second-stage regression postulates that, from the perspective of a Hong Kong branch, branch assets would need to be adjusted to counterbalance the repatriation of net internal funding by the parent bank. The adjustment would take various forms, including selling liquid assets and cutting domestic and foreign loans. The branch would also be cautious in providing credit commitments. How the adjustment is distributed across asset types hinges on the business model of the Hong Kong branch, which is proxied by its loan-to-asset ratio.

3.1 Data and Sample

We build our panel dataset based primarily on data from *the return of assets and liabilities* and *the return of liquidity position*, which AIs in Hong Kong are required to file to the HKMA. Data reported by foreign bank branches reflect the sole position of the Hong Kong branch, and therefore all branch variables (i.e. those variables defined in the previous sub-section with subscript *k*) are constructed using this data source. All dependent variables for the specification of (1) and (2) can be broken down by currency denomination into Hong Kong dollar, US dollar, and other foreign currencies. Parent-level variables (i.e. variables with subscript *i*) are based on consolidated data of their ultimate parents from *Bankscope*. We identify parent banks using information on the organisation structure of banking groups available at *Bankscope* and regulatory information. Parent-level data on access to the Federal Reserve's Discount Window and Term Auction Facility are from the Federal Reserve Board of Governors' website.

The estimation samples contain 37 foreign bank branches in Hong Kong, covering the period 2006Q1 – 2012Q4. These banks are selected using the following criteria: We first include all branches that belong to G-SIBs given that G-SIBs were presumably important vehicles for the propagation of shocks internationally during the GFC. Branches with a significant scale of operation in Hong Kong (that is with an average size accounting for at least 0.5% of the total assets of all foreign branches in Hong Kong) are then added. Since our goal is to estimate the impact of funding shocks during the GFC, we exclude those branches that did not operate in the full period of 2008-09. This gives a sample of 54 branches, accounting for at least 90% of the total assets of foreign bank branches in Hong Kong

[9] Non-related liabilities refer to total liabilities excluding equity and intra-group liabilities.

throughout the sample period. Those branches for which home-country data of the Libor-OIS spread (e.g. Mainland China) or parent-bank balance sheet variables (mostly credit commitments) are unavailable are further excluded. The aggregate assets of the estimation sample account for an average of 70% of the total assets of foreign bank branches in Hong Kong in the sample period. Table 1 reports summary statistics for all major variables before (from 2006Q1 to 2007Q2), during (from 2007Q3 to 2009Q2) and after the GFC (from 2009Q3 to 2012Q4).

4. Estimation Result

Column I of Table 2 shows the first- and second-stage regressions based on the specifications of (1) and (2) respectively.[10] The dependent variables are constructed using US-dollar denominated balance-sheet items.[11] Some specifications modified from the specifications of (1) and (2) are also estimated for robustness checks (see columns II to IV). All standard errors are clustered by banks. We also produce another set of estimates for dependent variables that are constructed using foreign-currency (i.e. non-Hong Kong dollar) denominated balance-sheet items (see Table 3).

Table 2 allows us to understand how global banks manage US-dollar liquidity in response to a parent-bank funding shock by examining the estimated coefficients on the interaction terms with the shock variable (i.e. *libois*) in the first-stage regression. Panel A of Column I shows that parent banks with less liquid assets and core liabilities, more credit commitments and of a larger size tend to rely more on internal funding from branches in Hong Kong to offset the increased liquidity risk in the home country. However, only the result for liquid assets is found to be statistically significant (i.e. (*liquid assets/assets*)**libois*). This finding suggests that from a liquidity management perspective, liquid assets held by parent bank and internal funding from their Hong Kong branches are regarded as close substitutes by global banks.

In addition, we find strong evidence that central bank liquidity significantly reduces global banks' reliance on internal funding from Hong Kong branches, as the coefficient on (*cbl/assets*)**libois* is found to be highly significant with an expected sign.

The estimation results also support the *locational pecking order* hypothesis (Cetorelli and Goldberg, 2012b). Specifically, a parent bank would repatriate more internal funding from Hong Kong if its Hong Kong branch *ex ante* plays an obvious funding role. By contrast, the parent bank is more likely to commit stable internal funding to the Hong Kong branch if loan prices are more attractive.

[10] For brevity, estimates of the control variables in the second-stage regression are not reported.

[11] Some variables, by construction, are more capable of explaining global banks' US-dollar liquidity management. In particular, *cip* is defined in terms of US dollar funding rates. Also, due to data unavailability, we can only trace global banks' access to US dollar central bank liquidity by looking at their drawdown of Federal Reserves' TAF and DW. We therefore focus our discussion on how global banks manage their US-dollar liquidity.

Panel B shows that from a branch's perspective, more internal funding to support the parent bank leads to a notable adjustment in the branch's portfolio.[12] The adjustment is broadly-based and closely tied to its business model (measured by the branch's loan-to-asset ratio). Specifically, a Hong Kong branch tends to reduce both the supply of US-dollar domestic loans (i.e. loans for use in Hong Kong) and that of US-dollar foreign loans (i.e. loans for use outside Hong Kong plus loans for trade finance) to counterbalance the increased net internal funding to the parent bank, with the adjustment being more intense for those branches that serve as a lending unit (i.e. high loan-to-asset ratio). Comparatively, the adjustment for the supply of foreign loans is more significant than that for the supply of domestic loans. An even more drastic downward adjustment is found for credit commitments, suggesting that the parent-bank funding shock produces a prolonged effect on the branch's loan supply. The adjustment for liquid assets is found to be closely tied to its business model also: those branches for which loan intermediation is not a main function (i.e. low loan-to-asset ratio) tend to accumulate more liquid assets, which may be driven by a precautionary motive in order to deal effectively with future liquidity needs by the parent bank. By contrast, those branches that serve as a lending unit may support the parent bank's funding need by partly running down their holding of liquid assets.

Columns II and III consider a similar specification to (1) and (2), but exclude control variables related to the branch's business model in the first-stage regression. The main argument for this is that including branch control variables could subject the instrumental variable to an endogeneity problem, as branch control variables may not be exogenous from a branch's perspective. Arguably, the resulting instrumental variable $\Delta NDF(IV)_{k,t}$ may not identify clearly internal funding flows that are solely driven by the parent bank's funding need, but may partly reflect the branch's decision on its balance sheet adjustment. The specification in Column II excludes two branch balance-sheet control variables and that in Column III further excludes $pri_{k,t} - pri_{i,t}$. The estimation results of these two specifications are broadly similar to that in Column I. Column IV reports the estimation result by excluding the two market-based control variables in the first-stage regression.

Table 3 reports the estimation results using dependent variables that are constructed using foreign-currency (i.e. non-Hong Kong dollar) denominated balance-sheet items. As expected, using foreign-currency denominated dependent variables significantly reduces the statistical significance of the estimates. Nevertheless, the results qualitatively paint a similar picture as Table 2. Specifically, liquid assets held by parent bank, central bank liquidity, and the branch business model are found to be main drivers for the internal funding flows from Hong Kong branches in the first-stage regression. For the second-stage regression, however, the robustness of the estimated impact on loans and credit does not carry over in Table 3.

[12] The estimation results remain broadly unchanged when a control variable for the business cycle (i.e. output gap) is added. This suggests that the time and bank dummies are able to capture changes in economic conditions in Hong Kong and unobservable heterogeneity across banks respectively (see previous section).

The final part of the estimation attempts to answer the question of whether Federal Reserve's central bank swap lines reduced the funding stress of global banks? To this end, we add variables in the first-stage regression which capture the impact of the Federal Reserve's central bank swap lines on US-dollar $\Delta NDF_{k,t}$ and re-run all the models in Table 2. In theory, a bank that gained access to liquidity from its central bank through swap lines should have less reliance on intragroup funding support and therefore, the estimated impact is expected to be similar to that of *cbl/assets*. However, unlike the variable of *cbl/assets* which is a bank-level variable, the swap line variable *cbsw/loans* can only be constructed as a country-level variable due to the unavailability of bank-level data.[13] Since *cbsw/loans* by construction cannot reveal how the liquidity measure is distributed across individual global banks within a country, the estimation results are expected to be less clear than that of *cbl/assets*. Table 4 reports the estimation results, which are broadly in line with those in Table 2. The impact of the central bank swap lines is given by the estimated coefficient on (*cbsw/loans*)**libois*. Only the estimate in Model IV is found to be statistically significant, although the estimated sign of the variable is in line with our expectations for all specifications considered in Columns I to IV. On the whole, the effectiveness of central banks swap lines in reducing global banks' funding stress is less clear than that of TAF and DW, although these liquidity measures are similar in nature. The weaker empirical results, however, may be partly attributable to data limitations.

4.1 Economic Significance

To investigate the economic significance of the role of liquid assets held by parent bank in determining internal funding flows from Hong Kong branches, we compare US-dollar $\Delta NDF_{k,t}$ for two hypothetical banks, one being less-liquid at the 25th percentile of *liquid assets/assets*$_i$ and another being more-liquid at the 75th percentile (i.e. 17.7% and 40.3% respectively, Panel C in Table 1). We compute the difference in $\Delta NDF_{k,t}$ between these two hypothetical banks using the coefficient estimate on (*liquid assets/assets*$_{i,t-1}$)**libois*$_{c,t}$ (= -29.2) in column I of Table 2 and assume a *libois*$_{c,t}$ shock of 250 basis points[14]. By taking advantage of more liquid assets to buffer the parent-bank funding shock, the more-liquid bank can afford to reduce internal funding support from its Hong Kong branch by an amount equivalent to 29.4% of the branch asset.[15] This compares to a lower estimate of 12.9% for the less-liquid bank. The difference (=16.5%) is the additional internal funding that the less-liquid parent bank would need because its holds less liquid assets.

How does this extra amount of internal funding reduce the credit supply of the less-liquid bank's branch in Hong Kong? We answer this question by using the second-stage estimation result in column I of Table 2 and further assume a loan-to-asset ratio of 17.7% (i.e. the average ratio for all

[13] Country-level variables of central bank swap line are constructed based on data from the Federal Reserve Board of Governors' website. In estimation, we standardise the swap amount outstanding of a country by the country's total loans.

[14] The shock is broadly comparable to the average level observed in October 2008.

[15] This can be calculated by multiplying a bank's *liquid assets/assets*$_{it}$ by -29.2*0.025. Since liquid assets held by parents reduce their reliance on internal funding support from Hong Kong branches to buffer the funding shock, the $\Delta NDF_{k,t}$ computed for the two hypothetical banks are negative.

foreign bank branches in Hong Kong in the pre-crisis period). The extra internal funding to support the parent bank would curtail loan supply of the Hong Kong branch by an amount equivalent to 1.6% of the branch assets. The estimate is considered economically significant, as it translates into a loan contraction by 9% (=1.6%/17.7%).

Likewise, we compute the economic significance of the differences arising from the variable of central bank liquidity. Panel C of Table 1 shows that global banks' reliance on the Federal Reserve's TAF and DW are significantly different during the peak of the crisis (i.e. the 25th and 75th percentiles of $cbl/assets_i$ during 2009Q1 are 0.2% and 1.8% respectively). With access to central bank liquidity, a global bank at the 75th percentile of $cbl/assets_i$ would reduce internal funding from its Hong Kong branch by an amount equivalent to 11.5% of the branch asset, which in turn can sustain the branch's loan supply by an amount equivalent to 1.13% of the branch assets (or by loan growth of 6.4%).

5. Conclusion

Through the lens of the two-stage econometric model using confidential data of global bank branches in Hong Kong, this paper finds clear host-country evidence of inward spillovers of shocks from the home countries of global banks to the Hong Kong banking sector through an internal capital market channel. The extent to which the shock affects the loan supply of their branches in Hong Kong is found to be primarily determined by central bank liquidity, the business model of branches and the amount of liquid assets held by the parent bank. These findings have two implications.

First, to the extent that central bank liquidity is a significant factor affecting global banks' cross-border internal funding flows and their foreign branches' loan supply, normalisation of liquidity by central banks in advanced economies would likely have an impact on the host countries of global banks' branches. Importantly, in the case of Hong Kong, the potential reduction in loan supply by global bank branches may be larger than that which occurred in the GFC. The reason is that many US and European-headquartered global banks have changed their business model from primarily a funding role before the GFC to more of a loan provider (see He and McCauley, 2013), and our findings suggest that loan providers (i.e. branches with a high loan-to-asset ratio) cut their loan supply more sharply than their counterparts when parent banks repatriated internal funding from Hong Kong. The increased sensitivity of foreign bank branches' loan supply to external financial shocks could be one significant source of financial instability. Although the recent macroprudential measures by the HKMA that require foreign bank branches in Hong Kong to ensure sufficient long-term funding to meet their loan growth (i.e. stable funding requirement[16]) in theory could dampen loan cyclicality. Looking forward, further research effort would be needed to assess the effectiveness of these measures empirically.

[16] http://www.hkma.gov.hk/media/eng/doc/key-information/insight/20140415e1a1.pdf

Second, our findings support the view that regulatory reforms may help to reduce the extent of cross-border transmission of financial shocks through the channel of global banks' internal capital markets. Specifically, our findings indicate that from a liquidity management perspective, liquid assets held by parents and internal funding from Hong Kong branches are regarded as close substitutes by global banks. Therefore, the liquidity requirements of Basel III, which require banks to hold adequate high-quality liquid assets to cover their cash outflows, may reduce global banks' reliance on cross-border internal funding support in times of stress.

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Table 1. Summary Statistics for Variables (Panel A)

The table shows summary statistics for all variables in the two-stage regressions. Subscript *k* denotes Hong Kong branch of global bank *i* with the headquarter in country *c. t* denotes time. Panel A shows the summary statistics for dependent variables. The numerators of these variables are constructed using data of US-dollar denominated balance-sheet items (except for liquid assets, which include both US- and HK-dollar liquid assets due to unavailability of the breakdown), while the denominators are total assets or total assets plus total unused commitments in the previous period. Panels B and C shows the summary statistics for parent-level and branch-level explanatory variables for the regressions respectively. These variables are standardized by total assets, liabilities or credit in the same period. The summary statistics are produced using the panel of 37 banks for estimations, covering the period 2006Q1 through 2012Q4. All variable are winsorized at the 1st and 99th percentiles, except $libois_{c,t}$, $cbl/assets_{i,t}$, $cds_{i,t}$ and $cip_{c,t}$. Before-crisis period is defined as 2006Q1–2007Q2, while the crisis period refers to 2007Q3–2009Q2. The after-crisis period covers 2009Q3–2012Q4. TAF refers to the Team Auction Facility programme by the Federal Reserve, which was launched in December 2007 and ended in March 2010. The summary statistics for $cbl/assets_{i,}$ during the crisis period (in Panel B) are computed based on observations in 2009Q1 where the TAF has been drawn heavily by the sample banks.

	Average	25th percentile	Median	75th percentile	Standard deviation
Panel A: USD dependent variables					
i) before crisis period (2006Q1 - 2007Q2)					
ΔNDF_k (percent)	0.84	-2.29	0.27	3.78	6.37
$\Delta liquid\ assets_{k,t}/assets_{k,t-1}$ (percent)	1.77	-0.55	1.02	3.43	5.06
$\Delta loans_{k,t}/assets_{k,t-1}$ (percent)	0.28	-0.29	0.03	0.64	1.52
$\Delta domestic\ loans_{k,t}/assets_{k,t-1}$ (percent)	0.00	-0.13	0.00	0.15	0.60
$\Delta foreign\ loans_{k,t}/assets_{k,t-1}$ (percent)	0.28	-0.15	0.03	0.40	1.33
$\Delta credit_{k,t}/(commitments + assets)_{k,t-1}$ (percent)	0.46	-0.39	0.13	1.08	2.43
ii) during crisis period (2007Q3 - 2009Q2)					
ΔNDF_k (percent)	-0.59	-5.12	-0.98	3.70	8.68
$\Delta liquid\ assets_{k,t}/assets_{k,t-1}$ (percent)	-0.35	-2.03	-0.10	1.49	4.97
$\Delta loans_{k,t}/assets_{k,t-1}$ (percent)	0.33	-0.26	0.06	0.68	1.59
$\Delta domestic\ loans_{k,t}/assets_{k,t-1}$ (percent)	0.07	-0.11	0.00	0.13	0.85
$\Delta foreign\ loans_{k,t}/assets_{k,t-1}$ (percent)	0.29	-0.15	0.07	0.46	1.27
$\Delta credit_{k,t}/(commitments + assets)_{k,t-1}$ (percent)	0.34	-0.44	0.04	0.83	1.97
Of which: before the launch of TAF program (2007Q3 - 2007Q4)					
ΔNDF_k (percent)	1.82	-2.62	1.06	5.11	8.40
$\Delta liquid\ assets_{k,t}/assets_{k,t-1}$ (percent)	0.33	-1.19	0.35	4.03	5.27
$\Delta loans_{k,t}/assets_{k,t-1}$ (percent)	0.32	-0.22	0.08	0.67	1.18
$\Delta domestic\ loans_{k,t}/assets_{k,t-1}$ (percent)	0.01	-0.14	0.00	0.11	0.87
$\Delta foreign\ loans_{k,t}/assets_{k,t-1}$ (percent)	0.31	-0.12	0.10	0.58	0.97
$\Delta credit_{k,t}/(commitments + assets)_{k,t-1}$ (percent)	0.27	-0.53	0.07	0.77	1.92
iii) after crisis period (2009Q3 - 2012Q4)					
ΔNDF_k (percent)	-0.96	-4.34	-0.46	2.04	8.11
$\Delta liquid\ assets_{k,t}/assets_{k,t-1}$ (percent)	-0.09	-1.77	0.00	2.18	4.87
$\Delta loans_{k,t}/assets_{k,t-1}$ (percent)	0.59	-0.18	0.12	1.09	2.20
$\Delta domestic\ loans_{k,t}/assets_{k,t-1}$ (percent)	0.17	-0.04	0.00	0.25	1.05
$\Delta foreign\ loans_{k,t}/assets_{k,t-1}$ (percent)	0.42	-0.19	0.06	0.73	1.74
$\Delta credit_{k,t}/(commitments + assets)_{k,t-1}$ (percent)	0.75	-0.25	0.18	1.58	2.84

Table 1. Summary Statistics for Variables (Panels B and C)

	Average	25th percentile	Median	75th percentile	Standard deviation
Panel B: Parent bank characteristics					
i) before crisis period (2006Q1 - 2007Q2)					
$libois_c$ (percent)	0.07	0.05	0.06	0.09	0.03
liquid assets/assets$_i$ (percent)	28.86	17.72	25.03	40.26	14.80
core liabilities/assets$_i$ (percent)	46.04	34.18	44.46	55.42	16.78
commitments/credit$_i$ (percent)	28.72	19.64	29.74	36.12	13.40
real asset$_i$ (USD billion)	1263.70	609.78	1271.38	1834.06	767.96
cbl/assets$_i$ (percent)	0.00	0.00	0.00	0.00	0.00
invest$_k$*/invest*$_i$ (percent)	0.83	0.24	0.49	0.78	1.81
GDF$_k$*/interbank borrowing*$_i$ (percent)	9.28	0.63	1.99	5.65	17.55
pri_k *-pri*$_i$ (percent)	0.48	-1.86	0.00	2.81	2.89
cds_i (percent)	0.10	0.07	0.09	0.13	0.04
cip_c (percent)	0.10	0.00	0.06	0.16	0.15
ii) during crisis period (2007Q3 - 2009Q2)					
$libois_c$ (percent)	0.71	0.44	0.64	0.76	0.39
liquid assets/assets$_i$ (percent)	25.47	14.57	24.33	33.29	12.98
core liabilities/assets$_i$ (percent)	44.83	29.57	43.55	54.66	17.72
commitments/credit$_i$ (percent)	35.55	21.76	32.82	41.19	21.38
real asset$_i$ (USD billion)	1638.28	715.59	1545.84	2339.30	1102.53
cbl/assets$_i$ (percent)	1.21	0.20	0.61	1.81	1.73
invest$_k$*/invest*$_i$ (percent)	0.83	0.19	0.47	0.87	1.75
GDF$_k$*/interbank borrowing*$_i$ (percent)	12.52	0.97	2.76	10.62	26.77
pri_k *-pri*$_i$ (percent)	0.93	-1.68	1.01	3.05	2.99
cds_i (percent)	1.20	0.67	1.09	1.45	0.83
cip_c (percent)	0.74	0.10	0.36	0.53	1.35
Of which: before the launch of TAF program (2007Q3 - 2007Q4)					
$libois_c$ (percent)	0.48	0.36	0.44	0.67	0.17
liquid assets/assets$_i$ (percent)	27.95	17.21	25.46	39.59	13.80
core liabilities/assets$_i$ (percent)	44.95	28.59	43.09	54.87	17.47
commitments/credit$_i$ (percent)	34.56	23.94	32.61	41.66	18.81
real asset$_i$ (USD billion)	1605.15	732.99	1525.66	2421.52	1079.50
cbl/assets$_i$ (percent)	0.02	0.00	0.00	0.00	0.06
invest$_k$*/invest*$_i$ (percent)	0.84	0.19	0.42	0.86	1.91
GDF$_k$*/interbank borrowing*$_i$ (percent)	10.99	0.91	2.58	9.41	22.85
pri_k *-pri*$_i$ (percent)	0.80	-1.74	0.62	2.67	3.24
cds_i (percent)	0.36	0.26	0.33	0.45	0.13
cip_c (percent)	0.23	0.23	0.25	0.32	0.12
iii) after crisis period (2009Q3 - 2012Q4)					
$libois_c$ (percent)	0.28	0.15	0.27	0.34	0.18
liquid assets/assets$_i$ (percent)	25.34	15.25	24.73	31.93	11.73
core liabilities/assets$_i$ (percent)	46.97	32.47	47.56	56.66	15.97
commitments/credit$_i$ (percent)	35.59	20.37	34.56	40.47	21.44
real asset$_i$ (USD billion)	1550.07	707.44	1586.35	2377.91	907.32
cbl/assets$_i$ (percent)	0.08	0.00	0.00	0.00	0.38
invest$_k$*/invest*$_i$ (percent)	1.00	0.24	0.60	0.96	1.91
GDF$_k$*/interbank borrowing*$_i$ (percent)	11.19	0.67	2.28	8.95	25.07
pri_k *-pri*$_i$ (percent)	2.18	-0.29	1.91	4.55	3.50
cds_i (percent)	1.71	1.04	1.42	2.12	0.95
cip_c (percent)	0.18	0.03	0.13	0.28	0.22
Panel C: Branch characteristics					
i) before crisis period (2006Q1 - 2007Q2)					
liquid assets/assets$_k$ (percent)	27.34	14.37	22.13	37.26	17.75
deposits/non-related liabilities$_k$ (percent)	46.39	24.18	45.42	67.01	28.23
commitments/credit$_k$ (percent)	34.07	12.43	29.77	54.80	24.68
real asset$_k$ (USD billion)	11.59	3.31	7.91	16.13	10.35
loans/assets$_k$ (percent)	17.72	6.19	16.54	25.03	12.56
ii) during crisis period (2007Q3 - 2009Q2)					
liquid assets/assets$_k$ (percent)	23.76	12.18	18.84	31.27	16.33
deposits/non-related liabilities$_k$ (percent)	44.90	16.58	45.08	65.75	28.41
commitments/credit$_k$ (percent)	31.79	12.89	26.47	48.40	23.90
real asset$_k$ (USD billion)	13.78	4.40	9.22	21.76	12.12
loans/assets$_k$ (percent)	18.05	8.35	16.79	25.66	13.29
Of which: before the launch of TAF program (2007Q3 - 2007Q4)					
liquid assets/assets$_k$ (percent)	25.22	12.72	19.93	33.65	17.47
deposits/non-related liabilities$_k$ (percent)	45.09	18.51	45.99	67.01	27.49
commitments/credit$_k$ (percent)	34.19	16.76	29.47	49.97	23.15
real asset$_k$ (USD billion)	14.28	4.42	10.69	23.04	11.96
loans/assets$_k$ (percent)	17.16	6.76	16.61	25.69	12.38
iii) after crisis period (2009Q3 - 2012Q4)					
liquid assets/assets$_k$ (percent)	25.17	12.64	20.95	33.95	17.03
deposits/non-related liabilities$_k$ (percent)	45.24	17.40	42.37	69.34	31.20
commitments/credit$_k$ (percent)	30.10	10.38	24.78	49.07	23.55
real asset$_k$ (USD billion)	13.30	4.40	8.18	19.76	12.35
loans/assets$_k$ (percent)	22.91	9.54	21.92	32.75	15.68

Table 2. Estimated Impact of Parent-Bank Funding Shock on US-Dollar Denominated *NDF*, Loans and Liquid Assets of Branches in Hong Kong

Model	**(I)**	**(II)**	**(III)**	**(IV)**
Panel A: First-stage regression				
Dependent Variable	$\Delta NDF_{k,t}$	$\Delta NDF_{k,t}$	$\Delta NDF_{k,t}$	$\Delta NDF_{k,t}$
Constant	4.578	3.214	3.600	3.715
	(3.244)	(3.099)	(3.075)	(3.009)
$libois_{c,t}$	-25.568	-15.692	-25.131	-26.655
	(37.599)	(36.767)	(36.126)	(35.868)
$liquid\ assets/assets_{i,t-1}$	0.161 **	0.171 **	0.172 **	0.157 **
	(0.070)	(0.069)	(0.069)	(0.068)
$(liquid\ assets/assets_{i,t-1})*libois_{c,t}$	-29.173 **	-27.726 **	-25.993 **	-23.421 *
	(12.661)	(12.687)	(12.285)	(12.523)
$core\ liabilities/assets_{i,t-1}$	0.107	0.025	0.008	0.020
	(0.163)	(0.153)	(0.152)	(0.155)
$(core\ liabilities/assets_{i,t-1})*libois_{c,t}$	-14.584	-7.995	-3.165	-3.173
	(9.866)	(9.533)	(8.346)	(9.004)
$commitments/credit_{i,t-1}$	-0.093	-0.099	-0.102	-0.104
	(0.065)	(0.076)	(0.078)	(0.080)
$(commitments/credit_{i,t-1})*libois_{c,t}$	2.709	7.061	10.395 *	8.881
	(5.897)	(6.066)	(6.079)	(6.065)
$log\ real\ assets_{i,t-1}$	-0.039 *	-0.033	-0.036	-0.035
	(0.021)	(0.022)	(0.022)	(0.022)
$log\ real\ assets_{i,t-1}*libois_{c,t}$	1.850	1.235	1.391	1.451
	(1.475)	(1.413)	(1.402)	(1.387)
$cbl/assets_{i,t}$	2.301 ***	2.838 ***	2.890 ***	3.155 ***
	(0.785)	(0.728)	(0.713)	(0.731)
$(cbl/assets_{i,t})*libois_{c,t}$	-284.881 ***	-354.363 ***	-369.847 ***	-366.443 ***
	(88.259)	(89.032)	(83.667)	(88.177)
$invest_{k,t-1}/invest_{i,t-1}$	-0.264			
	(1.136)			
$(invest_{k,t-1}/invest_{i,t-1})*libois_{c,t}$	-30.428			
	(217.618)			
$GDF_{k,t-1}/interbank\ borrowing_{i,t-1}$	-0.112 ***			
	(0.031)			
$(GDF_{k,t-1}/interbank\ borrowing_{i,t-1})*libois_{c,t}$	12.333 **			
	(4.607)			
$pri_{k,t} - pri_{i,t}$	0.299	0.180		
	(0.213)	(0.221)		
$(pri_{k,t} - pri_{i,t})*libois_{c,t}$	-97.954 **	-76.006		
	(46.552)	(45.870)		
$cds_{i,t}$	1.237 *	1.206	0.957	
	(0.729)	(0.715)	(0.657)	
$cip_{c,t}$	1.596 *	1.589 *	1.535 *	
	(0.855)	(0.829)	(0.821)	
Number of banks	37	37	37	37
Observations	755	755	755	755
Time period for analysis	1Q06-4Q12	1Q06-4Q12	1Q06-4Q12	1Q06-4Q12
Bank fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.091	0.087	0.085	0.079
Panel B: Second-stage regression				
Dependent Variables: $\Delta loans_{k,t}/assets_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.074	0.068	0.071	0.072
	(0.049)	(0.054)	(0.057)	(0.056)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.555 **	-0.586 **	-0.623 **	-0.611 **
	(0.252)	(0.265)	(0.269)	(0.289)
Adj. R-squared	0.044	0.046	0.048	0.045
Dependent Variables: $\Delta domestic\ loans_{k,t}/assets_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.034	0.027	0.029	0.014
	(0.024)	(0.026)	(0.026)	(0.024)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.255 **	-0.275 **	-0.295 **	-0.327 **
	(0.112)	(0.113)	(0.117)	(0.131)
Adj. R-squared	0.055	0.059	0.062	0.068
Dependent Variables: $\Delta foreign\ loans_{k,t}/assets_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.042	0.044	0.044	0.063
	(0.033)	(0.039)	(0.045)	(0.049)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.327 *	-0.334 *	-0.355 *	-0.296
	(0.175)	(0.186)	(0.189)	(0.197)
Adj. R-squared	0.024	0.024	0.026	0.021
Dependent Variables: $\Delta credit_{k,t}/(commitments + assets)_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.085	0.080	0.096	0.086
	(0.060)	(0.065)	(0.075)	(0.068)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.678 **	-0.706 **	-0.730 **	-0.697 *
	(0.317)	(0.332)	(0.340)	(0.350)
Adj. R-squared	0.034	0.035	0.035	0.032
Dependent Variables: $\Delta liquid\ assets_{k,t}/assets_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.318 **	0.200	0.250	0.398 **
	(0.132)	(0.165)	(0.169)	(0.168)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.670 *	-0.600 *	-0.698 *	-0.665 *
	(0.346)	(0.341)	(0.362)	(0.334)
Adj. R-squared	0.073	0.067	0.069	0.072

All variables are in decimal, i.e., 0.03 = 3% = 300 basis points, except that the real assets are in logarithmic form.
All variables are winsorized at the 1st and 99th percentiles, except $libois_{c,t}$, $cbl/assets_{i,t}$, $cds_{i,t}$ and $cip_{c,t}$.
Assets at the end of the previous quarter are used to standardised growth in net due from, loans and liquid assets, while assets and commitments together are used to standardised credit growth.
$\Delta NDF(IV)_{k,t-1}$ in the second-stage regression is based on the results in the first-stage regression. For brevity, all estimates for control variables in the second-stage regression are not reported in the table.
Figures in parentheses are standard errors clustered by bank.
***, **, and * respectively indicate significance at the 1%, 5%, and 10% level.

Table 3. Estimated Impact of Parent-Bank Funding Shock on Foreign-Currency Denominated *NDF*, Loans and Liquid Assets of Branches in Hong Kong

Model	**(I)**	**(II)**	**(III)**	**(IV)**
Panel A: First-stage regression				
Dependent Variable	$\Delta NDF_{k,t}$	$\Delta NDF_{k,t}$	$\Delta NDF_{k,t}$	$\Delta NDF_{k,t}$
Constant	5.826	6.434 *	6.952 *	7.050 **
	(3.477)	(3.532)	(3.465)	(3.458)
$libois_{c,t}$	-40.189	-49.188	-61.603	-62.905
	(42.224)	(42.095)	(40.844)	(41.260)
$liquid\ assets/assets_{i,t-1}$	0.157 *	0.185 **	0.190 **	0.178 **
	(0.084)	(0.083)	(0.083)	(0.084)
$(liquid\ assets/assets_{i,t-1})*libois_{c,t}$	-36.896 **	-39.007 **	-37.335 **	-35.172 **
	(15.016)	(14.408)	(14.165)	(14.602)
$core\ liabilities/assets_{i,t-1}$	0.074	-0.003	-0.016	-0.006
	(0.181)	(0.169)	(0.158)	(0.160)
$(core\ liabilities/assets_{i,t-1})*libois_{c,t}$	-5.971	-4.919	1.178	1.182
	(12.123)	(10.998)	(9.889)	(10.485)
$commitments/credit_{i,t-1}$	-0.162 **	-0.157 *	-0.160 *	-0.162 *
	(0.071)	(0.085)	(0.088)	(0.089)
$(commitments/credit_{i,t-1})*libois_{c,t}$	8.469	9.409	14.412 *	13.164 *
	(7.056)	(7.679)	(7.599)	(7.480)
$log\ real\ assets_{i,t-1}$	-0.043	-0.038	-0.042	-0.042
	(0.026)	(0.028)	(0.028)	(0.027)
$log\ real\ assets_{i,t-1}*libois_{c,t}$	2.406	2.743 *	2.946 *	2.996 *
	(1.602)	(1.598)	(1.569)	(1.582)
$cbl/assets_{i,t}$	3.858 **	4.241 ***	4.370 ***	4.594 ***
	(1.549)	(1.392)	(1.399)	(1.434)
$(cbl/assets_{i,t})*libois_{c,t}$	-473.918 ***	-485.140 ***	-511.915 ***	-509.294 ***
	(163.969)	(158.256)	(161.933)	(173.893)
$invest_{k,t-1}/invest_{i,t-1}$	0.522			
	(1.464)			
$(invest_{k,t-1}/invest_{i,t-1})*libois_{c,t}$	-244.792			
	(252.185)			
$GDF_{k,t-1}/interbank\ borrowing_{i,t-1}$	-0.121 ***			
	(0.042)			
$(GDF_{k,t-1}/interbank\ borrowing_{i,t-1})*libois_{c,t}$	4.402			
	(5.828)			
$pri_{k,t}-pri_{i,t}$	0.290	0.166		
	(0.308)	(0.310)		
$(pri_{k,t}-pri_{i,t})*libois_{c,t}$	-107.443 *	-103.830 *		
	(56.318)	(53.514)		
$cds_{i,t}$	1.252	1.235	0.814	
	(1.045)	(1.048)	(0.968)	
$cip_{c,t}$	1.400	1.323	1.275	
	(1.092)	(1.077)	(1.082)	
Number of banks	37	37	37	37
Observations	755	755	755	755
Time period for analysis	1Q06-4Q12	1Q06-4Q12	1Q06-4Q12	1Q06-4Q12
Bank fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.093	0.086	0.082	0.080
Panel B: Second-stage regression				
Dependent Variables: Δ loans$_{k,t}$/assets$_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.033	0.023	0.017	0.031
	(0.061)	(0.066)	(0.068)	(0.068)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.510 *	-0.553	-0.589	-0.512
	(0.268)	(0.343)	(0.349)	(0.347)
Adj. R-squared	0.072	0.074	0.077	0.070
Dependent Variables: Δ domestic loans$_{k,t}$/assets$_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.022	0.015	0.017	0.013
	(0.021)	(0.022)	(0.022)	(0.022)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.189	-0.220 *	-0.225 *	-0.242 *
	(0.113)	(0.120)	(0.125)	(0.132)
Adj. R-squared	0.072	0.076	0.076	0.079
Dependent Variables: Δ foreign loans$_{k,t}$/assets$_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.012	0.008	0.001	0.019
	(0.047)	(0.051)	(0.052)	(0.053)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.312 *	-0.322	-0.360	-0.257
	(0.175)	(0.244)	(0.247)	(0.231)
Adj. R-squared	0.049	0.049	0.052	0.045
Dependent Variables: Δ credit$_{k,t}$/(commitments + assets)$_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.034	0.024	0.033	0.033
	(0.063)	(0.069)	(0.075)	(0.073)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.617 *	-0.666 *	-0.680	-0.568
	(0.317)	(0.394)	(0.408)	(0.389)
Adj. R-squared	0.052	0.054	0.054	0.047
Dependent Variables: Δ liquid assets$_{k,t}$/assets$_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.286 **	0.235 *	0.259	0.266
	(0.105)	(0.135)	(0.154)	(0.167)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-1.131 ***	-0.985 **	-1.042 **	-0.938 **
	(0.318)	(0.393)	(0.431)	(0.455)
Adj. R-squared	0.123	0.117	0.118	0.116

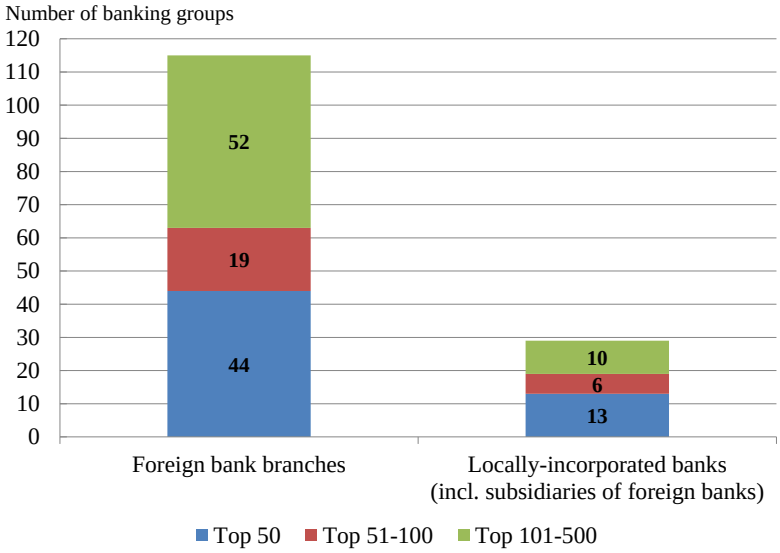
All variables are in decimal, i.e., 0.03 = 3% = 300 basis points, except that the real assets are in logarithmic form.
All variables are winsorized at the 1st and 99th percentiles, except $libois_{c,t}$, $cbl/assets_{i,t}$, $cds_{i,t}$ and $cip_{c,t}$.
Assets at the end of the previous quarter are used to standardised growth in net due from, loans and liquid assets, while assets and commitments together are used to standardised credit growth.
$\Delta NDF(IV)_{k,t-1}$ in the second-stage regression is based on the results in the first-stage regression. For brevity, all estimates for control variables in the second-stage regression are not reported in the table.
Figures in parentheses are standard errors clustered by bank.
***, **, and * respectively indicate significance at the 1%, 5%, and 10% level.

Table 4. Estimated Impact of Parent-Bank Funding Shock on US-Dollar Denominated *NDF*, Loans and Liquid Assets of Branches in Hong Kong (with Federal Reserve's Central Bank Swap Lines Included in the Models)

Model	(I)	(II)	(III)	(IV)
Panel A: First-stage regression				
Dependent Variable	$\Delta NDF_{k,t}$	$\Delta NDF_{k,t}$	$\Delta NDF_{k,t}$	$\Delta NDF_{k,t}$
Constant	3.463	2.467	2.835	2.642
	(3.358)	(3.170)	(3.093)	(2.973)
$libois_{c,t}$	-9.108	-3.588	-12.324	-9.248
	(38.467)	(37.095)	(35.808)	(34.879)
$liquid\ assets/assets_{i,t-1}$	0.159 **	0.172 **	0.174 **	0.161 **
	(0.070)	(0.069)	(0.068)	(0.067)
$(liquid\ assets/assets_{i,t-1})*libois_{c,t}$	-27.751 *	-26.975 *	-25.636 *	-22.759 *
	(13.708)	(13.703)	(13.206)	(13.384)
$core\ liabilities/assets_{i,t-1}$	0.122	0.038	0.024	0.040
	(0.163)	(0.150)	(0.150)	(0.150)
$(core\ liabilities/assets_{i,t-1})*libois_{c,t}$	-18.289 *	-11.323	-6.880	-8.118
	(9.590)	(9.342)	(8.275)	(8.780)
$commitments/credit_{i,t-1}$	-0.086	-0.094	-0.097	-0.096
	(0.064)	(0.075)	(0.078)	(0.079)
$(commitments/credit_{i,t-1})*libois_{c,t}$	-0.840	4.102	7.432	4.983
	(7.560)	(7.550)	(7.132)	(7.109)
$log\ real\ assets_{i,t-1}$	-0.037 *	-0.032	-0.035	-0.034
	(0.022)	(0.023)	(0.023)	(0.022)
$log\ real\ assets_{i,t-1}*libois_{c,t}$	1.341	0.892	1.038	0.956
	(1.513)	(1.426)	(1.392)	(1.353)
$cbl/assets_{i,t}$	2.324 ***	2.875 ***	2.947 ***	3.187 ***
	(0.737)	(0.674)	(0.661)	(0.657)
$(cbl/assets_{i,t})*libois_{c,t}$	-284.526 ***	-355.030 ***	-371.107 ***	-370.431 ***
	(83.933)	(84.546)	(78.391)	(80.836)
$cbsw_{c,t}/loans_{c,t-1}$	3.524	3.385	3.657	4.241
	(2.676)	(2.653)	(2.709)	(2.872)
$(cbsw_{c,t}/loans_{c,t-1})*libois_{c,t}$	-473.698	-434.079	-451.578	-575.412 *
	(304.322)	(310.409)	(323.491)	(338.669)
$invest_{k,t-1}/invest_{i,t-1}$	-0.249			
	(1.143)			
$(invest_{k,t-1}/invest_{i,t-1})*libois_{c,t}$	-73.730			
	(214.038)			
$GDF_{k,t-1}/interbank\ borrowing_{i,t-1}$	-0.112 ***			
	(0.030)			
$(GDF_{k,t-1}/interbank\ borrowing_{i,t-1})*libois_{c,t}$	12.384 **			
	(4.551)			
$pri_{k,t}-pri_{i,t}$	0.272	0.153		
	(0.218)	(0.224)		
$(pri_{k,t}-pri_{i,t})*libois_{c,t}$	-94.079 **	-72.680		
	(45.678)	(45.578)		
$cds_{i,t}$	1.205	1.170	0.911	
	(0.717)	(0.697)	(0.647)	
$cip_{c,t}$	1.327	1.355 *	1.303 *	
	(0.788)	(0.774)	(0.769)	
Number of banks	37	37	37	37
Observations	755	755	755	755
Time period for analysis	1Q06-4Q12	1Q06-4Q12	1Q06-4Q12	1Q06-4Q12
Bank fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.092	0.087	0.085	0.082
Panel B: Second-stage regression				
Dependent Variables: $\Delta loans_{k,t}/assets_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.073	0.067	0.067	0.066
	(0.048)	(0.054)	(0.056)	(0.053)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.561 **	-0.604 **	-0.637 **	-0.629 **
	(0.246)	(0.259)	(0.260)	(0.277)
Adj. R-squared	0.044	0.048	0.050	0.048
Dependent Variables: Δ *domestic loans* $_{k,t}/assets_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.036	0.029	0.031	0.021
	(0.025)	(0.027)	(0.028)	(0.026)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.251 **	-0.275 **	-0.291 **	-0.315 **
	(0.109)	(0.109)	(0.112)	(0.122)
Adj. R-squared	0.055	0.059	0.061	0.066
Dependent Variables: Δ *foreign loans* $_{k,t}/assets_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.039	0.040	0.039	0.049
	(0.033)	(0.039)	(0.043)	(0.045)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.335 *	-0.352 *	-0.371 **	-0.325 *
	(0.169)	(0.182)	(0.182)	(0.189)
Adj. R-squared	0.025	0.026	0.027	0.023
Dependent Variables: $\Delta credit_{k,t}/(commitments + assets)_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.091	0.086	0.099	0.094
	(0.060)	(0.066)	(0.074)	(0.068)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.674 **	-0.715 **	-0.735 **	-0.703 **
	(0.310)	(0.324)	(0.329)	(0.337)
Adj. R-squared	0.033	0.036	0.036	0.033
Dependent Variables: Δ *liquid assets* $_{k,t}/assets_{k,t-1}$				
$\Delta NDF(IV)_{k,t-1}$	0.369 **	0.270 *	0.328 *	0.477 ***
	(0.136)	(0.157)	(0.162)	(0.158)
$(loans/assets_{k,t-1})*\Delta NDF(IV)_{k,t-1}$	-0.727 **	-0.666 *	-0.771 **	-0.768 **
	(0.353)	(0.347)	(0.367)	(0.352)
Adj. R-squared	0.077	0.069	0.072	0.078

All variables are in decimal, i.e., 0.03 = 3% = 300 basis points, except that the real assets are in logarithmic form.
All variables are winsorized at the 1st and 99th percentiles, except $libois_{c,t}$, $cbl/assets_{i,t}$, $cds_{i,t}$ and $cip_{c,t}$.
Assets at the end of the previous quarter are used to standardised growth in net due from, loans and liquid assets, while assets and commitments together are used to standardised credit growth.
$\Delta NDF(IV)_{k,t-1}$ in the second-stage regression is based on the results in the first-stage regression. For brevity, all estimates for control variables in the second-stage regression are not reported in the table.
Figures in parentheses are standard errors clustered by bank.
***, **, and * respectively indicate significance at the 1%, 5%, and 10% level.

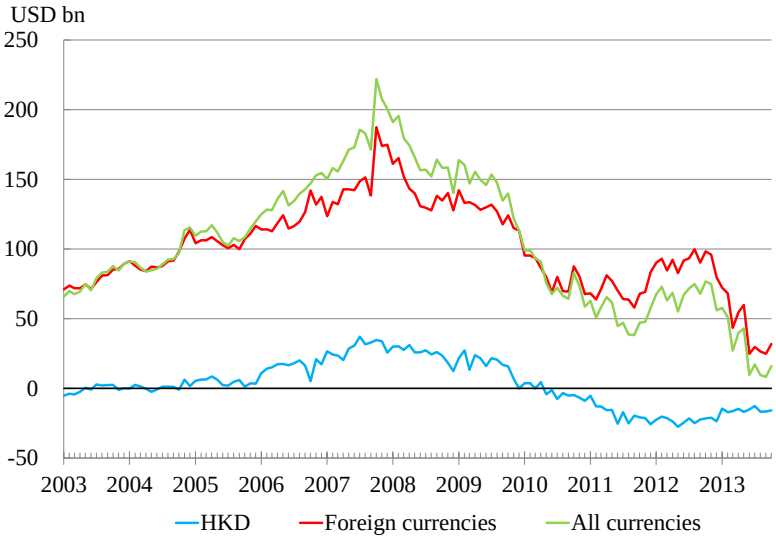
Figure 1. Presence of Global Banks in Hong Kong by Consolidated Asset Size and Mode of Operation



Note: The ranking is based on consolidated asset size in 2013. Some global banks operate both branches and subsidiaries in Hong Kong.

Source: HKMA staff estimates based on data from *the Banker*.

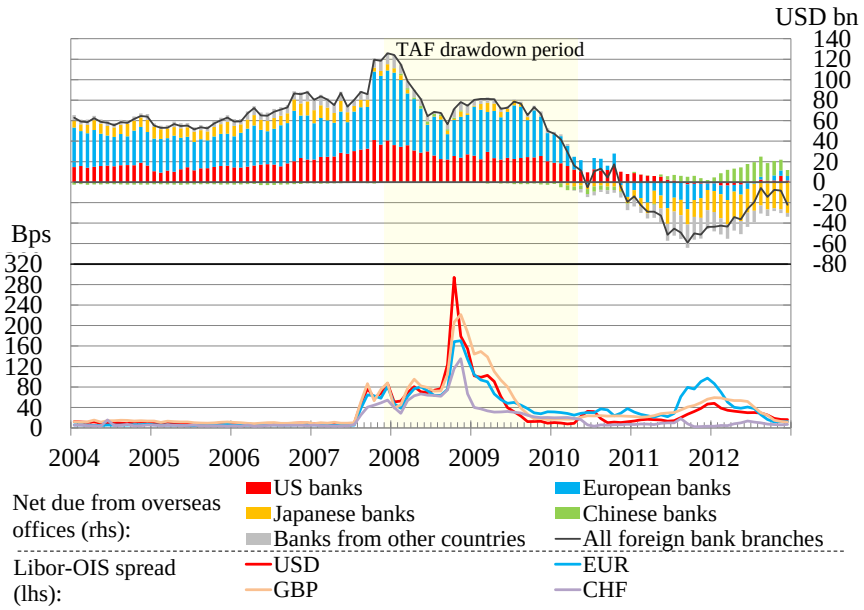
Figure 2. Hong Kong Banking Sector's Net Amount Due from Banks Abroad#



"Net amount due from banks abroad" refers to the amount due from banks abroad less the amount due to banks abroad. A positive (negative) figure means that the Hong Kong banking sector is a net lender (borrower).

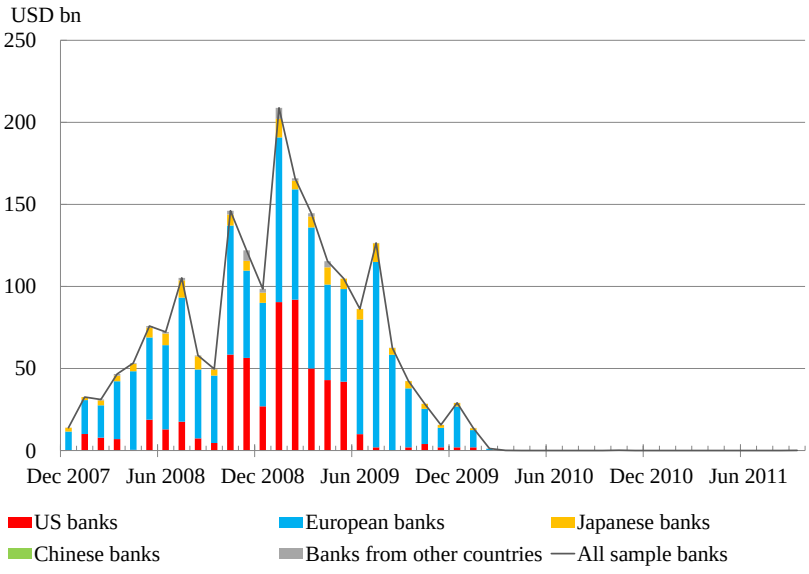
Source: HKMA

Figure 3. Foreign-Currency Net Due from Overseas Offices of Foreign Bank Branches in Hong Kong and Libor-OIS Spreads



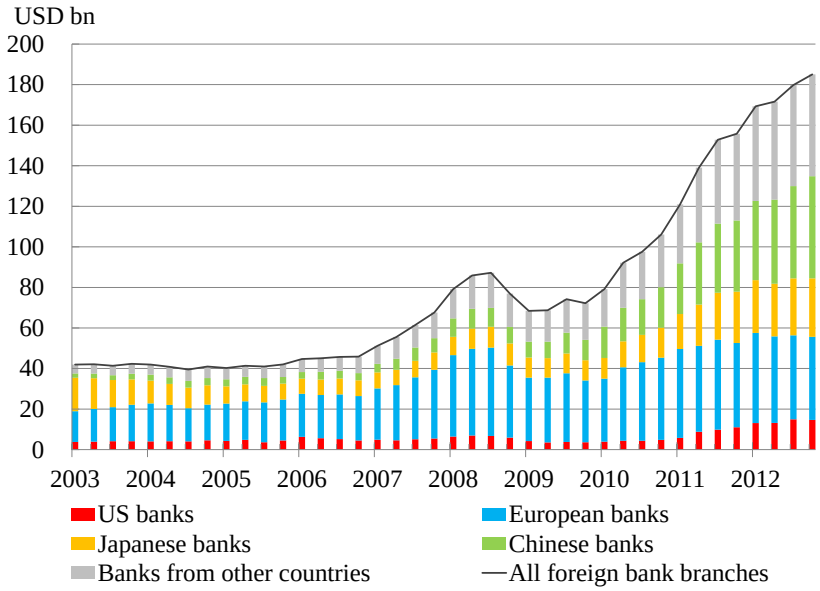
Sources: HKMA, data of Libor-OIS spread are contributed by International Banking Research Network

Figure 4. Total Amount of Drawdowns from the Term Auction Facility and Discount Window by Selected Global Banks with Branches in Hong Kong



Source: HKMA staff estimates based on data from the US Federal Reserve.

Figure 5. Foreign-Currency Loans and Advances to Customers by Foreign Bank Branches in Hong Kong



Source: HKMA.

Appendix. Definition of the Variables

Balance Sheet Variables for Parent Banks

Data are from Bankscope. Where quarterly data are not available, a linear interpolation method is applied to estimate the quarterly data from annual data.

Liquid assets$_i$: include trading securities and securities designated at fair value through income, loans and advances to banks, reverse repos and cash collateral, and cash and due from banks.
Commitments$_i$: include committed credit lines, guarantees, acceptances and documentary credits reported in the off-balance sheet, and other contingent liabilities.
Core liabilities$_i$: equal to the sum of total customer deposits and total equity (including preferred shares and hybrid capital accounted for as equity).
Real assets$_i$: in thousand constant 2012 US dollar.
Invest$_i$: includes loans (after deduction of reserves for impaired loans), loans and advances to banks and securities investments.
Interbank borrowing$_i$: includes deposits from banks and repos and cash collateral.
pri$_i$: the risk-adjusted loan prices of parent banks are proxied by the average rate of interest the bank is charging on its loans and other interest bearing assets *minus* the ratio of non-performing loan to gross loans.

Other Variables in the First Stage Regression

libois$_c$: the period average of the 3-month Libor-OIS spread in the country where the parent bank is located. The data are provided by the International Banking Research Network.
cbl$_i$: proxied by the sum of drawdowns from the DW and TAF at the group level. The data are sourced from the Federal Reserve.
cds$_i$: 5-year CDS spreads of parent banks from Bloomberg.
cip$_c$: the spread between the implied US-dollar funding rate by swapping home-country currency into the US dollar and the US-dollar Libor is calculated by this equation:

$$cip_c = \frac{S_t}{F_t}(1 + R_{c,t}) - (1 + R_{US,t})$$

where S is the spot exchange rate (the home-country currency value of a unit of USD), F is one-month forward exchange rate, R_c and R_{US} are the one-month home-country interbank offer rate and one-month USD libor respectively. Data on exchange rates and interest rates are quarter-end figures from Bloomberg.

Balance Sheet Variables for Branches in Hong Kong

Data are from *the return of assets and liabilities*, *the return of profit and loss account* and *the return of liquidity position* reported by foreign bank branches in Hong Kong to the Hong Kong Monetary Authority. All variables are quarterly average figures.

Net due from overseas offices (NDF$_k$): Due from overseas offices of the branches *minus* due to overseas offices from *the return of assets and liabilities*.

Liquid assets$_k$: the weighted amount of liquefiable assets in *the return of liquidity position*.

Loans$_k$: loans and advances to customers in *the return of assets and liabilities*.

Domestic loans$_k$: loans and advances to customers for use in Hong Kong in *the return of assets and liabilities*.

Foreign loans$_k$: loans and advances to customers not for use in Hong Kong *plus* trade financing in *the return of assets and liabilities*.

Commitments$_k$: the commitments for branches are other commitments in off-balance sheet exposures in *the return of assets and liabilities*.

Credit$_k$: the sum of ***Loans$_k$*** and ***Commitments$_k$***.

Deposits$_k$: deposits from customers in *the return of assets and liabilities*.

Real assets$_k$: in thousand constant 2012 US dollar.

Invest$_k$: the sum of loans and advances to customers, due from unrelated banks and other investments[17] in *the return of assets and liabilities*.

Gross due from overseas offices (GDF$_k$): due from overseas offices of the branches in *the return of assets and liabilities*.

pri$_k$: the risk-adjusted loan prices of branches are proxied by gross loans prices of the branch[18] *minus* the ratio of gross classified loans ratio of retail banks in Hong Kong.

[17] Including due from Exchange Fund, amount receivable under reverse repos, NCDs and all negotiable debt instruments held, investment in shareholdings and other investments.

[18] It is equal to the sum of four-quarter interest income of the branch in *the return of profit and loss account divided* by the interest-bearing assets of the branch, where the interest-bearing assets include loans and advances to customers, due from banks, due from Exchange Fund, amount receivable under reverse repos, NCDs and all other negotiable debt instruments held in *the return of assets and liabilities.*