



# IMF Working Paper

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## Financial Contagion through Bank Deleveraging: Stylized Facts and Simulations Applied to the Financial Crisis

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**IMF Working Paper**

Research Department

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**Abstract**

The financial crisis has highlighted the importance of various channels of financial contagion across countries. This paper first presents stylized facts of international banking activities during the crisis. It then describes a simple model of financial contagion based on bank balance sheet identities and behavioral assumptions of deleveraging. Cascade effects can be triggered by bank losses or contractions of interbank lending activities. As a result of shocks on assets or on liabilities of banks, a global deleveraging of international banking activities can occur. Simple simulations are presented to illustrate the use of the model and the relative importance of contagion channels, relying on bank losses of advanced countries' banking systems during the financial crisis to calibrate the shock. The outcome of the simulations is compared with the deleveraging observed during the crisis suggesting that leverage is a major determinant of financial contagion.

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## I. INTRODUCTION

The collapse of Lehman Brothers in September 2008 triggered the worst financial crisis since the Great Depression. The crisis, which originated in the U.S. subprime mortgage-backed securities and collateralized debt obligations markets, was amplified by financial institutions' reliance on short-term funding to finance holdings of illiquid assets. It spread internationally through financial, trade and confidence channels, causing a sharp drop in global real GDP. The global contagion and macroeconomic effects occurred in spite of rapid, coordinated and large policy responses involving liquidity provisions, bailout packages, and fiscal stimulus in trillions of US dollars.

The purpose of this paper is twofold. First, we make use of a dataset from the Bank for International Settlement to present a set of stylized facts of international banking activities in the run-up to and during the financial crisis. Second, we illustrate how a simple model can be used to simulate contagion and amplification mechanisms of shocks affecting banks' balance sheets, and compare the outcome of the simulations with the retrenchment of international banking activities observed during the crisis.

In the years preceding the crisis, foreign claims of large international banks grew rapidly, reaching about 26 trillions of dollars at their peak in the first quarter of 2008, from less than 7 trillions in 2000 (Figure 1).<sup>2</sup> This process of financial integration was, to a large extent, the outcome of European banks' foreign activities – in particular as financial integration intensified within the Euro area. A large proportion of this internationalization of banking activities was performed by local affiliates, in particular in emerging markets where foreign banks increased their participation in domestic banking systems. This increased internationalization of banking activities in years preceding the crisis resulted in networks of bilateral exposures, particularly among advanced economies, and centered around the financial systems of the U.S. and the U.K. (Milesi-Ferretti et al., 2010, characterize bilateral gross and net external positions in various financial instruments; Cecchetti et al., 2010, develop a global map of banks' risk exposures)<sup>3</sup>.

The crisis, however, caused a global retrenchment of capital flows and a sharp reduction in the value of international banks' foreign claims (see for instance Milesi-Ferretti and Tille, 2010).<sup>4</sup> During the crisis, cross-border activities and interbank lending adjusted sharply, while local

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<sup>2</sup> Reporting countries included in Figure 1 are 12 reporting countries in Euro area, the UK, the US, and Japan (consolidated banking statistics on an immediate borrower basis, also described in the BIS Quarterly Review Table 2B). Foreign claims are defined as the sum of cross-border claims of international banks and claims of their local affiliates (in local currency or in foreign currency) on the residents of the host country.

<sup>3</sup> Kubelec and Sa(2010) characterize bilateral international banking networks during 1980-2005.

<sup>4</sup> Hermann and Dubravko (2010) characterize the impact of the crisis on emerging markets. See also various issues of the BIS Quarterly Review (for instance June 2009 issue).

activities of affiliates remained relatively more stable. Maturity and currency mismatches played a key role in this adjustment, as large holdings of illiquid US dollar assets were financed short-term on wholesale markets, with heavy reliance on cross-currency funding through FX swaps. These funding patterns resulted in significant stress in European banking systems when interbank and swap markets became impaired in the 4<sup>th</sup> quarter of 2008 (McGuire and von Peter, 2009). However, as the initial financial turmoil recedes, Euro area banks retain a dominant position in international activities not only in advanced countries, but also in emerging markets, notably in Central and Eastern Europe and in Latin America.

We construct a simple, tractable model to analyze and quantify the importance of contagion and amplification mechanisms of financial shocks in interconnected banking systems. We focus on two contagion and amplification channels of financial shocks identified in the recent literature. First, a *deleveraging channel*, whereby, following a negative asset shock, banks adjust the size of their balance sheet to maintain a minimum capital-to-asset ratio; second, an *interbank funding shock channel*, whereby liquidity funding shocks originating from within the interbank market and coupled with fire sales amplify initial losses and the deleveraging of banking systems.

We present illustrative scenarios of contagion and amplification of shocks calibrated on losses incurred during the crisis. We rely on data of gross cross-country bilateral exposures of international banks compiled by the Bank for International Settlements, to calibrate the network of bilateral cross-country gross exposures of banking systems.<sup>5</sup> We characterize the relative importance of each of the two amplification mechanisms in causing cascade effects and contractions of banks' balance sheets. We compare the outcomes of the illustrative scenarios with the actual flows observed during the crisis.

The main findings are as follows. First, a scenario involving only losses on the asset side of the banks and no amplification through liquidity funding shocks and fire sales produces a deleveraging of foreign banking activities of the same order of magnitude, and generally with the same direction, as the deleveraging observed during the crisis – which occurred in presence of policies involving massive injections of liquidity. Specifically, most of the simulated and actual contraction in international banks activities takes place among advanced economies, and has, in relative terms, smaller effects on emerging markets (even though the magnitudes are large). Orders of magnitudes are also very similar to the observed retrenchment of bank capital for the large emerging markets.

Second, among a number of emerging markets in Central and Eastern Europe, the observed deleveraging of foreign claims was smaller than predicted by the simulations.<sup>6</sup> The resilience of foreign banks' cross-border investments in these countries may have been the result of

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<sup>5</sup> Gross positions exclude inter-office claims in the Consolidated Banking Statistics as claims are compiled at the group level.

<sup>6</sup> McGuire and Tarashev (2008) show that deteriorating bank health in advanced economies generally leads to a decline in the growth of credit in emerging markets.

various policy initiatives. Such differences between simulated and actual cross-border claims are not observed in other regions, but local claims of affiliates remained generally stable in most emerging markets.

Third, scenarios adding interbank market liquidity funding shocks and fire sales to the baseline scenario show that such shocks can strongly amplify the deleveraging process initially caused by asset losses. With such funding shocks, the deleveraging process is amplified in a highly non-linear fashion and causes very costly adjustments to balance sheets. These simulations illustrate the key role for liquidity provisions and for other policy interventions in halting the downward spiral of deleveraging and drying up of liquidity.

The paper is organized as follows. Section II discusses the literature. Section III describes the data and stylized facts of international banking activities during the crisis. Section IV is devoted to the model. Section V presents the scenario analysis, and compares the simulations with actual capital flows during the crisis. Section VI concludes.

## II. LITERATURE

A growing literature has analyzed factors leading to accumulation of fragilities in the financial system during the boom, and to amplification mechanisms during the crisis. First, herding behaviors and coordination on common risks contributed to the increased fragilities of financial systems to downturn in housing markets (Accharya, 2009, Fahri and Tirole, 2009). The trigger – the bust of the housing bubble and the collapse in the value of mortgage-backed securities and collateralized debt obligations – and amplification mechanisms that culminated in the turmoil of 2008-2009 have been characterized in a number of recent papers (Adrian and Shin, 2010; Brunnermeier, 2009; Gorton, 2008; Gorton and Metrick, 2010; Krishnamurthy, 2010). This literature has identified two key amplification factors. First, negative shocks (such as marked to market losses) to levered financial institutions balance sheets can lead them to liquidate assets, thereby amplifying and transmitting the shock to other financial institutions or other agents. Second, the reliance of financial institutions on short-term wholesale funding made them vulnerable to liquidity shocks that could result from Knightian uncertainty regarding the value of a class of assets or assets of a counterparty; the interaction between margin calls and market liquidity amplifies the initial shock for institutions that are the more dependent on short-term financing.

Recent empirical studies have uncovered the importance of financial institutions short-term funding patterns and leverage in the transmission of the shock. Global banks financed levered holdings of illiquid US\$ assets by issuing short-term asset-backed commercial paper through conduits, and experienced losses when rolling over these ABCP became difficult in 2007 and 2008 (Acharya and Schnabl, 2010). This finding is consistent with more general evidence that banks more reliant on short-term funding or which had higher leverage before the crisis were more fragile (Demirguc-Kunt and Huizinga, 2000), and experienced sharper stock price decline and worse performance during the crisis (Raddatz, 2010; Beltratti and Stulz, 2010). Heavy reliance on short-term funds by international banks in turn resulted in stronger contraction of loan supply in emerging markets either directly or indirectly through funding

provided to local affiliates (Cetorelli and Goldberg, 2010).<sup>7</sup> Other studies have also assessed the extent of cross-border contagion through asset market prices (Balakrishnan et al, 2009).

Closer to this paper are studies relying on network analysis to analyze implications of financial integration for the stability of the international financial system.<sup>8</sup> Recent papers have quantified financial contagion channels across countries by modeling cascades of bank defaults resulting from gross bilateral country exposures (recent papers include Degryse et al, 2008; Espinosa-Vega and Sole, 2010; Gai and Kapadia, 2010). In contrast to these papers, our model does not require the failure of banking systems to generate the transmission of shocks and contraction of financial institutions' balance sheets. The only assumption needed is that banks maintain a target minimum leverage ratio. Moreover, our model also illustrates how shocks can spread across countries through common lender effects as banks reduce their exposures to various borrowers, when experiencing losses originating from non-performing securities or loans, or from sudden increase in the cost of interbank funding.

### III. STYLIZED FACTS: INTERNATIONAL BANKING DURING THE CRISIS

#### A. Data

The main data source is the Consolidated Banking Statistics of the Bank for International Settlement compiled and published on a quarterly basis. This dataset provides information on the bilateral gross holdings of claims on non-residents by nationality of banks, consolidated at the banking group level, excluding inter-office claims, and reported aggregated at the country level.<sup>9</sup> There are two versions of the data (we will mostly rely upon the second version). The first version, on an immediate borrower basis, includes a breakdown by type of claims: (i) international claims (which comprise direct cross-border claims and local claims of affiliates in foreign currency); and (ii) local claims of affiliates in domestic currency. While the first version provides sector breakdown (banks, non-bank private sector, public sector and unallocated by sector) of international claims only, the second version includes a breakdown of foreign claims by sector of ultimate borrower : (i) public sector; (ii) private non-bank sector, and (iii) banks.; and a breakdown by type of foreign claims: cross-border claims and local claims.

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<sup>7</sup> More generally, there is also evidence of the transmission of liquidity shocks across borders by US financial institutions in periods of U.S. monetary tightening (Cetorelli and Goldberg, 2008).

<sup>8</sup> Seminal theories include the model of contagion in interbank markets developed by Allen and Gale (2000).

<sup>9</sup> A description of the BIS Consolidated Banking Statistics can be found at: <http://www.bis.org/statistics/consstats.htm> . see also McGuire and Tarashev (2008) for use of the data. There are two versions of the database: (i) foreign claims on an immediate basis, and (ii) foreign claims on an ultimate basis. In the former consolidated balance sheet data are aggregated by residency of the immediate borrower, and the latter by residency of the party ultimately responsible for the claims in case of default. Note that cross-border claims of foreign affiliates of reporting country banks vis-à-vis residents on of the parent country in question are not reported as bilateral foreign claims (for example, claims of UK affiliates of German banks on German residents are not recorded in the total foreign claims of German banks).

We complement this main database with a variety of other sources. First, we rely on data from the BIS Locational Banking Statistics which provides information on unconsolidated bilateral *capital flows and external positions of banks (of domestic and foreign banks located in a reporting country)* on a residency basis, and the same data are aggregated and presented by *nationality* of banks.<sup>10</sup> The main advantage of the Locational data is that quarterly flows are adjusted for exchange rate movements, thus allowing to compute accurate estimate of gross capital flows. However, this dataset does not include exposures of local affiliates to residents of a particular country; hence it provides only an incomplete snapshot of gross exposures at any point in time. We will use this data to compare the outcome of our simulations with actual exchange rate adjusted gross cross-border flows. Second, bank level consolidated balance sheets, including total assets, bank capital and wholesale funding are from Bankscope. The bank level balance sheet data, covering large international banks only, are next aggregated at the country level.<sup>11</sup>

## B. Stylized Facts

According to Figure 1, the fast rise of international banking activities after 2000 was to large extent the result of the diversification of Euro area banks' foreign activities – particularly French banks – and of British banks.<sup>12</sup> Between 2000 and the peak of March 2008, the *value* of foreign claims of French banks, of other Euro-area banks (excluding German banks and French banks) and of British banks grew respectively by about 425 percent, 420 percent and 330 percent, catching-up with German banks' dominant position.<sup>13</sup> Comparatively, US and Japanese banks' foreign activities expanded at a much slower pace during the same period.<sup>14</sup> During the crisis, the adjustment in the value of foreign claims was also more severe among Euro area and UK banks than among their US or Japanese peers.<sup>15</sup>

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<sup>10</sup> Locational statistics of international positions by nationality of banks are publicly available at <http://www.bis.org/statistics/bankstats.htm> ( Table 8).

<sup>11</sup> Internationally active banks are usually a handful of large banks in each country. For example, our sample includes, for the UK: Lloyds, HSBC, Barclays and Royal Bank of Scotland; for the US: Citigroup, Bank of America, Wells Fargo and Co., and JP Morgan Chase; for France: BNP Paribas, Credit Agricole SA, Societe Generale and Groupe Caisse D'Epargne; and for Germany: Deutsche Bank, Commerzbank, Landesbank Berlin, Deutsche Postbank, LBBW, Bayerische LB, and Sparkassen-Finanzgruppe Hessen-Thuringen; for Switzerland: UBS and Credit Suisse.

<sup>12</sup> The BIS consolidated banking statistics on an immediate borrower basis do not include off-balance sheet claims. This implies that the true expansion of international banking activities that took place in the years preceding the crisis is likely to be underestimated. However, the ultimate risk basis dataset (which was first compiled in 2005) includes a category “other exposures” covering on and off-balance sheet credit derivatives.

<sup>13</sup> These figures do not adjust for valuation effects due for instance to exchange rate fluctuations.

<sup>14</sup> See also McGuire and von Peter (2010).

<sup>15</sup> The increase in the stock of foreign claims of US banks between Q4 of 2008 and Q1 of 2009 reflects the inclusion of new reporters (the former investment banks).



Figure 2 presents a snapshot of the composition of these foreign claims between cross-border claims and local claims of affiliates as of June of 2009 from BIS consolidated ultimate risk statistics. It shows that a large share of international banks' activities are performed by local affiliates, with local claims accounting for about half of foreign claims for most internationally active banks – with the exception of Japanese banks with less than 20% local claims.<sup>16</sup> Moreover, the dominant and growing role of Euro-area banks in international banking is to a large extent explained by intra-Euro area financial integration, as about 40 percent of Euro area banks foreign claims are claims on residents of other Euro-area countries.<sup>17</sup>

Figure 3 presents the evolution of the *value* of foreign claims by region of host countries (unadjusted for valuation effects), and by type of claims, between the second quarter of 2005 and the end of the first semester of 2009.<sup>18</sup> The bulk of the international banking activities clearly takes place among advanced economies. However, until June of 2008, the percent increase in the US\$ value of foreign claims was particularly large in Central and Eastern European countries (about 190 percent), and in Asia and Latin America (by about 80 percent). The composition of claims also differs according to the destination of these claims. In advanced countries, cross-border liabilities account for about 60 percent of total foreign liabilities to international banks; in contrast, in emerging markets, they account for at most 40 percent of total foreign liabilities. This asymmetry in the structure of international banking activities between advanced economies and emerging markets reflects the surge in FDI in banking and penetration of local markets by foreign banks that started in emerging markets after the Asian crisis, and also as a result of the convergence process in Central and Eastern European countries.<sup>19</sup>

What are the main bilateral gross exposures to the main regions for the 4 main groups of international banks (Figure 4)? Euro area banks clearly account for most of the claims on advanced economies (both among European Union countries, and vis-à-vis the U.S.), on Central and Eastern European countries, but also on Latin America (mainly because of the large presence of Spanish banks' affiliates). In contrast, claims on Asian countries are more evenly distributed between US, Japanese, British and Euro area banks (with a higher proportion of cross-border claims for Euro area banks than for US or British banks).

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<sup>16</sup> See Mc Cauley, Mc Guire and von Peter (2010) for a more detailed characterization of the global business models of large internationally active banks.

<sup>17</sup> BIS reporting countries included in these figures are: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands and Spain.

<sup>18</sup> We follow a definition of regional groups consistent with the IMF vulnerability exercise classification (see Appendix Table A2). Several countries, sometimes classified as emerging markets, appear among advanced economies (for example Hong-Kong, Korea, Singapore, the Slovak Republic, and Slovenia).

<sup>19</sup> Spanish banks, in particular, follow such a decentralized model, with about 60 percent of their foreign assets and liabilities booked locally (Mc Cauley, MC Guire and von Peter (2010)).

Snapshots of the bilateral *composition* of gross exposures among international banks are reported in Table 1 and in Figure 5. Each line presents, for each country of nationality of international banks, the share of bilateral gross exposures of international banks by country of residence of borrowers, for the countries.<sup>20</sup> For example, the first line shows that 34.21 percent of British banks' foreign claims are claims on US residents, 6.47 percent on French residents, and 5.11 percent claims on German residents. Perhaps not surprisingly, the U.S. remains the main foreign market for British, Japanese, Swiss, French, Dutch and German banks, by decreasing orders of magnitude. In contrast, Spanish and Italian banks have large claims respectively on the U.K. and Germany, but relatively smaller exposures to the US. French and German banks also have large claims on Southern European countries (combined claims on Spain and Italy reach respectively 18 percent and 12 percent of total foreign claims). Figure 5 presents a similar network of exposures, when considering interbank claims only.<sup>21</sup> In this figure, the arrow width is proportional to the bilateral claims, with the arrow pointing in the direction of the claim, and the circle for each host country is proportional to its total foreign interbank claims and liabilities. It highlights the central role of the U.K. in interbank markets, presumably a reflection of the large claims of foreign-owned banks on other banks residing in London.

What happened to international banks' balance sheets and foreign claims during the crisis? Table 2 shows the evolution of simple leverage ratios (defined as the ratio of total bank capital to total assets) aggregated at the country level. Two simple facts emerge from this table. First, in 2007, banks from countries that were significantly exposed to US structured products (such as banks from Belgium, Germany or Switzerland) were also significantly levered.<sup>22</sup> Second, by the end of 2009, capital-to-asset ratios significantly improved in particular for Austrian, Belgium, French, Swiss and US banks. Two factors could explain these improvements: increase in capital (through recapitalization by governments, or through increased retained earnings), and deleveraging.

Some deleveraging of foreign activities of international banks took place during the crisis. Table 3, which shows the evolution of the value of foreign claims by region of borrowers, suggests that some deleveraging may have taken place in advanced countries, but also in emerging markets. It also shows that the deleveraging was more pronounced for interbank claims and also for cross-border claims, in particular among advanced economies.<sup>23</sup> In

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<sup>20</sup> We select only the countries with the 10 largest stocks of foreign assets and liabilities as of Q1 of 2009.

<sup>21</sup> Consolidated banking statistics do not include (1) inter-office claims and (2) claims on resident of respective reporting country. Hence, these claims are not included in the bilateral exposures reported in Table 1 and Figure 5.

<sup>22</sup> These measures exclude off-balance sheet activities, such as conduits, and therefore understate the true extent of leverage before the crisis (Acharya et al., 2010, provide evidence showing that banks used conduits to maximize leverage and evade capital requirements).

<sup>23</sup> For some banks (in particular French, British and Japanese banks), most of the reduction in their foreign claims between March of 2008 and June of 2009 was accounted for by interbank claims. In contrast, it accounted for about one third of German banks' deleveraging. See also Mc Cauley, MC Guire and von Peter (2010).

contrast, local claims remained generally more stable –local currency claims are often funded locally – while holdings of government bonds hardly declined, except in some Latin American countries. Claims on the non-bank private sector declined the most in advanced economies and in Central and Eastern European countries.

#### IV. MODEL OF FINANCIAL CONTAGION

We consider a stylized model of financial contagion emphasizing the transmission of shocks through bank deleveraging. The key behavioral hypothesis is that banks maintain a target minimum asset-to-capital ratio and sell off securities or cut their lending when the minimum leverage ratio becomes binding. The resulting deleveraging transmits the shock to other countries or banking systems. Further amplification occurs if the deleveraging causes additional losses (for instance as a result of fire sales). Furthermore, when a banking system fails, it triggers additional losses to creditor banks and causes additional rounds of deleveraging. The system converges when no banking system deleverages further. The complete financial contagion process results in: (a) a set of losses of national banking systems; and: (b) a combined reduction in foreign claims of all international banks on each borrowing country resulting from the deleveraging process.

Consider the stylized balance sheet of banking system  $i$  given by:

$$Assets_i = Capital_i + Other\_Liabilities_i \quad (1)$$

$$\text{Where: } Assets_i = \sum_j Foreign\_Assets_{ij} + Domestic\_Assets_i \quad (2)$$

$$\text{And: } Other\_Liabilities_i = Retail\_Deposits_i + Wholesale\_Funding_i \quad (3)$$

Where  $Foreign\_Assets_{ij}$  are total claims (loans, deposits, and securities) of banking system  $i$  on residents of country  $j$ . Wholesale funding is given by:  $Wholesale\_Funding_i = \sum_k Interbank_{ik} + Other_i$ , where  $Interbank_{ik}$  is interbank lending from banking system  $k$  to banking system  $i$ , and  $Other_i$  are other sources of wholesale funds, such as money market funds.<sup>24</sup>

The key behavioral assumption is that banks maintain a minimum capital-to-asset ratio:

$$\frac{Capital}{Assets} \geq CAP$$

This capital-to-asset ratio could reflect regulatory constraints (as is the case for bank holdings companies in the U.S.). Or it could be interpreted as the minimum capital to asset ratio below which wholesale markets demand a substantial premium to provide funding to a bank (this

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<sup>24</sup> Our use of consolidated data at the bank level implies that we are excluding inter-office lending and lending to resident of respective reporting country (remark: banks of the same nationality is only true in ultimate risk data and this follows from the fact that claims on residents of respective reporting country are not included) ..

would be the case if a low capital to asset ratio was perceived as an indication of fragility and excessive risk taking). Anticipating such market response, banks would avoid high leverage.<sup>25</sup>

### Asset Shocks

Consider a set of losses of banking system  $i$  on its foreign assets, where the aggregate reduction in the value of assets is given by:

$$Loss_i = \sum_j l_{ij} \times Foreign\_Assets_{ij} + l_{ii} \times Domestic\_Assets_i \quad (4)$$

Where  $l_{ij}$  is the loss rate on the claims of banking system  $i$  on residents of country  $j$ . These losses could be caused by marked-to-market losses on securities held in trading books, haircuts in repos transactions, or write-offs of non-performing loans or securities.

Foreign claims on each country  $j$  are broken down by sectors:

$$Foreign\_Assets_{ij} = Claims\_Public_{ij} + Claims\_PrivateNBank_{ij} + Interbank\_Claims_{ij}$$

Where  $Claims\_Public_{ij}$ ,  $Claims\_PrivateNBank_{ij}$ ,  $Interbank\_Claims_{ij}$  are respectively claims on the government, on the private non-bank sector, or on banks. If the shock is large enough and the leverage constraint becomes binding, the banking system can rely on a combination of deleveraging  $DEL_i$  and recapitalization  $Recap_i$  to restore the capital-to-asset ratio:

$$Capital_i - Loss_i + Recap_i = CAP \cdot (Assets_i - Loss_i - DEL_i) \quad (5)$$

Hence, the total deleveraging by banking system  $i$  is given by:

$$DEL_i = \sum_j del_{ij} = Assets_i - Loss_i - \frac{1}{CAP} \cdot (Capital_i - Loss_i + Recap_i) \quad (6)$$

(6)

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<sup>25</sup> Ideally, to interpret the minimum capital to asset ratio as a regulatory constraint, we should use a measure of risk weighted assets, to be able to define this minimum threshold as the regulatory capital adequacy ratio, or the Tier 1 ratio. Since the crisis, however, leverage has been identified as a valuable proxy for risk taking during booms (Adrian & Shin, 2009). Moreover, before the crisis, most large financial institutions appeared well capitalized from a regulatory perspective, even when they were significantly fragile, suggesting that regulatory capital ratios were not correctly capturing risk taking, as they do not capture off-balance sheet risk exposures through conduits and other special purpose vehicles, and because risk weights were not necessarily reflecting the true riskiness embedded in some investments (such as mortgage backed securities and other derivatives). See McGuire and Tarashev (2008) for an attempt at stress testing by assigning risk weights to bilateral foreign claims.

A particular case is when a banking system  $k$  becomes insolvent:  $Capital_k \leq Loss_k$ . We assume that, in absence of recapitalization, the banking system deleverages on all of its assets, and defaults on all its liabilities. Such a default triggers additional losses for other banking systems  $i$  holding interbank claims on banking system  $k$ :

$$Loss_{ik} = l_{ik} \times Interbank\_Claims_{ik} \quad (7)$$

This, therefore, causes additional rounds of deleveraging. The process of deleveraging converges when no additional banking system fails and all surviving banks have restored their desired leverage ratio given losses incurred.<sup>26</sup>

For each host country  $j$ , the reduction of foreign liabilities to international banks is given by:

$$DEL_j = \sum_i Del_{ij} \quad (8)$$

### **Amplification through Interbank Lending and Fire Sales**

Following a shock on its assets, the banking system of country  $i$  reduces its foreign claims on all debtor countries, including existing credit lines to foreign banking systems. Assume that banking system  $j$  loses its credit lines from country  $i$  and therefore experiences a *funding shock of size*  $Y_j$ . For example, assuming each banking system  $i$  deleverages proportionally across all sectors, the funding shock experienced by  $j$  is given by:

$$\Delta Wholesale\_Funding_j = \sum_i \frac{Interbank_{ij}}{Foreign\_claims_{ij}} \times Del_{ij}$$

The extent to which this funding shock causes additional deleveraging by banking system  $j$  depends on its ability to substitute other sources of funds for its lost interbank credit line  $Y_j$ . Other sources of funds would include retail deposits, other wholesale funds, or central bank facilities. Assume that the two last sources of funds are not available and that the likelihood to which alternative funding can be obtained depends on the share of retail deposits in banks' total liabilities. Specifically, we assume that the marginal share of retail deposits in funding is equal to the average share in total liabilities. Formally, for every 1\$ loss of wholesale funding, banking system  $j$  can offset  $x \times 1\$$  by raising additional deposits, but has to liquidate assets of value  $(1 - x) \times 1\$$ , where  $x$  is the share of retail deposits in total liabilities.

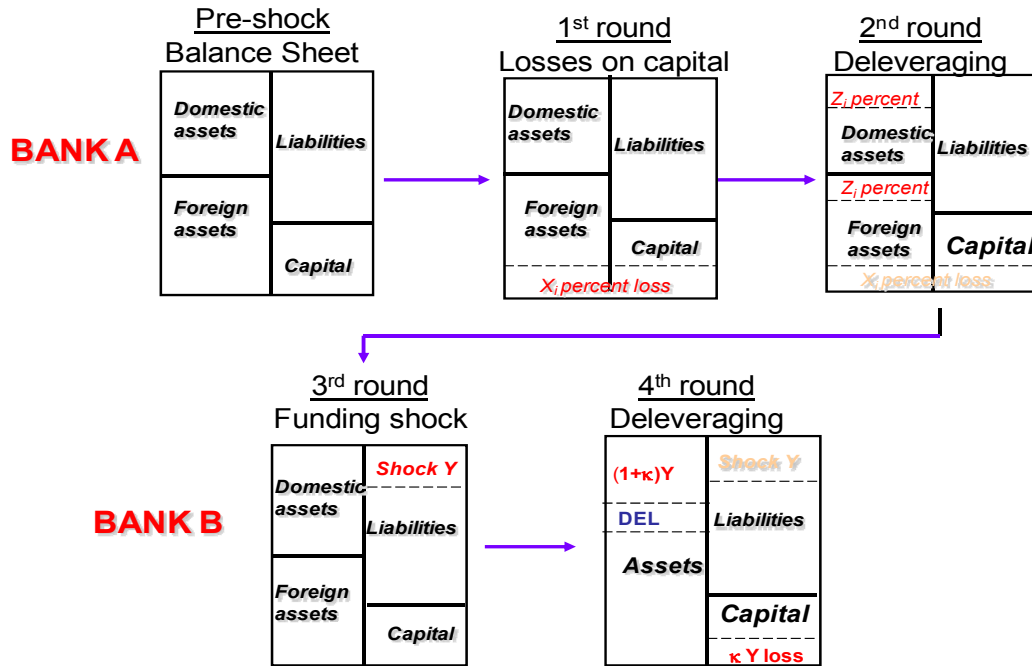
When liquidating assets of value  $(1 - x) \times 1\$$ , the banking system incurs a loss of  $\kappa_j$  per 1\$ of assets liquidated. Losses are absorbed by bank capital and may cause additional deleveraging  $DEL'_j$  if the leverage ratio falls below the threshold  $CAP$ , according to:

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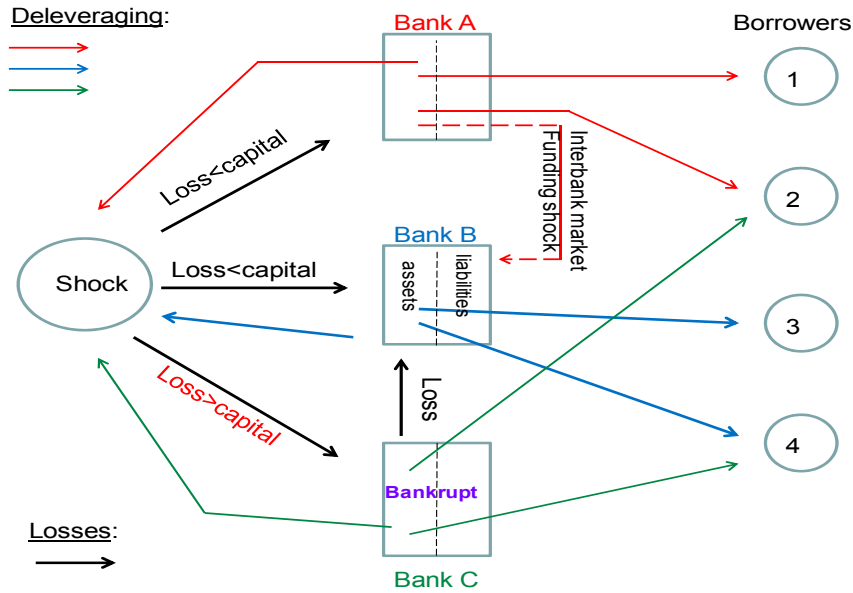
<sup>26</sup> The process of deleveraging can be further amplified by assuming additional losses when assets are sold on short notice (fire sales).

$$Capital - \kappa \cdot (1 - x) \cdot Y = CAP \cdot (Assets - (1 + \kappa) \cdot (1 - x) \cdot Y - DEL'_j) \quad (9)$$

**Figure 6. Effect of an Asset Shock and a Funding Shock on Bank Balance Sheet**



**Figure 7. The Complete Deleveraging Process**



### Deleveraging Assumptions

The simulations assume that deleveraging occurs whenever the capital to asset ratio falls below a given threshold, implying that deleveraging is possible even if banks' equity is not entirely wiped out by the shock. To pin down the bilateral deleveraging  $Del_{ij}$  between home country  $i$  and host country  $j$ , additional assumptions are needed.

#### (1) Proportional Deleveraging

The simplest approach and our baseline assumption is that the deleveraging is equally spread over all domestic and foreign assets of country  $i$ 's banking system.

The proportional deleveraging rule of country  $i$  in country  $j$  is given by:

$$Del_{ij} = DEL_i \cdot \frac{Claims_{ij}}{Claims_i} \quad (10)$$

where  $Claims_{ij}$  is total foreign claims of country  $i$ 's banking system on country  $j$  and  $Claims_i$  is total foreign claims of country  $i$ 's banking system on all countries. Other deleveraging rules can also be considered.

#### (2) Direct Cross-border Lending versus Lending through Local Affiliates

Foreign activities of international banks are often performed by their local affiliates, either subsidiaries or local branches, and local claims in local currency are often funded locally via residents' deposits. Such funding patterns would limit the transmission of shocks from the

parent bank. However, international transmission still occurs as parent banks adjust their credit lines to affiliates when experiencing shocks in the home market (Cetorelli and Goldberg, 2008). We allow for a different adjustment depending on the nature of the claim of country  $i$  on country  $j$  (whether these claims are direct cross-border claims, or local claims on residents of country  $j$  by bank affiliates), according to a modified version of equation (10):

$$Del_{ij}' = DEL_i \cdot \frac{(Cross\_Border\_Claims_{ij} + \lambda_i \cdot Local\_Claims)}{Claims_i} \quad (11)$$

Where:  $0 < \lambda_i < 1$ .<sup>27</sup>

## V. SIMULATED AND ACTUAL DELEVERAGING DURING THE FINANCIAL CRISIS

Our model allows us to gauge the importance of the various contagion channels highlighted in the literature and described in the theory section. We perform three simple illustrative simulation exercises, and compare the outcome of these exercises with the actual deleveraging observed during the crisis.

We rely on the gross bilateral exposures of international banks as of Q1 of 2008, and simulate the impact on banks' balance sheets of shocks to their holdings of US mortgage-backed securities.<sup>28</sup> Specifically, we assume that the entire holdings of MBSs are written-off.

We consider three scenarios. First, we consider a *deleveraging-only* scenario (the baseline scenario), under which the only contagion channel is the deleveraging that takes place as a result of the initial loss on banking assets. The implicit assumption in these simulations is that policy responses to the initial shock perfectly offset additional liquidity funding shocks in wholesale funding markets. In the formulation of the model (equation (9)), this implies  $x = 100$  percent). This allows isolating the cross-border contagion effects arising only from bank deleveraging.<sup>29</sup>

Second, we simulate a set of scenarios (presented as deviations from the baseline scenario) including *liquidity funding shocks*. The assumptions are that, for each 1\$ reduction in interbank lending, a banking system replaces  $x$ \$ by raising deposits (where  $x$  is the share of

<sup>27</sup> This parameter lambda reflects the extent to which affiliates are able to offset a shock transmitted by the parent firm, for instance by raising funds locally.

<sup>28</sup> There were some classification errors for Swiss banks fixed only in Q4 of 2009 (See BIS Quarterly Review, June 2010). This has no significant effects on our main results.

<sup>29</sup> Of course, we know that, in practice, wholesale markets became impaired during the crisis. However, there were also massive and coordinated liquidity injections by central banks. A possible interpretation of the scenario is that the actual funding shock *cum* policy responses was far smaller than the liquidity funding shock that would have taken place in absence of policy response.



retail deposits in total liabilities) and reduces its assets by  $(1-x)\$$  (either by selling securities, or by calling off short-term loans), causing additional losses of 10, 20 or 40 cents by dollar of asset liquidated. These scenarios illustrate how the initial shock would be amplified in absence of policy responses that would mitigate funding shocks in the interbank market resulting from the initial deleveraging.

Lastly, as an alternative to the deleveraging-only scenario, we consider a scenario in which the initial shock affects banks liabilities instead of bank assets. Specifically, we consider a *pure funding shock* scenario whereby the cost of interbank funds rise by 500 basis points for all banks.<sup>30</sup> This scenario provides an estimate of the deleveraging that would have occurred in presence of funding shocks only (and in absence of any write-offs). We augment this scenario by also considering amplification through fire sales causing an additional loss of 10 percent per dollar of asset liquidated.

The two sets of key assumptions for the simulations include the initial shock and the minimum capital to asset ratio of banking systems. The main source of information for the loss estimates is the fiscal estimates of recapitalization agreed upon during the first Semester of 2009 (from IMF, 2009), complemented by estimates of exposures to US MBS (from the Treasury TIC) for some countries. The total initial shock to the global financial system reaches \$670 billion, or 2.3 percent of total foreign claims of international banks at the end of the first quarter of 2008 (losses of banking systems are reported in Table A1). As expected, countries most exposed to the shock are, in absolute terms and decreasing order, the U.S., the U.K., Germany, Switzerland, Belgium and Dutch banks. Next, we assume that international banks start deleveraging when their capital-to-asset ratio falls below 4 percent. Some downward adjustments are assumed for German, French and Swiss banks (to a minimum capital-to-asset ratio of 2.25-2.75 percent), because of the high initial leverage of these banks, and an upward adjustment to 5 percent is applied to US banks.<sup>31</sup> Initial leverage ratios are reported in Table 2.

### **A. Scenario 1: Cross-border Contagion through Deleveraging**

The simulated deleveraging by banking system is reported in column 1 of Table 4. The total simulated reduction in foreign claims of international banks reaches US\$ 3,076 billion, about 5 times the size of the initial shock. The simulation reported in column 1 shows a large deleveraging of foreign assets by Belgium and Swiss banks (about 30 percent of foreign assets), followed by British and German banks (with deleveraging of respectively 24 percent and 21 percent), US and Dutch banks (13 percent), and French banks (10 percent).

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<sup>30</sup> This is the order of magnitude of the shock experienced by banks at the time of the collapse of Lehman Brothers.

<sup>31</sup> A leverage ratio of 5 percent corresponds to the minimum for a US bank holding company to be considered well capitalized by the Fed.

The actual reductions in (unconsolidated) international claims of banks by nationality are reported in column 2 to 5 (fourth quarter of 2008, the cumulative deleveraging Sept 30<sup>th</sup> 2008-June 30<sup>th</sup> 2009, and second half of 2009).<sup>32</sup> The simulation results appear slightly on the high side relative to the deleveraging observed between September of 2008 and June of 2009. However, the ranking of countries is correct, and the simulation outcome is close to the actual outcome for Belgium (-37 percent) and Dutch banks (-12 percent).<sup>33</sup> The observed reduction in foreign assets was also large for Swiss (-19 percent) British (-16 percent), and Germany banks (-13 percent), but it was significantly smaller for French banks (-2 percent). However, in the second half of 2009, even after markets had stabilized, Belgium banks (-6 percent), German banks (-4 percent), Dutch banks (-6 percent), Swiss banks (-10 percent), but also for Danish banks (-12 percent) and Italian banks (-4 percent) continued to reduce their international claims. The reduction in international claims included a significant reduction in inter-office credit lines between headquarters of international banks and their affiliated offices in host countries, consistent with the hypothesis that the shocks were transmitted across borders to local affiliates through internal capital markets (column 5).<sup>34</sup>

Table 5 reports the simulated reduction in foreign liabilities by region of host country, as well as several estimates of the reduction in foreign bank liabilities between Sept 30<sup>th</sup> 2008 and June 30<sup>th</sup> 2009 (country-by-country results are reported in the appendix). Two sets of statistics are reported: a simple country average in percent of 2008 GDP, and the aggregate deleveraging by region and in US\$.

Two main findings emerge from the simulations (columns 1 to 4). First, the deleveraging is the strongest among advanced economies, a consequence of the strong financial integration described in section III. In aggregate, the total contraction in foreign claims of international banks reaches US\$ 2.6 trillion among advanced economies, about four times the initial shock. The advanced economies that are the most affected, in percent of their 2008 GDP, are Iceland, Ireland, the U.K, and the Netherlands. The deleveraging is also large in Austria, Belgium and Greece. However, in absolute terms, the deleveraging by foreign banks is the largest in the US (US\$ 680 billion), the UK (US\$ 480 billion), and also in France, Italy and the Netherlands.

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<sup>32</sup> Exchange rate adjusted changes in total international claims are from the BIS Locational Statistics, Tables 8a and 8b. Local claims in local currency on residents of host countries are therefore not included in these figures, which however include claims on affiliates. Column 4 reports percent changes in claims on related offices. Claims on related offices account for about 45 percent of total international assets of US banks, and about 30 percent of international assets of French and German banks. The BIS locational statistics report quarterly exchange rate adjusted flows, based on which we compute quarterly rate of change in flows. Rate of change over longer periods are simply compounded rates of change, which therefore correct for quarterly exchange rate movements.

<sup>33</sup> A large part of the decline in these claims is explained by the break-up of Fortis and ABN Amro that resulted from their large exposures to toxic assets. In principle, a break-up of a bank and sale of assets to another entity can be seen as a form of deleveraging. Belgium and the Netherlands do not have a key impact on the aggregate deleveraging.

<sup>34</sup> See Cetorelli and Goldberg (2010) for empirical evidence.

Second, the total deleveraging among emerging markets is one order of magnitude smaller than among advanced economies, at US\$ 240 billion. But some countries, in particular in Central and Eastern Europe, experienced significant contractions of foreign banks activities. Other emerging markets are much less affected, mainly because of smaller foreign liabilities to banks affected by the initial shock.<sup>35</sup> Countries significantly affected by the deleveraging process in percent of their GDP include the Czech Rep, Hungary, Croatia, Slovenia, Slovakia and Bulgaria. This reflects their exposures to Germany (Croatia, the Czech Republic, Hungary), Belgium (Slovak rep., the Czech rep.), or Switzerland (Bulgaria). In absolute terms, the predicted deleveraging is the largest in Russia, Poland, the Czech Rep., and Brazil (at around US\$ 25 billion).

The reduction in bilateral foreign claims of international banks observed during the crisis is broadly consistent with the outcome of the simulations. During the crisis, the actual deleveraging was large among advanced countries, as the value of total *consolidated* foreign claims of international banks fell significantly, by US\$ 2.1 trillion. The actual contraction in cross-border banking claims on non-residents (including claims on affiliated banks) and after adjusting for exchange rate movements, reached US\$2.4 trillion.<sup>36</sup> Results are also broadly consistent with the simulations at the country level. Countries experiencing the largest outflows of banking claims, in percent of their GDP, were Iceland, Belgium, the Netherlands, Switzerland, and the UK.<sup>37</sup> In absolute terms, the contraction in cross-border bank capital inflows were the largest for the UK (US\$630 billion) and the US (US\$ 490 billion), while the value of liabilities to foreign banks fell by US\$ 825 billion for the US and US\$325 billion for the UK. Local claims in local currency of affiliated banks remained more stable, with the exception of the US where they fell sharply (by around US\$ 500 billion).

In emerging markets, cross-border claims of international banks (including claims on affiliated banks) fell by US\$280 billion, while local claims in local currency of their affiliates remained broadly stable in all regions. In absolute terms, the reduction in unconsolidated cross-border claims of international banks was the largest for the large emerging markets

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<sup>35</sup> The finding that, among emerging markets, CEE countries are the most affected by the deleveraging is robust to assuming a limited (20 percent) pass-through of the shock to local affiliates of international banks. This suggests that other emerging markets (for instance in Latin America) were relatively insulated from the shock not only because of the *composition* of foreign claims (as claimed by many observers), but also because they had significantly lower *total* liabilities to foreign banks than CEE countries. Indeed, as discussed in section III, the composition of foreign claims (between local claims and cross-border claims) was broadly similar in CEE countries and in Latin America.

<sup>36</sup> Consolidated data netting out interoffice claims are appropriate to gauge the exposure of national banking systems to residents of other countries, and to assess the overall impact of the deleveraging on the local economy. However, in absence of information on the currency composition of foreign claims, we can only consider changes in stocks, which are the total of flows and valuation effects (the valuation effect caused by exchange rate movements can however be netted out of local claims of affiliates in local currency). In contrast, residency basis data from the locational banking statistics are adjusted for valuation effects, but do not net out inter-office claims on affiliates located in host countries.

<sup>37</sup> Because Iceland experienced a severe financial crisis in 2008, the simulations largely underestimate the reduction of foreign banks' claims on Iceland.

(Russia, China, India, Indonesia, Turkey and Brazil), and of similar order of magnitudes as in the simulations. However, while significant, reversals in bank capital inflows were significantly lower than in the simulations in a number of CEE countries and reached 5 percent of annual GDP in only a few countries (Latvia, Estonia) –in spite of large external imbalances in some of these countries. Policy initiatives – the Vienna initiative (and moral suasion by host country central banks), EC financing and IMF programs (such as in Hungary) – probably explain why foreign banks’ presence was successfully stabilized at the height of the crisis. Such differences between simulations and actual cross-border flows are not observed in other emerging market regions.

## **B. Scenario 2: Amplification of the Shock through Interbank Markets**

We now turn to the analysis of the interbank market amplification mechanism. The underlying assumption is that there is no liquidity provision by central banks that would offset funding shocks.

Allowing for liquidity funding shocks in the simulations shows how losses are built up in the system when the interbank market becomes impaired and when a lender of last resort is not providing liquidity. Second, it shows how the deleveraging and contraction of capital flows are amplified by multiple rounds of stress in the interbank market. To assess this amplification mechanism, we assume that assets sold as a result of liquidity funding shocks incur a loss of 10 percent, 20 percent or 40 percent per each dollar of assets liquidated.

The outcome of the simulations, reported in Table 6, shows that the interbank market amplification mechanism is highly non-linear and can be very strong depending on the extent of fire sale losses. The losses eventually incurred by banking systems are highly non-linear because multiple rounds of contraction of interbank gross claims result in accumulation of losses in banking systems. With 10 percent fire sale haircut, the additional losses remain relatively small and below 1 percent of GDP for all banking systems with the exception of the Irish banking system. With 20 percent fire sale haircut, final losses increase sharply and become significant for a group of European banking systems including the U.K., Ireland and the Netherlands. With 40 percent fire sale haircut, eventual losses become large and exceed or are a multiple of the initial shock for many countries (including in particular Belgium, Denmark, France, Ireland, the Netherlands, Spain, Switzerland and Spain).

Table 7 shows that, as a consequence of multiple rounds of liquidity funding shocks, the contraction in foreign claims of international banks would become staggering. For advanced economies the reduction in gross foreign claims would for instance reach, on average, an additional 12 percent of GDP with 20 percent fire sale losses, and 65 percent of GDP with 40 percent fire sale losses. These simulations illustrate how liquidity funding shocks strongly amplify small perturbations in the international financial system and can cause high losses and a collapse of international banking activities.

During the crisis, large, rapid and coordinated injections of liquidity took place. How does the magnitude of interbank market stress predicted by these simulations compare with actual liquidity provision during the crisis? The first round of deleveraging results in a total

reduction in gross interbank claims of 1,580 billion US\$, affecting first Euro area banks, followed by US and British banks (Table 8). After multiple rounds of deleveraging, and 20 percent fire sale losses, the reduction of interbank claims would be about 70 percent higher.

**Table 8. Predicted Reduction in Interbank Claims**

<i>Reduction in interbank claims (US\$ bil.)</i>	<i>First round</i>	<i>20 percent loss</i>
All countries	1,580	2,740
Euro area	640	1,130
US	240	410
UK	200	365
Japan	40	64

As a comparison, at the onset of the financial crisis in the 4th quarter of 2008 and the 1<sup>st</sup> quarter of 2009, liquidity provision by the ECB, the Fed and the Bank of England reached about US\$ 2,200 billion; with US\$ 1,150 billion provided by the ECB (US\$ swaps and Long-Term Refinancing Operations), US\$ 600 billion by the Fed, and US\$480 billion by the Bank of England.

### C. Scenario 3: Pure Liquidity Funding Shock

Lastly, we compare the baseline scenario in which banks experience losses on their assets with a scenario in which banks experience only liquidity funding shocks. The initial losses caused by the interbank market funding shock are reported in Table A1, and are somewhat smaller (US\$ 420 billion) than in the baseline scenario.<sup>38</sup> There are country-specific differences too: US, Belgium, German and Swiss banks experiences smaller losses, while Italian and Spanish banks experience higher losses, as a result of the increase in funding costs. Generally, this scenario has a weaker fit to the data than the baseline scenario.

Table 9 reports, region by region, the average deleveraging in percent of host country GDP, and the aggregate deleveraging in US\$. The figures reported in the table are expressed in deviation from the baseline scenario (scenario 1). Two conclusions can be drawn from this analysis. First, the deleveraging caused by the increase in funding costs is somewhat smaller than in the baseline scenario (by around 10 percent), in particular in advanced economies and in emerging markets. Among advanced economies, the pure funding shock scenario results in significantly smaller reduction in foreign banks' claims for the US (US\$315 billion), the UK (US\$ 111 billion), Japan (US\$47 billion) and France (US\$ 26 billion). Brazil (US\$ 11 billion) and Russia (US\$ 7 billion) also experience smaller reduction in foreign banks' claims than in the baseline scenario. Moreover, among CEE countries, bank capital outflows are generally

<sup>38</sup> The model is simulated by applying the 500 bps increase in funding costs to all interbank liabilities, and treat it as a loss equivalent.

smaller by a few percentage points of GDP. However, some countries (such as the Netherlands or Ireland) experience significantly larger bank capital outflows.

Finally, fire sales of assets triggered by the funding shocks would, however, significantly amplify the deleveraging, in particular in advanced economies, and in Central and Eastern European countries.

## VI. CONCLUSION

This paper describes the growing internationalization of international banking activities before the crisis, and the adjustment that took place during the crisis. To illustrate what amplification mechanisms are consistent with the adjustment that took place during the crisis, we construct a simple model of financial contagion based on bank balance sheet identities and behavioral assumptions of deleveraging. Cascade effects can be triggered by bank losses or impairment of interbank markets. As a result of shocks on assets or on liabilities of banks, a global deleveraging of international banking activities can occur. Simple simulations are presented to illustrate the use of the model and the relative importance of contagion channels.

If banks can offset most of the liquidity funding shocks originating in the interbank market, the initial losses cause a deleveraging of international banks' activities of the same order of magnitude as was observed during the crisis for many countries. Specifically, in relative terms, the deleveraging has a stronger effect on advanced economies than on emerging markets. In absolute terms, large emerging markets were the most affected among these countries, while the actual impact on Central and Eastern European countries was, generally, smaller than in our simulations. If, however, banks cannot access substitute sources of funding when the interbank market becomes impaired, losses accumulate in banking systems as a result of a lack of market liquidity, and are highly non-linear functions of the fire sale losses. The eventual deleveraging can then be staggering.

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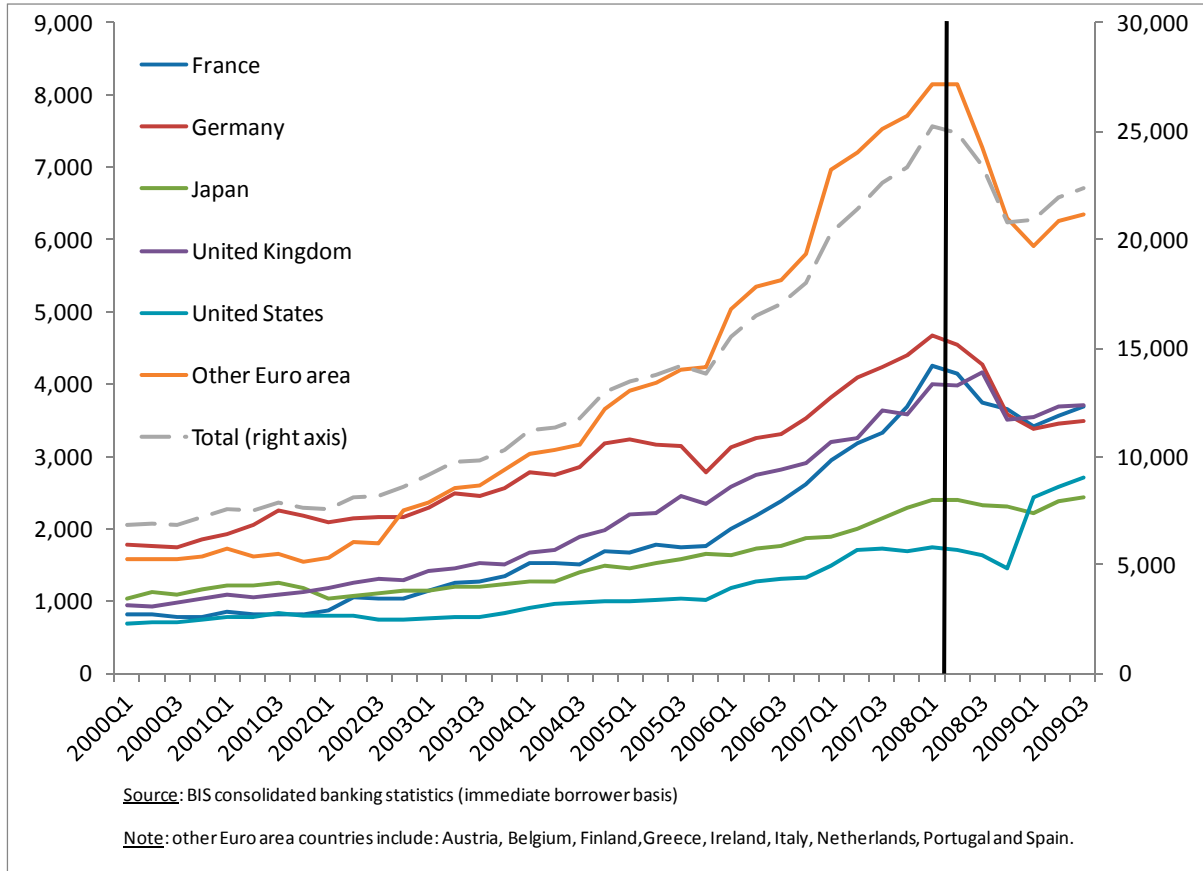
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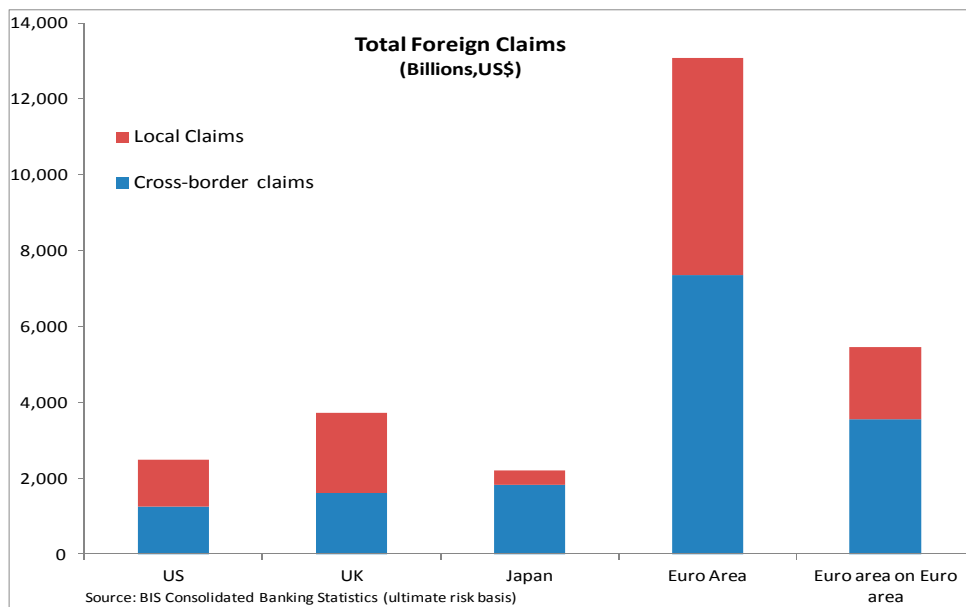
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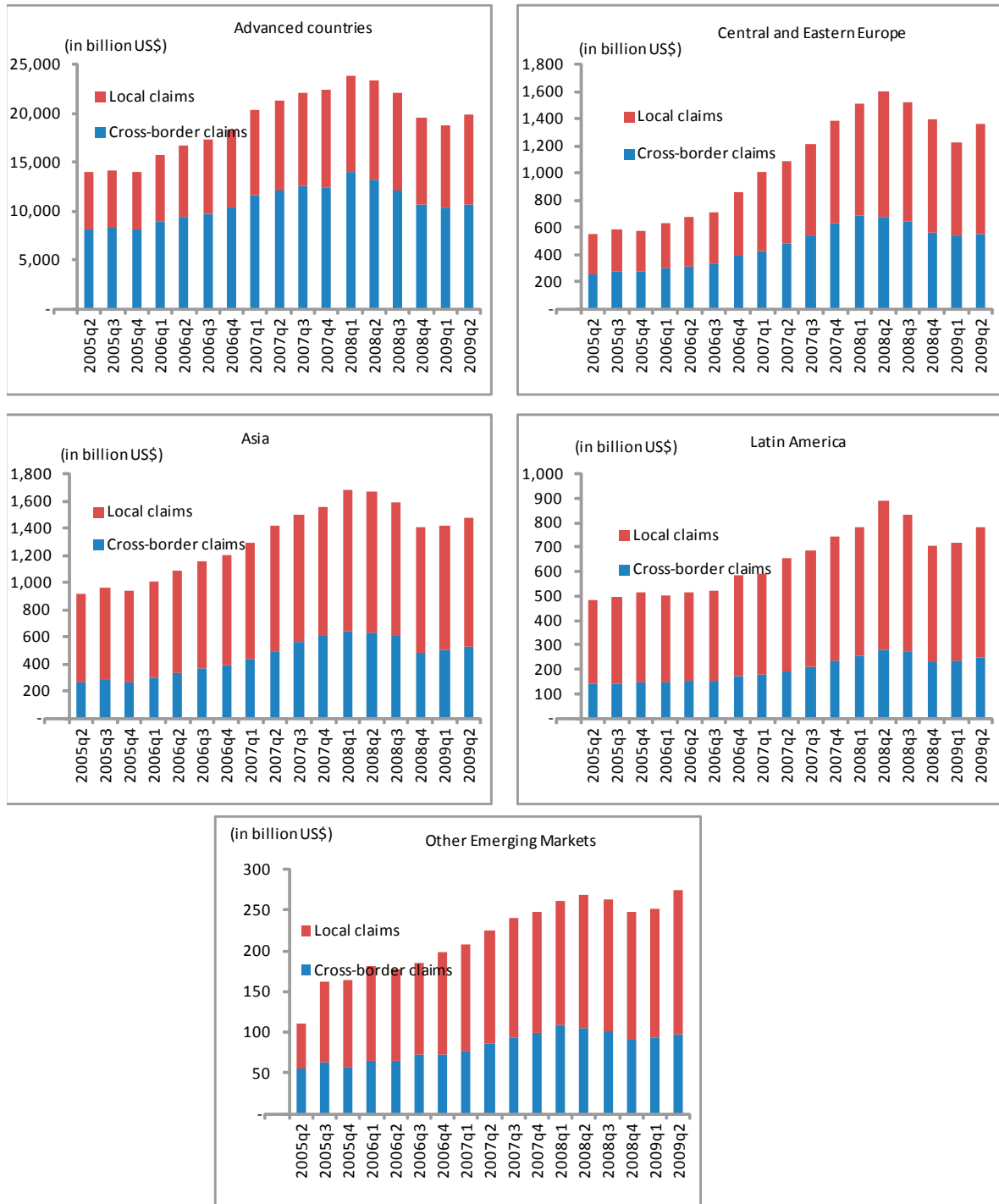
**Figure 1. Foreign Claims of Large International Banks 2000-2009**



**Figure 2. Foreign Claims of International Banks by Type of Claims (Q2 of 2009)**

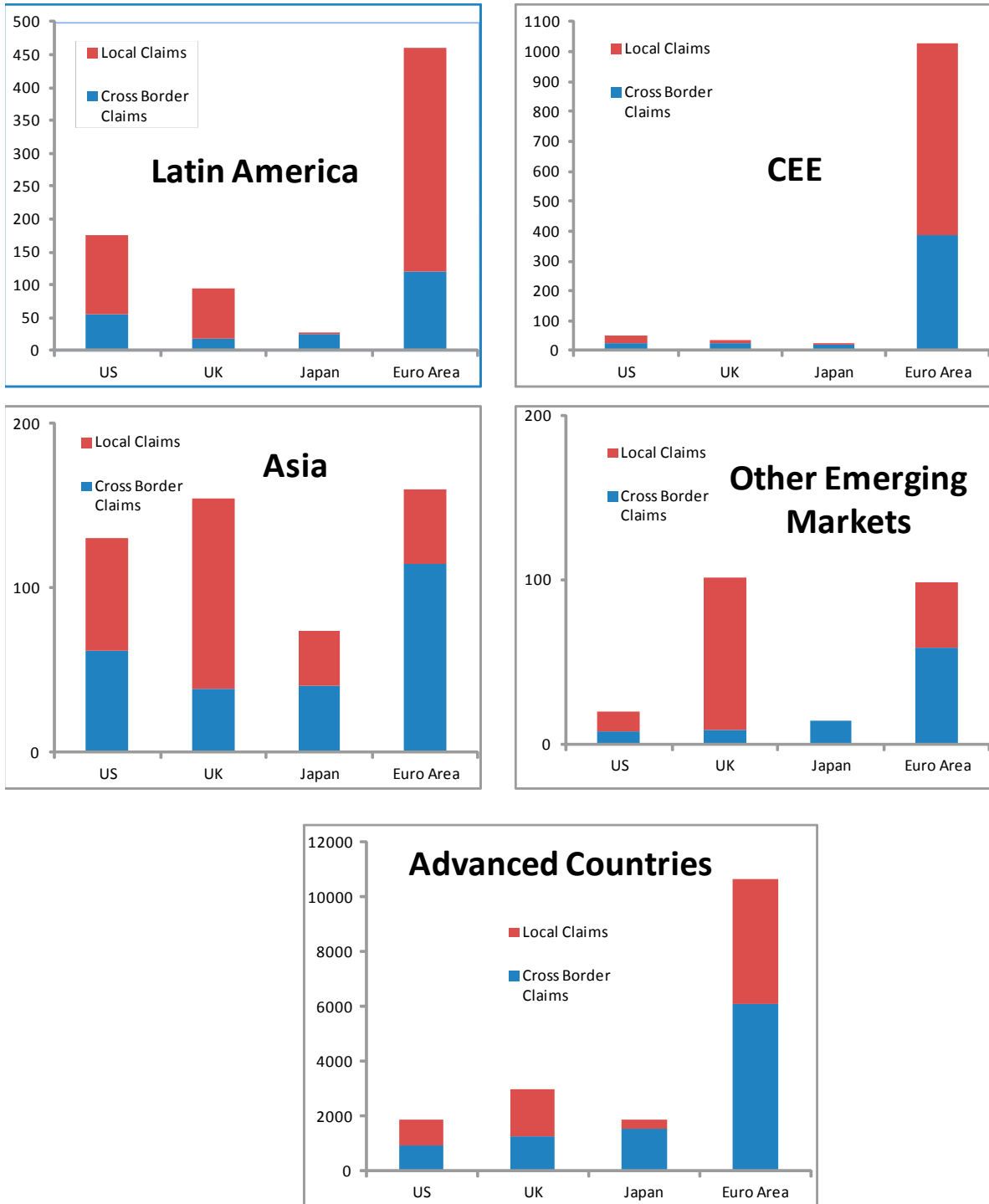


**Figure 3. Foreign Liabilities to International Banks by Region (2005 - Q2 of 2009)**



Source: BIS consolidated banking statistics (ultimate risk basis)

**Figure 4. Foreign Claims by Host Region and Home Country of International Banks  
In billion US\$ (Q2 of 2009)**



Source: BIS Consolidated Banking Statistics (ultimate risk basis)

**Table 1. Network of bilateral country gross exposures (Q1 of 2009)**

	United Kingdom	France	Germany	United States	Japan	Switzerland	Netherlands	Spain	Italy	Belgium
United Kingdom		6.47%	5.11%	34.21%	2.65%	1.09%	2.71%	3.32%	2.24%	1.12%
France	10.39%		8.21%	20.15%	5.98%	1.62%	3.69%	5.10%	13.35%	3.73%
Germany	14.70%	5.53%		17.71%	1.50%	1.86%	4.56%	6.71%	5.83%	1.13%
United States	20.17%	4.58%	8.21%		10.78%	1.92%	3.46%	2.19%	1.85%	1.33%
Japan	8.07%	4.07%	5.99%	38.27%		0.84%	2.15%	1.10%	1.94%	1.01%
Switzerland	11.97%	3.79%	5.47%	43.36%	4.19%		2.42%	0.91%	1.30%	0.82%
Netherlands	10.94%	6.78%	10.89%	18.06%	1.27%	1.51%		7.32%	4.43%	9.03%
Spain	28.56%	3.59%	3.74%	16.20%	0.14%	0.48%	1.67%		3.28%	0.68%
Italy	5.77%	4.63%	28.26%	4.87%	0.00%	1.20%	2.98%	3.17%		0.89%
Belgium	12.36%	13.56%	6.42%	13.61%	0.22%	1.09%	9.38%	4.84%	5.41%	

Source: BIS Consolidated Banking Statistics (immediate borrower basis)

**Figure 5. Interbank market gross exposures (Q1 of 2009)  
(BIS Consolidated Banking Statistics on an ultimate risk basis)**

**Table 2. Capital to Asset ratio of Large International Banks  
(Aggregated by Country)**

Country	2007	2009	Change
Australia	6.0	5.8	-0.2
Austria	6.5	7.7	1.1
Belgium	2.2	4.8	2.6
Canada	5.2	5.6	0.5
Denmark	3.9	4.6	0.7
France <sup>1/</sup>	2.8	4.1	1.4
Germany	2.8	3.4	0.6
Greece	6.8	6.7	-0.1
Ireland	7.0	6.6	-0.4
Italy	5.6	5.9	0.4
Japan	6.9	5.7	-1.2
Netherlands	4.1	4.7	0.7
Norway	7.2	6.6	-0.6
Portugal	7.6	8.3	0.7
Spain	7.0	7.2	0.2
Sweden	4.6	4.8	0.2
Switzerland	2.5	3.7	1.3
United Kingdom	4.3	4.4	0.1
United States	7.7	9.4	1.7

<sup>1/</sup> Leverage ratio of 2008 instead of 2007

Source: Bankscope

**Table 3. Change in Foreign Claims by Type and Sectors**

<b>Percent change in stock of:</b> (between peak and Q2 of 2009)						
host region	Total foreign claims	By type		By type of claims		
		Cross-border claims	Local claims	Claims on banks	Claims on public sector	Claims on non-bank private sector
Advanced countries	-16%	-24%	-6%	-32%	2%	-17%
Central and Eastern Europe	-15%	-19%	-13%	-30%	-3%	-12%
Latin America	-12%	-10%	-13%	-18%	-13%	-7%
Asia	-12%	-18%	-9%	-25%	9%	-5%
Other emerging markets	2%	-6%	7%	-6%	-2%	3%

Note: peak is Q1 of 2008 except for CEE, LAM and other EM for which it is Q2 of 2009

Source: BIS Consolidated Banking Statistics (ultimate risk basis)

**Table 4. Deleveraging by Nationality of Banks**

	Simulation	Actual			(vis-à-vis related offices)
		Q4, 2008	Q4 2008 - Q2 2009	Q2 2009 - Q4 2009	Q4 2008 - Q2 2009
Australia	0%	-3%	-5%	1%	6%
Austria	0%	-5%	-7%	0%	18%
<b>Belgium</b>	<b>-33%</b>	<b>-26%</b>	<b>-37%</b>	<b>-6%</b>	<b>-49%</b>
Canada	0%	1%	-3%	10%	7%
Denmark	0%	5%	-7%	-12%	-7%
France	-10%	-2%	-3%	-1%	6%
<b>Germany</b>	<b>-22%</b>	<b>-8%</b>	<b>-13%</b>	<b>-4%</b>	<b>-13%</b>
Greece	0%	9%	31%	4%	6%
Ireland	0%	4%	-2%	-3%	12%
Italy	0%	-1%	<b>-10%</b>	<b>-4%</b>	-11%
Japan	0%	3%	5%	1%	8%
<b>Netherlands</b>	<b>-13%</b>	<b>-6%</b>	<b>-12%</b>	<b>-6%</b>	<b>-23%</b>
Norway	0%	8%	10%	7%	31%
Portugal	0%	-3%	0%	-5%	15%
Spain	0%	-2%	2%	3%	12%
Sweden	0%	0%	-3%	2%	3%
<b>Switzerland</b>	<b>-31%</b>	<b>-13%</b>	<b>-19%</b>	<b>-10%</b>	<b>-10%</b>
<b>United Kingdom</b>	<b>-24%</b>	<b>-15%</b>	<b>-16%</b>	<b>-2%</b>	<b>-10%</b>
<b>United States</b> <sup>1/</sup>	<b>-13%</b>	<b>10%</b>	<b>-9%</b>	<b>-3%</b>	<b>-5%</b>

Source: Author simulations and BIS locational statistics by nationality with correction for exchange rate movements (Tables 8a and 8b).

<sup>1/</sup> Break in the data in 2008 Q4 with inclusion of former investment banks. Q1-Q2 2009 reported instead of Q4 2008 - Q2 2009



**Table 5. Deleveraging from Host Country Perspective**  
**(country average in percent of host country GDP, and regional total in billion of US \$)**

	<b>Simulations</b>				<b>Actual: end Sept 2008 - end June 2009</b>					
	Complete pass-through to local claims		20 percent pass-through to local claims		Change in Value of Consolidated Total Foreign Claims		Change in Exchange Rate Adjusted Cross-Border Claims		Change in Exchange Rate Adjusted Local Claims in Local Currency	
	Percent of GDP	Billion US\$	Percent of GDP	Billion US\$	Percent of GDP	Billion US\$	Percent of GDP	Billion US\$	Percent of GDP	Billion US\$
Advanced countries	-11%	-2,630	-9%	-1,769	-12%	-2,142	-11%	-2,427	1.1%	-570
CEE countries	-6%	-132	-3%	-77	-3%	-120	-2%	-94	0.6%	24
Asian countries	-1%	-49	-1%	-41	-1%	-40	-3%	-119	0.1%	5
Latin America	-1%	-40	-1%	-27	-1%	-42	-2%	-58	1.2%	29
Other emerging markets	-4%	-18	-4%	-15	2%	.	0%	-5	-0.1%	5

Source: Author simulations and BIS international banking statistics

Notes: Foreign claims and local claims in local currency are from the consolidated banking statistics and are consolidated at the banking group level, thus netting out inter-office claims. Local claims are adjusted for exchange rate fluctuations and are expressed in end of 2008 US\$. Cross-border claims are from the locational banking statistics and are not consolidated at the banking group level (they include claims on affiliates), but are adjusted for exchange rate fluctuations. Percent of GDP figures are averages across countries in a given region. Billion of US\$ figures are aggregated at the regional level.

Luxembourg is excluded from the figures.

**Table 6. Losses of International Banks (in percent of home country GDP)**

Country	Initial shock	Fire sale loss (deviation from initial shock)		
		10 percent	20 percent	40 percent
Australia	0.0%	0.2%	0.7%	3.7%
Austria	2.0%	0.3%	0.9%	5.3%
Belgium	6.6%	0.5%	1.4%	9.2%
Canada	0.7%	0.0%	0.1%	0.4%
Denmark	0.0%	0.4%	1.2%	7.8%
Finland	2.2%	0.1%	0.4%	3.6%
France	0.9%	0.5%	1.4%	7.3%
Germany	1.6%	0.2%	0.6%	3.5%
Greece	2.0%	0.1%	0.2%	1.1%
Ireland	4.1%	1.1%	3.4%	17.7%
Italy	0.0%	0.1%	0.4%	2.3%
Japan	0.4%	0.0%	0.1%	0.5%
Netherlands	3.0%	0.6%	1.7%	8.5%
Norway	0.0%	0.2%	0.6%	3.8%
Portugal	1.7%	0.2%	0.7%	4.1%
Spain	0.0%	0.3%	1.0%	5.9%
Sweden	0.5%	0.2%	0.5%	4.1%
Switzerland	8.2%	0.3%	1.1%	6.1%
United Kingdom	3.9%	0.5%	1.5%	9.1%
United States	2.3%	0.1%	0.2%	1.3%

Source: author's simulations

**Table 7. Reduction in Foreign Liabilities (Scenario 2)**  
(in percent of host country GDP)

	Initial shock	Deleveraging (deviation from initial shock)		
		10 percent	20 percent	40 percent
Advanced countries	-16%	-3%	-12%	-65%
CEE countries	-6%	-1%	-4%	-26%
Asian countries	-1%	0%	-1%	-5%
Latin America	-1%	0%	-1%	-4%
Other emerging market	-4%	-1%	-3%	-17%

Source: author's calculations

**Table 9. Reduction in Foreign Liabilities (Scenario 3)**  
(in percent of host country GDP and regional aggregate in billion US\$)

(Deviation from baseline scenario 1)	Funding shock		Funding shock + fire sales	
	Percent of GDP	billion US\$	Percent of GDP	billion US\$
Advanced countries	1.4%	494	-8%	-1,184
CEE countries	1.2%	13	-4.0%	-62
Asian countries	0.6%	17	-0.4%	-13
Latin America	0.2%	16	-0.6%	-9
Other emerging markets	2%	4	-1.4%	-8

Source: author's calculations

**Note:** Funding shock scenario assumes a 500 bps increase in interbank interest rates. Funding shock + fire sales scenario assumes in addition a 10 percent loss on sale of assets.

### Appendix Tables

**Table A1. Initial Shock by Banking System (billion US\$)**

	Baseline scenario	Funding shock scenario
Austria	7	10
Belgium	30	16
Denmark	0	10
Finland	5	0
France	24	39
Germany	53	37
Greece	6	2
Ireland	11	19
Italy	1	24
Netherlands	23	20
Norway	0	9
Portugal	4	5
Spain	0	24
Sweden	2	5
Switzerland	35	7
United Kingdom	109	83
Australia	0	0
Canada	10	5
Japan	19	19
United States	315	83

Note: Initial loss in billion of US\$, in scenario 1 (baseline scenario) and in scenario 3 (funding shock scenario).

**Table A2. Country by country results (scenario 1)**  
**Change in International Banks claims in percent of host GDP**

	Simulations		Change in Consolidated Foreign Claims	Changes in Exchange Rate Adjusted Cross-Border Claims Q4 of 2008 - Q2 of 2009	Change in local currency consolidated local claims
	Complete pass-through to local claims	20 percent pass-through to local claims			
<b>Advanced countries</b>					
Australia	-5%	-3%	-5%	-2%	-5%
Austria	-11%	-8%	-14%	-9%	-2%
Belgium	-12%	-9%	-3%	-23%	6%
Canada	-2%	-1%	-1%	-1%	0%
Cyprus	-29%	-28%	-38%	125%	6%
Denmark	-7%	-6%	2%	-1%	-5%
Finland	-3%	-3%	-3%	0%	0%
France	-6%	-6%	-5%	-7%	-1%
Germany	-4%	-3%	-1%	-2%	0%
Greece	-13%	-9%	-5%	0%	1%
Hong Kong	-8%	-5%	9%	-16%	20%
Iceland	-34%	-34%	-116%	-155%	0%
Ireland	-43%	-37%	-64%	-21%	-6%
Italy	-8%	-6%	-1%	-3%	1%
Japan	-2%	-2%	1%	1%	1%
Luxembourg	-162%	-116%	-183%	-180%	-27%
Malta	-15%	-14%	-21%	-63%	10%
Netherlands	-21%	-13%	-22%	-24%	-21%
New Zealand	-2%	-2%	11%	29%	-2%
Norway	-8%	-7%	-11%	-13%	-2%
Portugal	-9%	-8%	1%	-4%	1%
Singapore	-11%	-6%	-15%	-43%	-1%
Slovakia	-7%	-3%	-18%	-9%	-4%
Slovenia	-9%	-7%	-4%	-5%	2%
South Korea	-2%	-2%	-4%	-6%	-1%
Spain	-9%	-7%	-4%	-4%	0%
Sweden	-4%	-4%	-5%	-6%	-2%
Switzerland	-8%	-7%	-3%	-18%	1%
United Kingdom	-17%	-10%	-12%	-23%	1%
United States	-5%	-3%	-6%	-3%	-4%
<b>CEE countries</b>					
Bosnia and Herzegovin	-5%	-2%	-4%	2%	2%
Bulgaria	-8%	-5%	2%	0%	0%
Croatia	-10%	-7%	-1%	1%	-2%
Czech Republic	-13%	-5%	-6%	-2%	-2%
Estonia	-2%	-2%	-5%	-5%	-3%
Hungary	-11%	-6%	-4%	-1%	-2%
Latvia	-4%	-2%	-5%	-6%	-1%
Lithuania	-2%	-1%	0%	-1%	-2%
Poland	-6%	-3%	-6%	-2%	-6%
Romania	-4%	-2%	-2%	-1%	-1%
Russia	-2%	-2%	-2%	-3%	-1%
Serbia	-4%	-3%	-4%	0%	-4%
Turkey	-2%	-2%	-2%	-3%	0%
Ukraine	-3%	-3%	-8%	-4%	-3%

**Asian countries**

China	-1%	0%	0%	-1%	0%
India	-1%	-1%	-1%	-2%	0%
Indonesia	-1%	-1%	-1%	-4%	0%
Kazakhstan	-2%	-2%	-3%	-2%	0%
Malaysia	-3%	-2%	-3%	-6%	-1%
Pakistan	-1%	0%	0%	0%	0%
Philippines	-2%	-2%	-2%	-1%	0%
Sri Lanka	-1%	-1%	-2%	-2%	0%
Thailand	-1%	-1%	1%	0%	1%
Vietnam	-1%	-1%	-2%	-7%	0%

**Latin America**

Argentina	-1%	-1%	-1%	-1%	-1%
Brazil	-2%	-1%	0%	-2%	1%
Chile	-2%	-2%	2%	-2%	5%
Colombia	0%	0%	0%	-1%	1%
Costa Rica	0%	0%	-1%	-4%	0%
Dominican Republic	-2%	-2%	-7%	-1%	0%
Ecuador	0%	0%	0%	-1%	1%
El Salvador	0%	0%	-3%	-3%	-12%
Guatemala	-1%	-1%	-1%	-1%	0%
Jamaica	-1%	-1%	-5%	-5%	3%
Mexico	-1%	-1%	-4%	-1%	-3%
Peru	-1%	-1%	-2%	-3%	1%
Uruguay	-2%	-1%	11%	2%	7%

**Other emerging markets**

Algeria	0%	0%	0%	0%	0%
Egypt	-2%	-2%	3%	-1%	4%
Israel	-1%	-1%	0%	0%	0%
Jordan	-1%	-1%	-4%	2%	-1%
Morocco	-3%	-2%	2%	1%	0%
South Africa	-1%	-1%	1%	-1%	1%
Tunisia	-2%	-2%	0%	0%	-1%
Lebanon	-4%	-4%	-1%	0%	0%
Panama	-24%	-24%	16%	4%	-5%

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Sources: author's calculations and BIS International Banking Statistics.