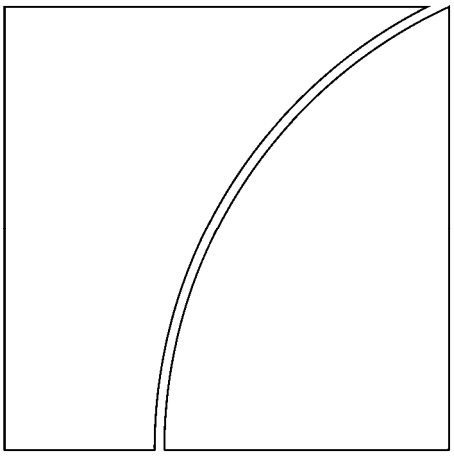
BANK FOR INTERNATIONAL SETTLEMENTS



BIS Working Papers

No 291

The US dollar shortage in global banking and the international policy response

by Patrick McGuire and Götz von Peter

Monetary and Economic Department

October 2009

JEL classification: F34, F55, G01, G21.

Keywords: International banking, financial crises, funding risk, US dollar shortage, central bank swap lines.

BIS Working Papers are written by members of the Monetary and Economic Department of the Bank for International Settlements, and from time to time by other economists, and are published by the Bank. The papers are on subjects of topical interest and are technical in character. The views expressed in them are those of their authors and not necessarily the views of the BIS.

Copies of publications are available from:

Bank for International Settlements
Communications
CH-4002 Basel, Switzerland

E-mail: publications@bis.org

Fax: +41 61 280 9100 and +41 61 280 8100

This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)

ISBN 1682-7678 (online)

The US dollar shortage in global banking and the international policy response

Patrick McGuire and Goetz von Peter[1]

Abstract

Among the policy responses to the global financial crisis, the international provision of US dollars via central bank swap lines stands out. This paper studies the build-up of stresses on banks' balance sheets that led to this coordinated policy response. Using the BIS international banking statistics, we reconstruct the worldwide consolidated balance sheets of the major national banking systems. This allows us to investigate the structure of banks' global operations across their offices in various countries, shedding light on how their international asset positions are funded across currencies and counterparties. The analysis first highlights why a country's "national balance sheet", a residency-based measure, can be a misleading guide to where the vulnerabilities faced by that country's national banking system (or residents) lie. It then focuses on banking systems' consolidated balance sheets, and shows how the growth (since 2000) in European and Japanese banks' US dollar assets produced structural US dollar funding requirements, setting the stage for the dollar shortage when interbank and swap markets became impaired.

JEL classification: F34, F55, G01, G21.

Keywords: International banking, financial crises, funding risk, US dollar shortage, central bank swap lines.

[1] Bank for International Settlements. Patrick.McGuire@bis.org, Goetz.von.Peter@bis.org. This paper is a substantially revised and extended version of a feature in the March 2009 *BIS Quarterly Review*. The authors thank Claudio Borio, Ben Craig, Linda Goldberg, Robert McCauley, Perry Mehrling, Leonardo Morales-Arias, Frank Packer, Frank Warnock, Philip Wooldridge and the International Financial Statistics unit at the BIS for helpful comments on earlier drafts, and gratefully acknowledge feedback from seminar participants at the Bank of England, the Bank of Japan, the Hong Kong Monetary Authority, the Reserve Bank of Australia, the Reserve Bank of New Zealand, and the INFINITI Conference on International Finance (Trinity College, Dublin). The views expressed are those of the authors and do not necessarily reflect those of the BIS.

Contents

1. Introduction

The global financial crisis has shown just how unstable banks' sources of funding can become. Throughout the crisis, but particularly following the collapse of Lehman Brothers in September 2008, many banks faced severe difficulties securing short-term US dollar funding. In response, central banks around the world adopted extraordinary policy measures, including international swap arrangements with the US Federal Reserve, to enable them to provide US dollars to commercial banks in their respective jurisdictions. What caused this global shortage of US dollars? Which banking systems have been most affected? How could a shortage develop so quickly after dollar liquidity had been viewed as plentiful?

This paper provides a systematic analysis of the build-up of stresses on banks' international balance sheets which set the stage for the shortage of US dollars.[2] It relies on the BIS international banking statistics to reconstruct the global balance sheet positions for each of the major *national banking systems.*[3] These data provide information on both the currency and the counterparty of banks' foreign assets and liabilities, facilitating an analysis of how banks *funded* their foreign currency investments. With this dataset, the dynamics of the crisis can be analysed along the contours of banks' *consolidated* global balance sheets, arguably the most appropriate framework for assessing funding pressures, rather than along geographical (ie residency-based) lines.

Understanding the global US dollar shortage requires a departure from the familiar domestic bank run story. In the open economy version of the traditional bank run model, depositors run the bank and convert their domestic deposits to foreign currency (Chang and Velasco (2000, 2001)) or, in the case of liability dollarization, directly withdraw dollars (Rajan and Tokatlidis (2005)). The resulting demand for foreign currency, being proportional to domestic bank liabilities, can easily exhaust the country's FX reserves (Obstfeld et al (2009)). While the domestic run story remains relevant in the emerging market context, this paper traces the origins of the US dollar shortage to the *international operations* of the major banking systems and to the global funding and swap markets on which they rely. Previous episodes with similar international dimensions include the lengthening of the maturity of Latin American dollar debt in the early 1980s, which raised concerns about a maturity mismatch on European banks' balance sheets (McCauley (1984)). Another case is the "Japan Premium" faced in the 1990's by Japanese banks, which had financed their global expansion in the eurodollar and euroyen markets (Peek and Rosengren (2001)).

The funding difficulties which arose during the crisis are directly linked to the remarkable expansion in banks' global balance sheets over the past decade. Reflecting in part the rapid pace of financial innovation, banks' (particularly European banks') foreign positions have surged since 2000, even when scaled by measures of underlying economic activity. As banks' balance sheets grew, so did their appetite for foreign currency assets, notably US dollar-denominated claims on non-bank entities. These assets include retail and corporate lending, loans to hedge funds, and holdings of structured finance products based on US mortgages and other underlying assets. During the build-up, the low perceived risk (high ratings) of these instruments appeared to offer attractive return opportunities; during the crisis they became the main source of mark to market losses.

---

[2] The historical usage of the term "dollar shortage" (notably by Kindleberger (1950), and Triffin (1957)) refers to the main structural monetary problem of the postwar period, namely the global scarcity of gold and dollar assets which resulted from chronic US current account surpluses. The use of the term here refers to the difficulty banks face in securing short-term US dollar funding.

[3] "National banking system", the primary unit of analysis in this paper, refers to the set of large internationally active banks *headquartered* in a particular country (eg US banks, German banks, Swiss banks), as opposed to banks *located* in a particular country.

The accumulation of US dollar assets saddled banks with significant funding requirements, which they scrambled to meet during the crisis, particularly in the weeks following the Lehman bankruptcy. To better understand these financing needs, we break down banks' assets and liabilities by currency to examine *cross-currency funding*, or the extent to which banks fund in one currency and invest in another. We find that, since 2000, the Japanese and the major European banking systems took on increasingly large *net* (assets minus liabilities) on-balance sheet positions in foreign currencies, particularly in US dollars. While the associated currency exposures were presumably hedged off-balance sheet, the build-up of net foreign currency positions exposed these banks to foreign currency *funding risk*, or the risk that their funding positions (FX swaps) could not be rolled over.

The magnitude of this risk is gauged in a second step, where we attempt to quantify banks' total short-term US dollar financing needs at the onset of the crisis. This requires breaking down banks' US dollar-denominated assets and liabilities further, by residual maturity, to quantify the degree of maturity transformation embedded in banks' balance sheets. Although data limitations make direct measurement of the maturity of banks' positions impossible, we argue that information on counterparty type (bank, non-bank or central bank) can serve as a proxy since the average maturity of positions is likely to vary systematically with the sector of the counterparty, with interbank positions having a shorter maturity than positions vis-à-vis non-bank entities. This yields a lower-bound estimate of banks' *US dollar funding gap* – the amount of short-term US dollar funding banks require – measured here as the net amount of US dollars channelled to non-banks. By this estimate, European banks' need for short-term US dollar funding was substantial at the onset of the crisis, at least $1.0–1.2 trillion by mid-2007.

Events during the crisis led to severe disruptions in banks' sources of short-term funding. Interbank markets seized up, and dislocations in FX swap markets made it even more expensive to obtain US dollars via swaps. Banks' funding pressures were compounded by instability in *non-bank* sources of funds as well, notably dollar money market funds and dollar-holding central banks. The market stress meant that the effective maturity of banks' US dollar funding shortened just as that of their US dollar assets lengthened, since many assets became difficult to sell in illiquid markets. This endogenous rise in maturity mismatch, difficult to hedge ex ante, generated the global US dollar shortage. Our estimate of the size of banks' US dollar funding gaps at the onset of the crisis shed light on why the international policy response was necessary, and why it took the form of a global network of central bank swap lines.

One point highlighted throughout this analysis is the importance of taking banks' worldwide consolidated positions as the unit of analysis. Banks have become so globalised, with offices in many countries around the world, that it is impossible to identify vulnerabilities in their balance sheets using residency-based statistics alone (eg, domestic credit data, balance of payments data, the BIS locational banking statistics by residency). Stresses build up *across* the global balance sheet, as mismatches in the currency or maturity of assets and liabilities, and thus can be understood only by looking at banks' worldwide positions consolidated across all office locations. In some cases, banks' cross-border assets booked by offices in a particular host country can account for the bulk of that country's external asset position, and yet still represent a relatively small part of the consolidated banking systems' worldwide assets. This fact clouds the interpretation of the "national balance sheet" for many host countries, since banks' long or short currency positions booked in one office location and offset in another may signal a "mismatch" in the host country's net external position when none may, in fact, exist.

The remainder of the paper is organised as follows. The next section introduces concepts related to banks' international investment and funding choices, from which we derive the data requirements. Section 3 examines banks' investment and funding patterns since 2000 which set the stage for the US dollar shortage and policy responses examined in Sections 4 and 5.

The final section concludes, and the data appendix provides detail on the BIS international banking statistics and the construction of the dataset.

2. Banks' international positions: concepts and data

We first introduce concepts related to an internationally active bank's investment and funding choices. Consider a bank that seeks to diversify internationally, or expand its presence in a specific market abroad. This bank will have to finance a particular portfolio of loans and securities, some of which are denominated in foreign currencies (eg a German bank's investment in US dollar-denominated structured finance products). The bank can finance these foreign currency positions in several ways:

1. The bank can borrow domestic currency, and convert it in a straight FX spot transaction to purchase the foreign asset in that currency.
2. It can also use FX swaps to convert its domestic currency liabilities into foreign currency and purchase the foreign assets.[4]
3. Alternatively, the bank can borrow foreign currency, either from the interbank market, from non-bank market participants or from central banks.

The first option produces no subsequent foreign currency needs, but exposes the bank to currency risk, as the on-balance sheet mismatch between foreign currency assets and domestic currency liabilities remains unhedged. Our working assumption is that banks employ FX swaps and forwards to hedge any on-balance sheet currency mismatch.[5] That is, a bank funding in domestic currency (option 1 or 2) is likely to do so as described in option 2. Importantly, the second leg of the swap in option 2 is not that different from funding a position through foreign currency borrowing in the first place (option 3): in both cases, the bank needs to "deliver" foreign currency when the contractual liability comes due.

For concreteness, let A_i denote the bank's claims (assets) denominated in currency i, with $i=0$ representing the domestic currency. The assets are financed by liabilities L_i (where L_0 includes equity). The *net* position in currency i equals $(A_i–L_i)$, where the term "long" ("short") is used to denote a positive (negative) net on-balance sheet position. Funding option 1 above produces a long foreign currency position of $A_i>0$ financed by $L_0=A_i$. Option 2 couples the same on-balance sheet positions with a(n off-balance sheet) promise to repay A_i when the swap comes due, to be met by the proceeds from, or sale of, A_i. Option 3 matches foreign currency funding to foreign assets, leaving a zero net position ($A_i–L_i=0$). The balance sheet identity implies that net foreign currency positions (if positive) are mirrored in net borrowing in domestic currency. That is,

$$\sum_{i=1}^{n}(A_i - L_i) = L_0 - A_0. \quad (1)$$

The various funding options expose the bank to *funding risk*, or the risk that funding liabilities cannot be rolled over. The magnitude of this risk depends on the degree of maturity transformation embedded in the bank's balance sheet. The bank is said to face a *foreign currency funding gap* if the investment horizon of its foreign currency assets A_i exceeds the maturity of its foreign currency funding or FX swaps. The portfolio's investment horizon

[4] An FX swap is an exchange of two currencies at the current spot exchange rate today, coupled with the promise to exchange back at a future date at a fixed exchange rate.

[5] Stigum and Crescenzi (2007) describe in detail how banks use derivatives to hedge their international operations. In some circumstances, banks may find it advantageous to maintain open foreign currency positions (eg to insulate capital/asset ratios against a depreciation of the domestic currency (Fukao (1991)).

depends on the desired holding period, on the maturity of the underlying assets and on market liquidity. If the contractual liabilities (L_i, or swaps) cannot be rolled over for some reason, then foreign currency assets that were intended to be held have to be sold instead, possibly in distressed market conditions.

Suppose the bank finances its foreign currency assets A_i by fully hedging currency risk, ie by a combination of foreign currency borrowing L_i and FX swaps S_i such that $A_i = L_i + S_i$. Denote by $A_i^{LT}(L_i^{LT})$ the foreign currency assets (liabilities) with a long investment horizon or long effective maturity. Ideally, one would measure short-term funding liabilities (including FX swaps) in currency *i directly*, as $(L_i - L_i^{LT}) + S_i$. However, since FX swaps are typically (unobserved) off-balance sheet transactions, we use the hedging equality to replace S_i and express short-term funding liabilities as $(A_i - L_i^{LT})$. These short-term foreign currency liabilities can be met with banks' liquid or maturing assets, worth $(A_i - A_i^{LT})$. The difference yields the foreign currency funding gap:[6]

$$(A_i - L_i^{LT}) - (A_i - A_i^{LT}) = A_i^{LT} - L_i^{LT}. \quad (2)$$

Why is funding risk in *foreign* currencies of special interest? Banks also face the risks inherent in transforming maturities in their domestic currency market, of course. Indeed, maturity transformation is an essential function of banking, and banks would find it unprofitable to eliminate maturity mismatch altogether (Morgan and Smith (1987), Goodhart (1995), Diamond and Rajan (2001), Stigum and Crescenzi (2007)). However, in a purely domestic banking context, the central bank can act as lender of last resort and provide sufficient liquidity to eliminate a domestic funding shortage; doing so is both time-honoured practice (Bagehot (1873), Goodhart (1995)) as well as optimal policy (Allen and Gale (1998), Diamond and Rajan (2006)). By contrast, central banks cannot create *foreign* currencies; their ability to meet banks' demand for foreign currencies is constrained by the exchange rate regime or limited to available FX reserves (Chang and Velasco (2000, 2001), Obstfeld et al (2009)). Banks' foreign currency requirements may therefore have to be met from international sources (Fischer (1999), Mishkin (1999)).

Funding risk is inherently tied to stresses *across* the global balance sheet: mismatches between the maturity, currency and counterparty of assets and liabilities. Quantifying this risk requires measurement of banking activity on a *consolidated* basis, preferably at the level of the decision-making economic unit (ie individual banks). Data designed to identify vulnerabilities in banks' funding patterns would ideally include, for both assets and liabilities, a complete breakdown of positions by currency, maturity and counterparty type, along with the relevant risk characteristics and off-balance sheet positions.

The publicly available information on banks' international positions typically falls far short of this ideal. Published accounts (collected in BankScope and Bloomberg) are available at the level of individual (consolidated) banks, but lack the essential breakdowns (counterparty, maturity and currency) needed here. Such information may be collected by bank examiners in the course of their supervisory activity, but is not included in publicly available data sources.[7] Statistics compiled at the national level (from national authorities, the IMF and the OECD) generally do not provide a complete picture either. As shown in Section 3.1, banks

---

[6] If a bank borrows more than it invests in currency *i*, it can swap the proceeds into domestic currency to increase A_0. The resulting swap position, $S_i = A_i - L_i < 0$, represents a short-term *claim* on currency *i*, but to realise this claim the bank must come up with as much domestic currency at short notice. If the proceeds were channelled into long-term domestic assets, then the foreign currency funding gap is measured as $(A_i^{LT} - L_i^{LT}) + (L_i - A_i) = (L_i - L_i^{LT}) - (A_i - A_i^{LT})$. In the extreme case where $A_i = 0$, the gap simply equals foreign currency short-term liabilities, $(L_i - L_i^{LT})$.

[7] Also, their focus on individual banks may mean that macroprudential issues, such as the extent to which different banks rely on the same funding patterns or trade and invest in the same direction, can be overlooked.

have become so globalised that residency-based data are insufficient for identifying vulnerabilities in any particular national banking system.

The analysis in this paper relies on the BIS international banking statistics, the most comprehensive source of information on banks' international balance sheet positions.[8] With these data, it is possible to reconstruct the consolidated global balance sheets for the major national banking systems. This effectively involves adding up the cross-border and local (ie vis-à-vis residents of the host country) balance sheet positions reported by banks' home offices and their offices in host countries around the world into a consolidated whole for each banking system. The end result is a dataset with the consolidated balance sheet positions for 19 banking systems for the Q2 1999–Q1 2009 period at a quarterly frequency. It is important to note that the constructed positions are estimates based on imperfect underlying data, and in places require assumptions to address known data limitations. More information on these assumptions and the construction of the dataset is provided in the appendix.

We use this dataset to investigate how banks fund their foreign currency investments, and to derive their funding requirements across currencies and counterparties. While not at the individual bank level, the advantages of these data are that they provide (i) the consolidated foreign assets *and* liabilities for each banking system, (ii) estimates of the gross and net positions *by currency*, and (iii) information on the sources of financing (ie interbank market, central banks and non-bank counterparties).

Table 1 presents summary statistics on the 11 banking systems analysed in later sections. Row 1 lists the number of *internationally active* banks which are *headquartered* in the country listed in the column heading, and whose foreign claims (row 4) are thus included in the BIS consolidated banking statistics.[9] Row 2 provides the *total* assets for this select group of banks in each banking system. For some banking systems (eg Germany, France and Italy), the number of individual reporting institutions is large since it includes many banks that hold small foreign exposures. However, international banking is highly concentrated. Estimated concentration ratios (row 3) for each banking system, calculated using bank-level information on total assets from BankScope, indicate that the five largest institutions account for more than 90% of Belgian, Swiss, French and Dutch banks' total assets (row 2) and more than 70% of Canadian, Italian and UK banks' assets. Across all banks in BankScope, the top 50 institutions account for some 80% of total bank assets in the database. Banks' *foreign* positions (row 4) is even more concentrated in the familiar names.

---

[8] The Bank for International Settlements disseminates four sets of international banking statistics compiled from underlying data reported by monetary authorities in over 40 countries, including the major offshore centres. As described in the appendix, the analysis in this paper relies (primarily) on two of these: the *BIS consolidated banking statistics on an immediate borrower basis* (CBS) and the *BIS locational banking statistics by residency* (LBSN).

[9] A banking system's foreign positions (assets or liabilities) are composed of four components: (i) cross-border positions booked by all offices worldwide and in all currencies; (ii) "local positions", or claims booked by banks' foreign offices vis-à-vis residents of the host country (in either the local currency or a foreign currency); (iii) positions booked by the home office vis-à-vis residents of the home country in foreign currencies; and (iv) cross-border positions booked by banks' foreign offices vis-à-vis residents of the home country. Only by splicing the CBS and the LBSN can these four components be assembled into a consolidated whole for each banking system (see Table A in the appendix). The remaining component, banks' "strictly domestic" activity, or positions booked by home offices vis-à-vis residents of the home country in the domestic currency, is not included in the BIS banking statistics.

3. The long and short of banks' global balance sheets

3.1 The structure of banks' operations

Internationally active banks have offices in many countries around the world. Their currency and maturity positions are managed across the consolidated global entity rather than office by office. Thus, large measured "mismatches" on the balance sheet of an office in one location may be hedged off-balance sheet or offset by on-balance sheet positions booked by offices elsewhere, leaving a matched book for the bank as a whole. This section provides some simple measures of how banks' offices are organised across countries, and highlights the importance of measuring stresses across the balance sheets of *consolidated* entities.

Overall, foreign offices account for a significant share of banks' worldwide consolidated balance sheets. The bottom five rows of Table 1 show the share of banks' total foreign claims (assets) which are booked by their offices in various countries/regions.[10] In most cases, *less than half* of banks' foreign claims are booked by their home offices, with French and Japanese banks being exceptions. At the extreme are Swiss banks, with more than $3 trillion in foreign claims, accounting for over 80% of their total balance sheet assets. Only 18% of their foreign claims are booked by offices *in* Switzerland. Banks' offices in the United Kingdom tend to be the largest outside the home country, followed by offices in the United States; combined, US and UK offices account for roughly one third of German, Spanish and Dutch banks' foreign claims.

Looking at these data from the perspective of *host countries* shows just how large banks' international operations really are. Table 2, where the column headings now indicate host countries, shows the gross and net international asset position of each country, and compares these to banks' *cross-border* claims (here, including banks' cross-border *inter-office* positions as well). The table distinguishes between positions booked by offices of "domestic" and "foreign" banks in each host country. In five countries (BE, CH, DE, JP and UK), banks' cross-border positions accounted for almost half of that country's external assets at end-2007, and as much as a quarter in five other countries (CA, ES, FR, IT and NL). The offices of *foreign* banks alone accounted for nearly 40% of the United Kingdom's external assets. In contrast, positions booked by the home offices of *domestic* banks were much larger in the case of Belgium, Germany, Japan and Switzerland.

What Tables 1 and 2 make clear is that "bank nationality" and "bank residency" are fundamentally different concepts. Positions booked by offices in any one country are generally a small part of that banking system's global consolidated balance sheet (Table 1), yet cross-border positions booked by banks' offices in any one country can be large relative to that host country's external asset position (Table 2). This has implications for how one should interpret a "national balance sheet", the unit of analysis used in a growing literature on international investment and capital mobility.[11] For at least two reasons, the national balance sheet may be a poor indicator of vulnerabilities (eg currency or maturity mismatches) faced by residents of a particular country.

---

[10] For banks' home offices, the figures in Table 1 include cross-border lending in all currencies and lending to residents of the home country in foreign currencies. For banks' foreign offices, the figures include cross-border and local claims in all currencies, ie the complete balance sheet of the foreign office. See footnote 9.

[11] Lane and Shambaugh (2009a) construct estimates of the currency composition of the external asset and liability positions for a large sample of *countries*, and show that the effect of exchange rate movements is sizeable. Lane and Shambaugh (2009b) and Faria and Mauro (2009) build on this by investigating the determinants of countries' long and short currency positions. See Lane and Milesi-Ferretti (2001) for background, Forbes (2008) for an analysis of capital flows into the United States, and Tille and van Wincoop (2007) and Devereux and Sutherland (2009) for recent models of international portfolio choice.

Table 1

Size and structure of banks' foreign operations

Positions at end-2007

Banking system		**BE**	**CA**	**CH**	**DE**	**ES**	**FR**	**IT**	**JP**	**NL**	**UK**	**US**
Number of banks[1]		18	17	23	1,801	96	135	724	106	49	17	33
Total assets ($bn)[2]		2,218	2,437	3,810	10,585	4,541	8,359	4,180	9,845	4,649	10,008	9,904
Asset concentration[3]		94.9	72.4	89.3	53.5	62.9	96.1	70.6	62.3	93.6	75.3	50.5
Foreign claims($bn)[4]		1,608	912	3,390	5,177	1,416	4,456	1,543	2,571	2,962	4,378	2,285
over total assets (%)		72	37	89	49	31	53	37	26	64	44	23
over annual GDP (%)		348	63	776	155	98	171	18	58	378	157	16
US dollar share (%)		23	70	60	33	36	31	10	48	31	42	52
Foreign claims, by office location (%)[5]	Home cntry[6]	42	23	18	44	27	51	39	75	27	44	22
	UK	6	18	30	22	28	6	5	6	20		25
	US	6	41	23	6	9	12	3	9	12	16	
	Euro Area	37	2	4	16	10	15	35	2	23	11	7
	OFC[7]	3	9	21	7	2	6	2	6	6	14	24
	Other	6	7	4	4	24	10	17	3	13	15	22
Assets booked by foreign offices (%)[8]		42	26	80	27	22	27	19	7	47	29	21

[1] Number of banking groups (headquartered in the country shown in the columns) that report in the BIS consolidated banking statistics. [2] Total assets (including "strictly domestic assets") aggregated across BIS reporting banks. For reporting jurisdictions which do not provide this aggregate (DE, ES, FR, IT, JP), total assets are estimated by aggregating the worldwide consolidated balance sheets (from BankScope) for a similar set of large banks headquartered in the country. [3] Share of total assets accounted for by the five largest reporting institutions. [4] Foreign claims as reported in the BIS consolidated banking statistics (immediate borrower basis) plus foreign currency claims vis-à-vis residents of the home country booked by home offices (taken from the BIS locational banking statistics by nationality). See footnote 9 in the main text. Excludes inter-office claims. [5] Total claims (cross-border claims plus claims on residents of the host country) booked by offices in each location over total worldwide consolidated foreign claims. [6] Excludes banks' "strictly domestic" claims, or their claims on residents of the home country in the domestic currency. [7] Offshore financial centres: here Bahamas, Bahrain, Bermuda, the Cayman Islands, Guernsey, Hong Kong SAR, the Isle of Man, Jersey, Macao SAR, Panama and Singapore. [8] Share of total assets (row 2) booked by offices outside the home country.

Sources: IMF IFS; BankScope; BIS consolidated statistics (immediate borrower basis); BIS locational banking statistics by nationality.

First, changes in a country's external position can be driven to a large extent by the activity of *foreign* banks' offices, and thus be only loosely related to vulnerabilities in residents' portfolios. For instance, suppose banks headquartered in country A double their balance sheet size through greater cross-border lending and/or acquisition of foreign banks. If the balance sheet adjustment occurs in these banks' foreign offices, it can generate large swings in *other* countries' external positions without necessarily affecting country A's external position. For instance, the expansion in the global balance sheets of Swiss, German and Dutch banks since 2000 was driven to a large extent by greater cross-border positions booked by their offices in the United Kingdom (see next section). Indeed, as shown in the bottom rows of Table 2, the offices of foreign banks located there saw larger changes in their net cross-border balance sheet positions in the pre-crisis period than did UK headquartered banks (–$490 billion compared to –$190 billion). Over this same period, foreign banks'

Table 2

Bank assets in total external assets

Positions at end-2007

Country	BE	CA	CH	DE	ES	FR	IT	JP	NL	UK[2]	US
Gross external assets ($bn)[1]	2,407	1,199	3,231	7,367	2,091	7,758	2,827	5,355	3,795	12,777	17,640
Net external assets ($bn)	141	–127	635	949	–1,081	375	–119	2,195	14	–586	–2,442
Cross-border bank claims ($bn)[3]											
All banks	1,162	303	1,539	3,561	613	2,821	648	2,402	1,342	6,844	2,961
Domestic banks	881	282	1,235	2,953	471	2,497	478	2,169	1,133	1,966	1,113
Foreign banks	280	21	304	608	141	324	169	233	209	4,878	1,848
Cross-border bank claims / external assets (%)[4]											
All banks	48	25	48	48	29	36	23	45	25	54	17
Domestic banks	37	24	38	40	23	32	17	41	30	15	6
Foreign banks	12	2	9	8	7	4	6	4	5	38	10
Net cross-border bank claims ($bn)											
All banks	191	40	146	1,568	–89	11	–294	1,690	149	–1,274	–754
Domestic banks	160	64	117	1,339	68	123	–130	1,623	207	–400	–814
Foreign banks	32	–24	30	229	–157	–111	–165	67	–59	–874	60
Pre-crisis: change in net positions Q4 2000–Q2 2007 ($bn)											
External assets	3	36	221	882	–729	145	–143	844	21	–488	–1,003
All banks	126	24	50	1,276	18	89	–176	771	109	–680	–573
Domestic banks	97	32	48	986	124	172	–63	631	161	–190	–420
Foreign banks	30	–8	2	290	–106	–84	–113	140	–51	–490	–152
During crisis: change in net positions Q2 2007–Q4 2007 ($bn)											
External assets	–5	–23	128	5	–202	111	–16	193	53	46	–108
All banks	51	17	25	277	–18	–32	–41	284	49	–269	7
Domestic banks	47	24	14	327	10	–46	–18	301	39	–107	–194
Foreign banks	3	–6	10	–50	–29	14	–23	–16	10	–162	200

[1] Stock of international assets held by residents (banks and non-banks) of the country listed in the column heading. [2] The calculations in the bottom half of the table on banks' net cross-border positions should be interpreted with caution. Banks located in the United Kingdom reported roughly $800 billion in liabilities for which the residency of the counterparty is unknown (see data appendix). The calculation in the table assumes that these "unallocated" liabilities are held by *non-residents*. Were we to assume that they were held by residents, then the net cross-border claims of domestic (foreign) banks would change from –$400 billion (–$874 billion) to –$48 billion (–$412 billion). [3] Cross-border claims (including inter-office claims) booked by banks' offices located in the country in the column heading. [4] Ratio of cross-border bank claims to gross external assets (row 1).

Sources: IMF IFS; BIS locational statistics by nationality.

offices contributed significantly to the change in the net external position in Italy and Spain as well. In any particular host country, a long or short net cross-border positions in a particular *currency* booked by the offices of foreign banks there may be offset or hedged elsewhere on those banks' global balance sheet. How, then, should we interpret the associated

"mismatches" on the national balance sheet of the host country? And to what extent do they reflect vulnerabilities faced by the host country residents?

The converse of this point is that it is generally difficult to identify a particular banking system's vulnerabilities by looking at the home country's domestic and external positions data. For example, in at least six countries (BE, CH, DE, FR, JP and NL), domestic banks' cross-border positions account for a third or more of the home country's external position (Table 2). Yet, Table 1 (bottom row) indicates that assets booked by offices *outside* the home country account for a significant share (a quarter or more) of each of these countries' national banking systems' total worldwide assets (with the exception of Japanese banks, at 6%). Therefore, vulnerabilities in these banks' balance sheets may not be visible in the home country's external position, even when combined with data on these banks' domestic positions (eg domestic credit and other such aggregates). Vulnerabilities can only be measured by taking into account the entire balance sheet of the consolidated global entity. Moreover, these vulnerabilities relate to domestic residents only to the extent that the residents hold exposures in the national banking system.

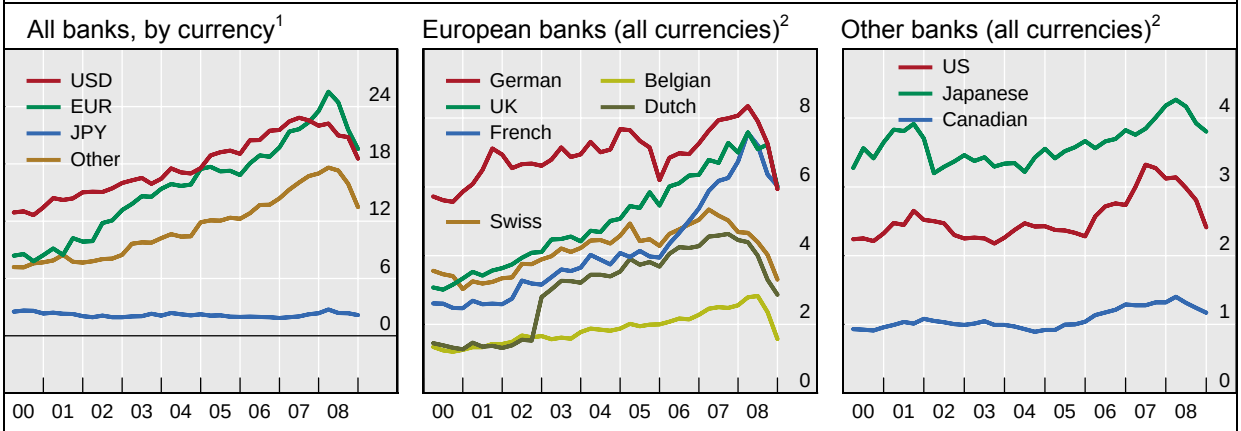
3.2 Balance sheet expansion since 2000

The origins of the US dollar shortage during the crisis are linked to the expansion since 2000 in banks' international balance sheets. The outstanding stock of banks' foreign claims grew from $10 trillion at the beginning of 2000 to $34 trillion by end-2007, a significant expansion even when scaled by global economic activity (Figure 1, left panel). The year-on-year growth in foreign claims approached 30% by mid-2007, up from around 10% in 2001. This acceleration took place during a period of financial innovation, which included the emergence of structured finance, the spread of "universal banking", which combines commercial and investment banking and proprietary trading activities, and significant growth in the hedge fund industry to which banks offer prime brokerage and other services.

At the level of individual banking systems, the growth in European banks' global positions is most noteworthy (Figure 1, centre panel). For example, Swiss banks' foreign claims jumped from roughly five times Swiss nominal GDP in 2000 to more than seven times in mid-2007 (Table 1). Dutch, French, German and UK banks' foreign claims expanded considerably as well. In contrast, Canadian, Japanese and US banks' foreign claims grew in absolute terms over the same period, but did not significantly outpace the growth in domestic or world

Foreign claims scaled by world GDP

In per cent



[1] Estimated totals for 19 banking systems (see data appendix). [2] Foreign claims excluding claims on residents of the home country booked by banks' foreign offices.

Sources: IMF; BIS consolidated statistics (immediate borrower basis); BIS locational statistics by nationality. Figure 1

GDP (Figure 1, right panel). While much of the increase for some European banking systems reflected their greater intra-euro area lending following the introduction of the single currency in 1999, their estimated US dollar- (and other non-euro-) denominated positions accounted for more than half of the overall increase in their foreign assets between end-2000 and mid-2007.

3.3 Cross-currency funding positions

How did banks finance this expansion, especially their foreign currency asset positions? This section examines *cross-currency* funding, or the extent to which banks invest in one currency and fund in another. This requires a breakdown by currency of banks' gross foreign positions, as shown in Figure 2, where positive (negative) positions represent foreign claims (liabilities). For some European banking systems, foreign claims are primarily denominated in the home country (or "domestic") currency, typically representing intra-euro area cross-border positions (eg Belgian, Dutch, French and German banks). For others (eg Japanese, Swiss and UK banks), foreign claims are predominantly in foreign currencies, mainly US dollars.

Foreign currency assets often exceed the extent of funding in the same currency. This is shown in Figure 3, where, in each panel, the lines indicate the overall *net* position (foreign assets minus liabilities) in each of the major currencies.[12] If we assume that banks' on-balance sheet *open* currency positions are small, these cross-currency net positions are a measure of banks' reliance on FX swaps. Many banking systems maintain long positions in foreign currencies, where "long" ("short") denotes a positive (negative) net position. These long foreign currency positions are mirrored in net borrowing in domestic currency from home country residents (recall equation (1)).[13] UK banks, for example, borrowed (net) in sterling (some $550 billion in mid-2007, both cross-border and from UK residents) in order to finance their corresponding long positions in US dollars, euros and other foreign currencies. By mid-2007, their long US dollar positions stood at $200 billion, on an estimated $2 trillion in gross US dollar claims. Similarly, German and Swiss banks' net US dollar books approached $300 billion by mid-2007, while that of Dutch banks surpassed $150 billion. In comparison, Belgian and French banks maintained a relatively neutral overall US dollar position prior to the crisis, while Spanish banks had borrowed US dollars to finance euro lending at home, at least until mid-2006.[14]

Taken together, Figures 2 and 3 thus show that several European banking systems expanded their long US dollar positions significantly since 2000, and funded them primarily by borrowing in their domestic currency from home country residents. This is consistent with European universal banks using their retail banking arms to fund the expansion of investment banking activities, which have a large dollar component and are concentrated in

---

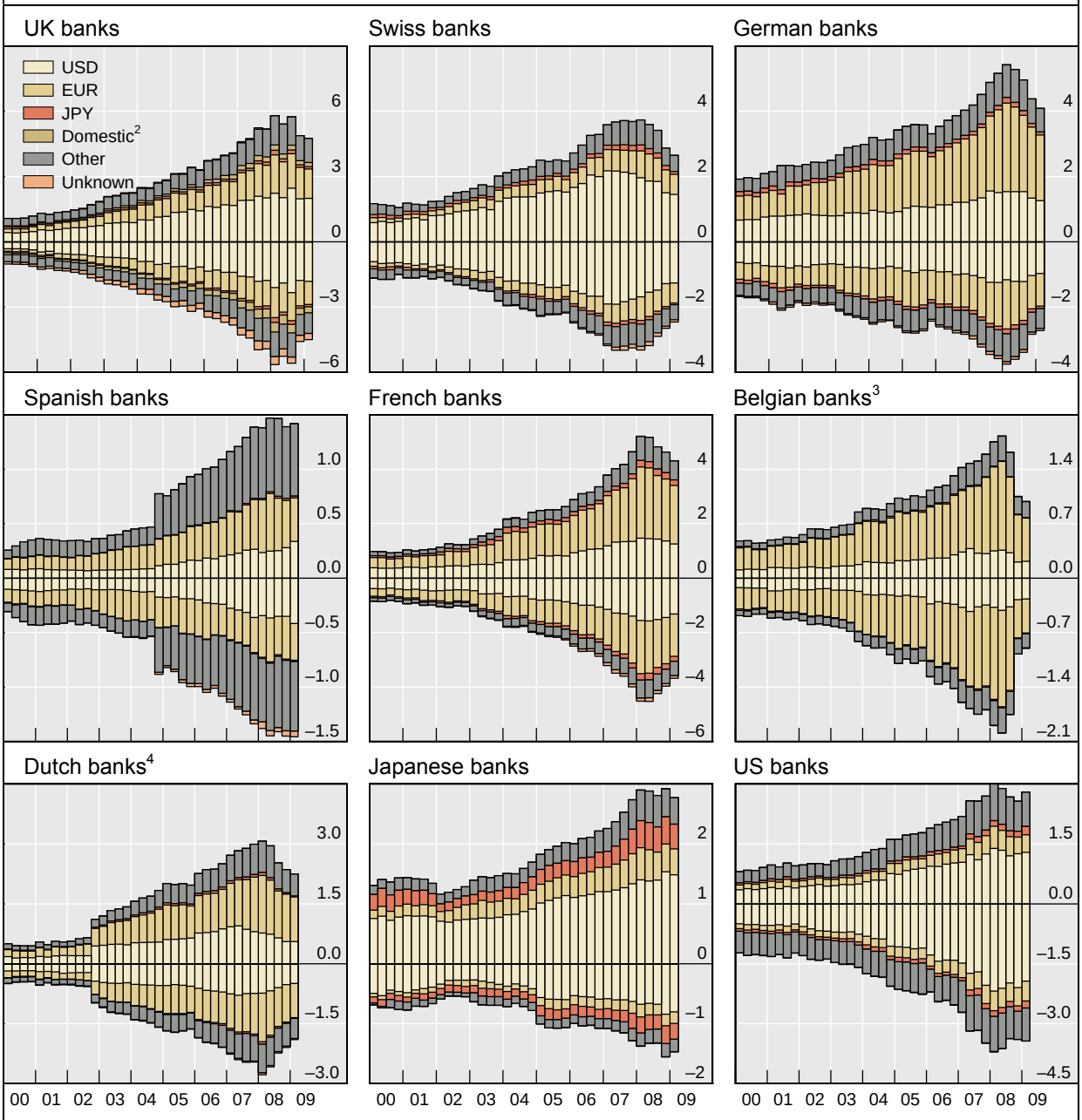
[12] The "unknown" liabilities in Figure 2 have been allocated (by currency) in Figures 3-5 using information on the currency split from the BIS International Debt Securities database (see the appendix for explanation).

[13] As mentioned in footnote 9, banks' "strictly domestic" positions are not reported in the BIS banking statistics. Their *gross* positions in their domestic currency booked by their home offices vis-à-vis home country residents are therefore unknown, but their *net position* (shown as the shaded area in Figure 3) can be inferred as a residual from the balance sheet identity (see equation (1) and data appendix). German banks' foreign claims in Figure 2, for example, comprise *all* of their foreign currency positions, but their euro positions only vis-à-vis counterparties outside Germany.

[14] The long net foreign claims of Japanese banks and the short net foreign claims of US banks mirror the (cumulative) current account positions of their respective home countries, reflecting the degree to which domestic banks' home offices accommodate international capital transfers. However, for the reasons elaborated in Section 3.1, the relationship between a country's external position and the foreign assets of the banks headquartered there is tenuous.

Gross foreign assets and liabilities, by currency[1]

In trillions of US dollars



[1] Positive (negative) values are assets (liabilities). [2] For UK banks, gross positions in domestic currency booked by these banks' home offices. [3] Prior to Q4 2005, local liabilities in local currency (LLLC) vis-à-vis some large European countries are estimated. The contraction in positions in Q4 2008 in part reflects the sale of some business units of Fortis. [4] Local positions (LCLC and LLLC) vis-à-vis advanced economies are available from Q4 2002. The contraction in positions in Q3 2008 in part reflects the sale of some business units of ABN AMRO.

Sources: BIS consolidated statistics (immediate borrower basis); BIS locational statistics by nationality. Figure 2

major financial centres. In aggregate, European banks' combined long US dollar positions grew to roughly $700 billion by mid-2007 (Figure 5, top left panel), funded by short positions in sterling, euros and Swiss francs.[15] As banks' cross-currency funding grew, so did their

[15] Adding in Japanese banks' $600 billion long US dollar position (Figure 3) brings the estimated total to $1.3 trillion.

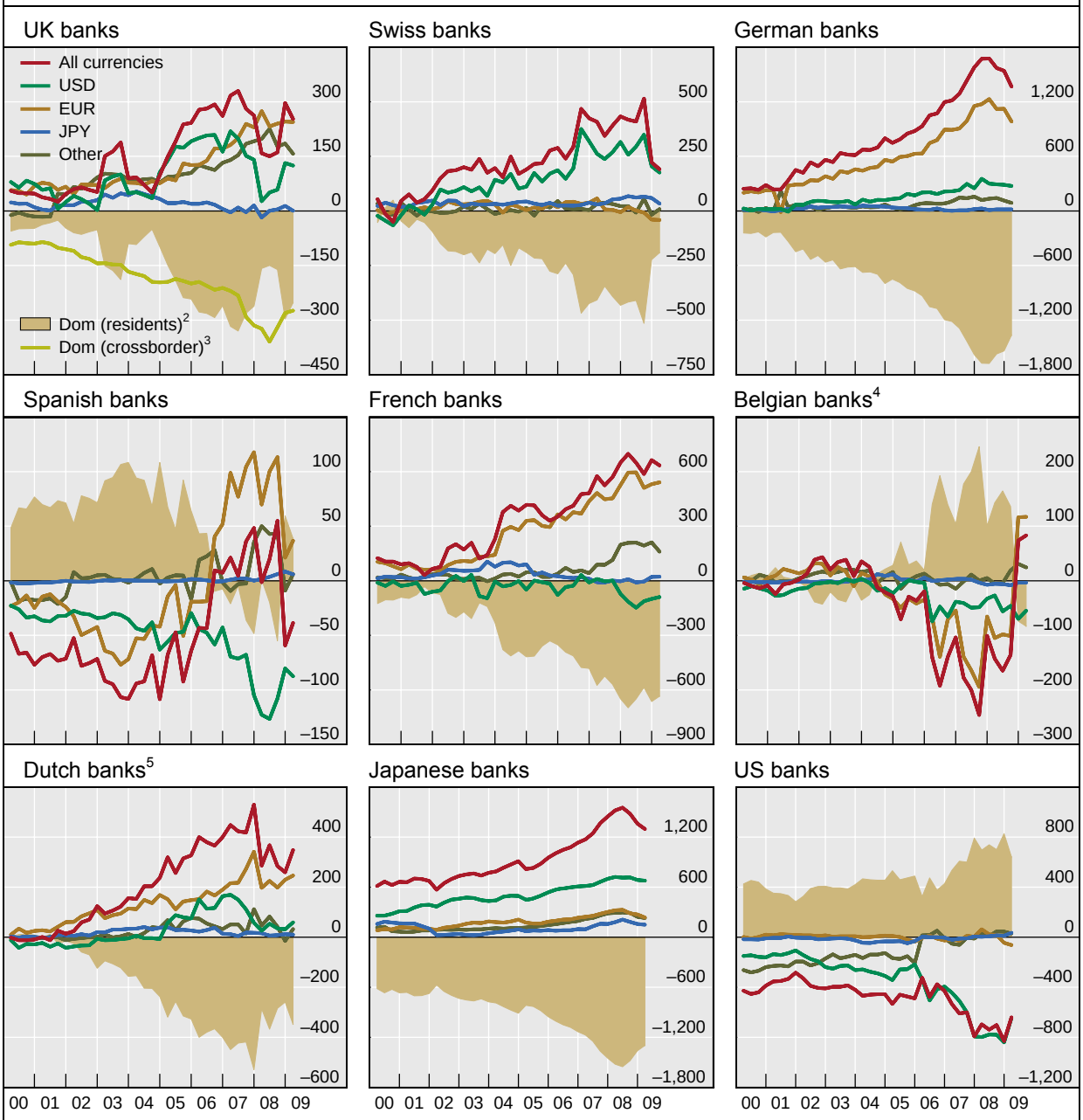
hedging requirements and FX swap transactions, which are subject to funding risk when these contracts have to be rolled over.

3.4 Maturity transformation across banks' balance sheets

As discussed in Section 2, funding risk hinges on the degree of maturity transformation embedded in banks' balance sheets. Unfortunately, data limitations make it difficult to obtain

Net foreign positions, by currency[1]

In billions of US dollars



[1] Net foreign positions are assets minus liabilities. [2] Implied net positions in domestic currency vis-à-vis residents of the home country, inferred from the balance sheet identity (see data appendix). [3] For UK banks, net cross-border positions in domestic currency booked by these banks' home offices. [4] Prior to Q4 2005, local liabilities in local currency (LLLC) vis-à-vis some large European countries are estimated. The contraction in positions in Q4 2008 in part reflects the sale of some business units of Fortis. [5] Local positions (LCLC and LLLC) vis-à-vis advanced economies are available from Q4 2002. The contraction in positions in Q3 2008 in part reflects the sale of some business units of ABN AMRO.

Sources: BIS consolidated statistics (immediate borrower basis); BIS locational statistics by nationality. Figure 3

an aggregate maturity profile of banks' foreign assets and liabilities. In this section, we argue that the *counterparty sector* breakdown available in the BIS banking statistics can serve as a proxy for maturity transformation, and hence funding risk, since the maturity of positions is likely to vary systematically with the type of counterparty.[16] We use this counterparty information to construct a measure of banks' *US dollar funding gap*, the amount of US dollars invested in longer-term assets which is not supported by longer-term US dollar liabilities, this gap being the amount that banks must roll over before their investments mature (equation (2)). We build up this argument in several steps.

The counterparty sector breakdown for European banks' gross US dollar assets and liabilities is shown in Figure 5 (top right panel). Interbank claims, which include interbank loans and debt securities claims, tend to be shorter-term or can be realised at shorter notice than claims on non-banks. We think of US dollar claims on *non-banks* as banks' *desired* US dollar investment portfolio. This portfolio of non-bank assets includes banks' retail and corporate lending, lending to hedge funds, and holdings of securities ranging from US Treasury and agency securities to structured finance products.[17] Whether these non-bank assets can be readily converted to cash depends upon the maturity of the underlying positions as well as on their market liquidity.

These US dollar investments are funded by liabilities to various counterparties. Banks can borrow US dollars directly from the interbank market, typically short-term. They can also raise US dollars via FX swaps (with bank or non-bank counterparties), which are even shorter-term on average.[18] In contrast, US dollar funding provided directly by *non-banks* includes corporate and retail deposits, deposits from central banks, and financing from money market funds, and is thus of varying maturities.[19] As described in Baba et al (2009), money market funds had become an important source of short-term US dollar financing, providing an estimated $1 trillion to European banks in 2007. If the effective maturity of liabilities to non-banks matches that of their investments in non-banks (ie is "longer-term"), then a lower-bound estimate of their US dollar funding gap is the *net* US dollar position vis-à-vis non-banks. If, on the other hand, banks' liabilities to non-banks were *all* short-term, then an upper-bound estimate of their funding gap is their *gross* US dollar position in non-banks. Figure 4, which focuses on the lower-bound measure, shows the considerable heterogeneity in the way European banks met their US dollar funding requirements. For example, Dutch, German, Swiss and UK banks had the largest funding gaps (green lines) by mid-2007.

---

[16] Using the counterparty sector also addresses the common problem that the effective maturity may differ from the maturity stated on bank balance sheets (Flannery and James (1984)). Demand deposits held by households, for instance, are a stable source of funding with a long *effective* maturity.

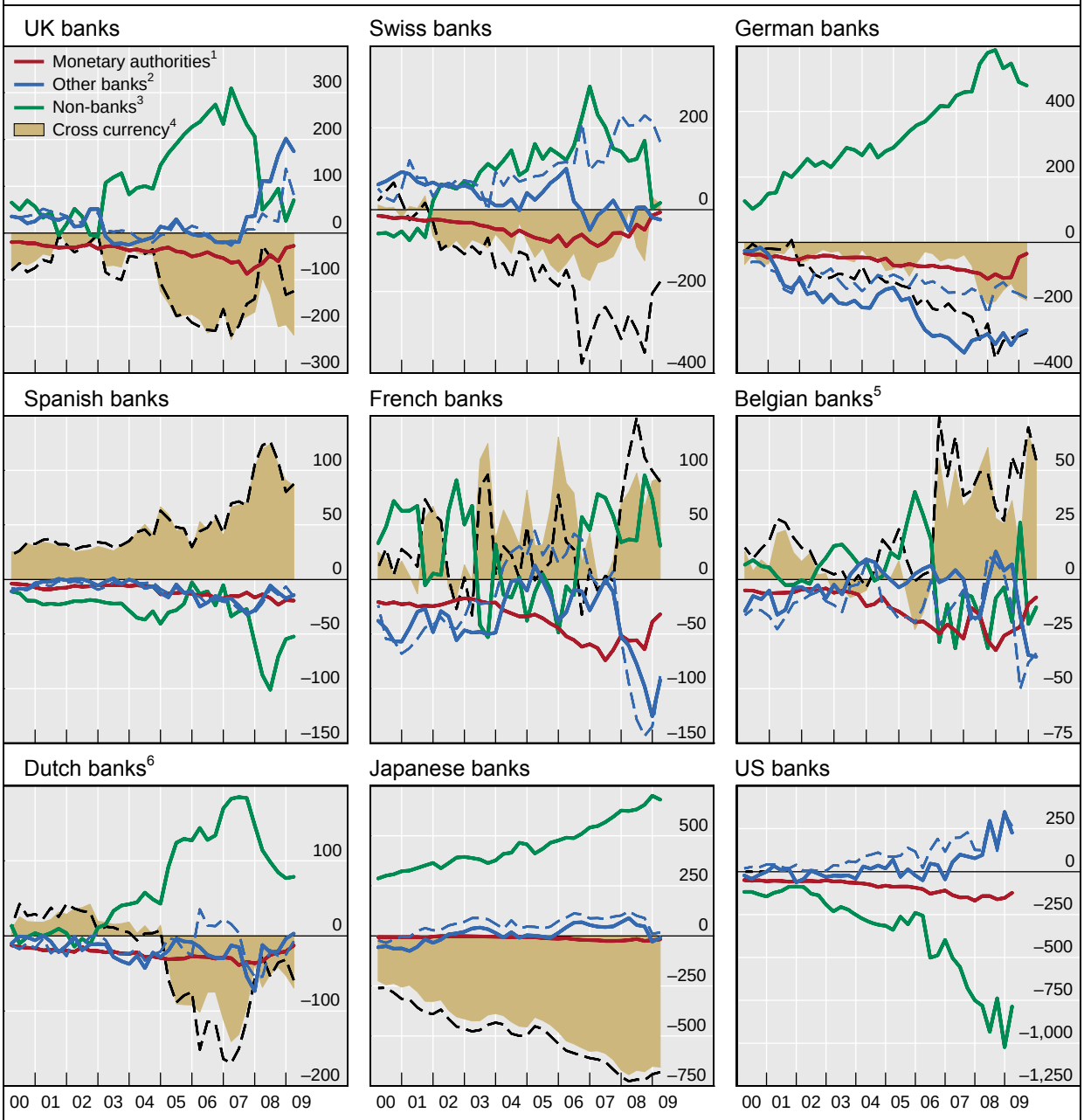
[17] No counterparty sector breakdown is available for banks' US dollar claims on US residents booked by their offices in the United States ("Local US positions" in Figure 5, top right panel), since these positions are taken from the CBS (see Table A in appendix). Overlaying our data set with the *BIS consolidated banking statistics (ultimate risk basis)* suggests that over 70% of these positions are vis-à-vis *non-bank private* entities. Alternative sources of data also indicate that the bulk of these positions is likely to be transactions with non-bank counterparties. For instance, BankScope data suggest that European bank subsidiaries in the United States book a small share (below 5%) of their total assets as interbank assets. Data on foreign banks' offices in the United States from the Federal Reserve H.8 release point in the same direction. Thus, our estimate of US dollar positions vis-à-vis non-banks (in Figures 4 and 5) is the sum of banks' *international* US dollar positions in non-banks and their local US positions.

[18] Evidence from the BIS Triennial Central Bank Survey (of 2007) indicates that 78% of FX swap turnover is accounted for by contracts with a maturity of less than seven days.

[19] In the BIS banking statistics, reporting banks' liabilities to official monetary authorities mostly reflect international deposits of foreign exchange reserves.

Net US dollar-denominated foreign positions, by counterparty sector

In billions of US dollars



[1] Cross-border positions in all currencies and local positions in foreign currencies vis-à-vis official monetary authorities. Excluding liabilities to Japanese monetary authorities placed in banks located in Japan. [2] The solid blue line tracks net interbank lending to other (unaffiliated) banks. The dashed blue line is an alternative measure of interbank positions which makes use of the available information on inter-office positions (see data appendix). [3] The estimated net position vis-à-vis non-banks is the sum of net international claims on non-banks and net local claims on US residents (vis-à-vis all sectors) booked by the US offices of the reporting bank. See footnote 17 in the main text. [4] Implied cross-currency funding (ie FX swaps) which equates gross US dollar assets and liabilities. The dashed black line is an alternative measure of cross-currency funding which makes use of the available information on inter-office positions (see data appendix). [5] Prior to Q4 2005, local liabilities in local currency (LLLC) vis-à-vis some large European countries are estimated. The contraction in positions in Q4 2008 in part reflects the sale of some business units of Fortis. [6] Local positions (LCLC and LLLC) vis-à-vis advanced economies are available from Q4 2002. The contraction in positions in Q3 2008 in part reflects the sale of some business units of ABN AMRO.

Sources: BIS consolidated statistics (immediate borrower basis); BIS locational statistics by nationality. Figure 4

However, their reliance on the interbank market (blue line), central bank deposits (red line) and FX swaps (shaded area) differed markedly.[20] UK banks maintained largely balanced net interbank US dollar positions, thus implying cross-currency funding, while German banks relied relatively more on interbank funding.

Taken together, these estimates suggest that European banks' US dollar investments in non-banks were subject to considerable funding risk at the onset of the crisis. The net US dollar book, aggregated across the major European banking systems, is portrayed in Figure 5 (bottom left panel), with the non-bank component tracked by the green line. By this measure, the major European banks' US dollar funding gap had reached $1.0–1.2 trillion by mid-2007. Until the onset of the crisis, European banks had met this need by tapping the interbank market ($432 billion) and by borrowing from central banks ($386 billion),[21] and used FX swaps ($315 billion) to convert (primarily) domestic currency funding into dollars.[22] If we assume that these banks' liabilities to money market funds (roughly $1 trillion, Baba et al (2009)) are also short-term liabilities, then the estimate of their US dollar funding gap in mid-2007 would be $2.0–2.2 trillion. Were *all* liabilities to non-banks treated as short-term funding, the upper-bound estimate would be $6.5 trillion (Figure 5, bottom right panel).

The funding patterns for Japanese and US banks in Figure 4 deserve comment as well. Japanese banks' estimated net US dollar claims on non-banks had risen beyond $600 billion by end-2007 and, compared with other banking systems, were skewed towards holdings of US government securities.[23] They financed these holdings primarily by borrowing in yen from Japanese residents. In contrast to Japanese banks, the data show that US banks borrowed roughly $750 billion internationally by end-2007, and channelled these funds to US residents (as implied by the shaded area in Figure 3). A closer look at the underlying data suggests that a large portion of their international liabilities to non-banks were booked by their offices in Caribbean offshore centres as liabilities to non-bank counterparties *located in* the United States (eg firms or money market mutual funds). This could be regarded as an extension of US banks' domestic activity since it does not reflect (direct) funding from non-banks outside the United States. Netting these positions would imply that their US dollar net borrowing from non-banks in the rest of the world is smaller than the green line in Figure 4 suggests (some $500 billion at end-2007).

---

[20] The figures on net interbank lending to other (unaffiliated) banks should be interpreted with caution. Incomplete reporting of inter-office positions makes it impossible to precisely pin down banks' net position vis-à-vis other banks, and hence their net FX swap position, which is backed out as a residual. In Figures 4 and 5, the solid blue lines and the corresponding shaded areas are the primary set of estimates; the dashed blue lines and corresponding dashed black lines are alternative estimates (see data appendix). This problem is particularly severe for Swiss banks.

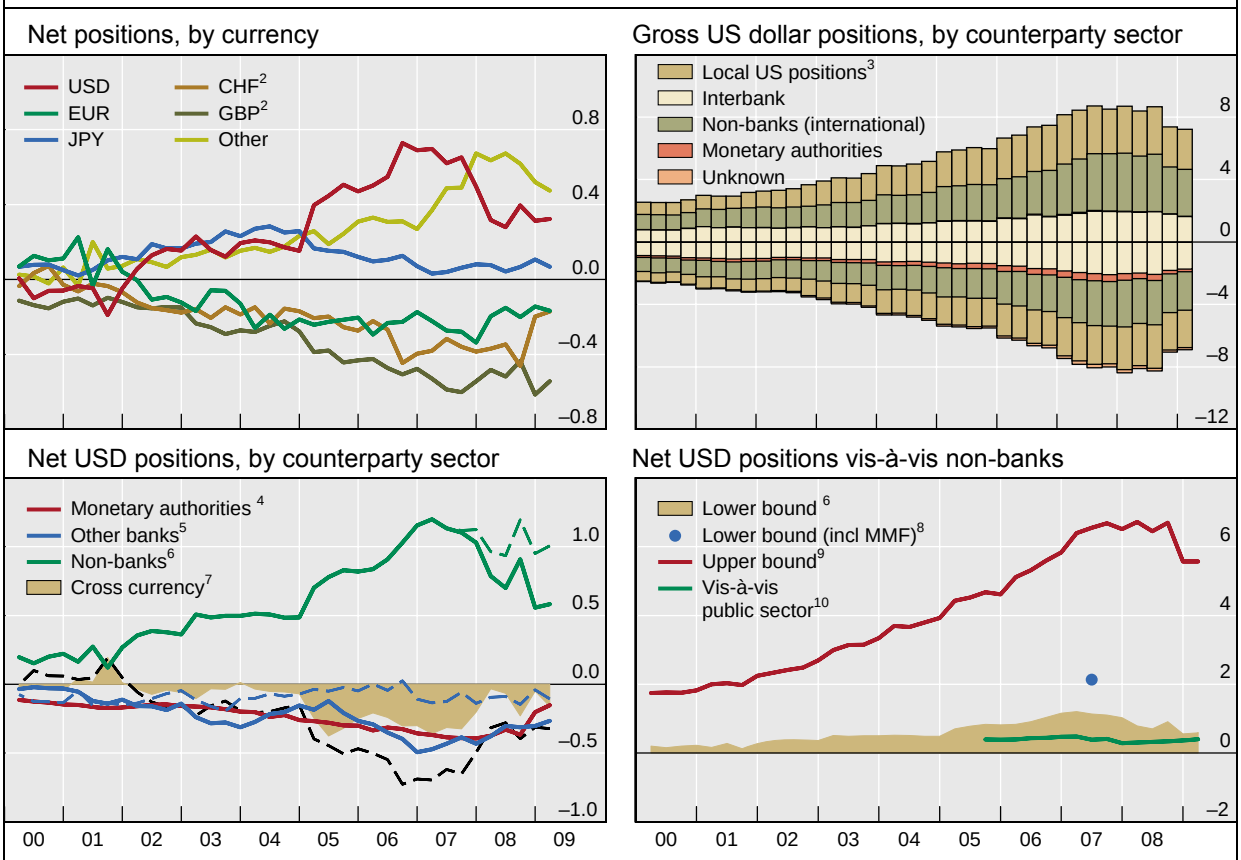
[21] In the BIS locational banking statistics, several countries (eg Germany, Japan and the United States) do not report liabilities (in foreign currency) vis-à-vis *domestic* official monetary authorities, which makes it difficult to identify precisely total liabilities to these counterparties. For example, data on foreign exchange reserve holdings reported to the IMF indicate that Japanese monetary authorities held roughly $118 billion in banks *located in* Japan in mid-2007 ($26 billion in Japanese banks and $92 billion in foreign banks in Japan). To the extent that these reserves are US dollar-denominated, the red lines in Figure 4 understate liabilities to official monetary authorities for all those banking systems which have offices in Japan, and which receive deposits from Japanese monetary authorities.

[22] The alternative estimates in Figure 5 (bottom left panel) for net interbank borrowing (dashed blue line) and cross-currency financing (dashed black line) were $127 billion and $620 billion, respectively, in mid-2007.

[23] Japanese banks' foreign claims on the public sector stood at $627 billion at end-2007, or 29% of their foreign claims. These public sector shares are higher than for any other banking system.

European banks' balance sheet positions[1]

In trillions of US dollars



[1] Estimates are constructed by aggregating the on-balance sheet cross-border and local positions reported by Belgian, Dutch, French, German, Italian, Spanish, Swiss and UK banks' offices. [2] Positions booked by offices located in Switzerland (for CHF) and in the United Kingdom (for GBP). CHF and GBP positions reported by offices located elsewhere are included in "Other". [3] US dollar positions vis-à-vis US residents booked by banks' offices in the United States (LCLC and LLLC). No sectoral breakdown is available for these positions. See footnote 17 in the main text. [4] Cross-border positions in all currencies and local positions in foreign currencies vis-à-vis official monetary authorities. Excluding liabilities to Japanese monetary authorities placed in banks located in Japan. [5] The solid blue line tracks net interbank lending to other (unaffiliated) banks. The dashed blue line is an alternative measure of interbank positions which makes use of the available information on inter-office positions (see data appendix). [6] The net position vis-à-vis non-banks is estimated as the sum of net international positions vis-à-vis non-banks and net local US positions (vis-à-vis all sectors). The dashed green line is the estimate of the US dollar funding gap when (cumulative) writedowns are incorporated (see text). [7] Implied cross-currency funding (ie FX swaps) which equates gross US dollar assets and liabilities. The dashed black line is an alternative measure of cross-currency funding which makes use of the available information on inter-office positions (see data appendix). [8] Lower bound estimate plus estimated US dollar liabilities to money market funds. [9] Consolidated *gross* claims on non-banks. [10] Consolidated *gross* claims (ultimate risk basis) on the US public sector.

Sources: BIS consolidated statistics (immediate borrower and ultimate risk basis); BIS locational statistics by nationality. Figure 5

4. The US dollar shortage

The implied maturity transformation in Figure 5 became unsustainable as banks' major sources of short-term funding turned out to be less stable than expected. Beginning in August 2007, heightened counterparty risk and liquidity concerns compromised short-term interbank funding (Taylor and Williams (2009)), visible in the rise of the blue line in the lower left panel. The related dislocations in FX swap markets made it even more expensive to obtain US dollars via currency swaps (Baba and Packer (2009a)), as European banks' US dollar funding requirements exceeded other entities' funding needs in other currencies.

European banks' funding difficulties were compounded by instability in the *non-bank* sources of funds as well. Money market funds, facing large redemptions following the failure of

Lehman Brothers, withdrew from bank-issued paper, threatening a wholesale run on banks (Baba et al (2009)). Less abruptly, a portion of the US dollar foreign exchange reserves that central banks had placed with commercial banks was withdrawn during the course of the crisis.[24] In particular, some monetary authorities in emerging markets reportedly withdrew placements in support of their own banking systems in need of US dollars.

Market conditions during the crisis have made it difficult for banks to respond to these funding pressures by reducing their US dollar assets. While European banks held a sizeable share of their net US dollar investments as (liquid) US government securities (Figure 5, bottom right panel), other claims on non-bank entities – such as structured finance products – have been harder to sell into illiquid markets without realising large losses. Other factors also hampered deleveraging of US dollar assets: banks brought off-balance sheet vehicles back onto their balance sheets and prearranged credit commitments were drawn.[25] Indeed, as shown in Figure 5 (top right panel), the estimated outstanding stock of European banks' US dollar claims actually rose slightly (by $248 billion or 3%) between Q2 2007 and Q3 2008.[26] It was not until the fourth quarter of 2008 that signs of deleveraging emerged.[27]

The frequency of rollovers required to support European banks' US dollar investments in non-banks became difficult to maintain as suppliers of funds withdrew from the market. Banks were thus forced to come up with US dollars, given their reliance on wholesale funding and short-term FX swaps. Essentially, the effective holding period of assets lengthened just as the maturity of funding shortened. This endogenous rise in maturity mismatch, difficult to hedge ex ante, generated the US dollar shortage.

Banks reacted to the dollar shortage in various ways, supported by actions taken by central banks to alleviate the funding pressures.[28] Prior to the collapse of Lehman Brothers (up to end-Q2 2008), European banks tapped funds in the United States; their local US dollar liabilities booked by their US offices, which included their borrowing from Federal Reserve facilities,[29] grew by $329 billion (13%) between Q2 2007 and Q3 2008, while their local assets remained largely unchanged (Figure 6, left panel). This allowed European banks to channel funds out of the United States via inter-office transfers (right panel), presumably to help their head offices replace US dollar funding previously obtained from the market.[30]

---

[24] Data complied from the 63 monetary authorities which report details on their foreign exchange holdings to the IMF indicate that central bank deposits with commercial banks dropped by $257 billion between mid-2007 and end-2008. See BIS (2009a) for discussion.

[25] Consistent with lines being drawn (or discontinued), unused credit commitments reported by European banks declined by $657 billion (18%) between mid-2007 and Q1 2009, primarily vis-à-vis US entities (down 29%).

[26] This is despite substantial asset writedowns of $280 billion by end-Q3 2008; by Q1 2009, the writedowns of European banks and brokers had reached $441 billion (Bloomberg).

[27] Between end-Q3 2007 and end-Q1 2009, the outstanding stock of European banks' US dollar claims fell by $1.5 trillion (17%). It is difficult to distinguish reductions in lending and asset disposal from writedowns of assets still on bank balance sheets (see BIS (2009a) for discussion). In addition, part of the overall reduction reflects the restructuring of several major European banks.

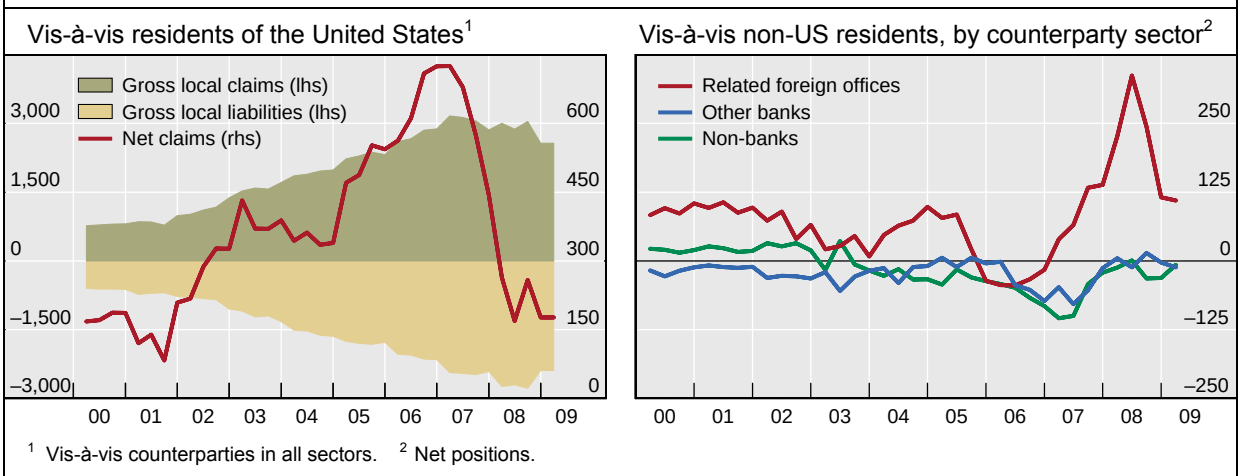
[28] The range of rescue programmes and their effects are reviewed in BIS (2009b) and ECB (2009).

[29] European banks with an established presence in the United States can borrow against collateral from the facilities the Federal Reserve makes available to depository institutions. A number of European banks have access to additional facilities in their capacity as primary dealers. The borrowing of US dollars by European banks' US offices from the Federal Reserve is captured in banks' local liabilities in local currency vis-à-vis the United States. This is not captured in their international liabilities to official monetary authorities (as in Figures 4 and 5), as it is neither in foreign currency nor cross-border.

[30] Similarly, Cetorelli and Goldberg (2008) present evidence that internationally active US banks often rely on internal markets, ie borrow from foreign affiliates to smooth liquidity shortages.

US dollar positions of European banks' US offices

In billions



[1] Vis-à-vis counterparties in all sectors. [2] Net positions.

Sources: BIS consolidated banking statistics (immediate borrower basis); BIS locational banking statistics by nationality. Figure 6

From the onset of the crisis to end-Q1 2009, the lower bound estimate of European banks' US dollar funding gap declined by nearly 50% (Figure 5, bottom panels). However, writedowns of securities and other mark-to-market losses during the crisis make this observed decline difficult to interpret. Specifically, writedowns of assets lead to decreases in the reported stock of US dollar claims, and thus a decline in net claims on non-banks. Ideally, we would measure the US dollar funding gap *directly*, as the sum of net interbank funding, net FX swap transactions and (possibly) net liabilities to official monetary authorities, in order to pick up the changes in *actual* net short-term funding liabilities (see equation (2)). However, in this analysis, the net FX swap positions are backed out as a residual. Thus, any writedown on the asset side is automatically reflected in a reduction in the estimated net FX swap positions.[31]

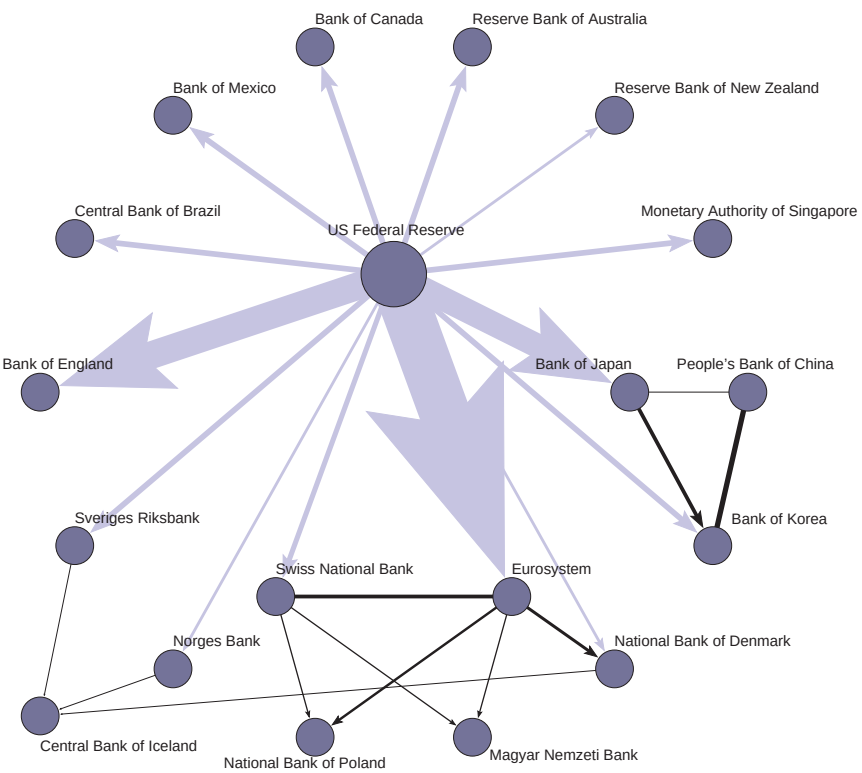
When asset writedowns are positive, the accuracy of the estimated US dollar funding gap thus depends on the extent to which banks *actually* unwound the funding positions supporting these written-down assets. If banks closed out all these funding positions by, for example, *buying* US dollars in the spot market, then the original estimate of the US dollar funding gap (solid green line in Figure 5, lower left panel) is correct through end-Q1 2009. If, on the other hand, banks have not closed out their funding positions, but rather rolled them over, then the observed measure will underestimate the true funding gap by the amount of the writedowns. In this case, if we assume that the bulk of European banks' writedowns (estimated by Bloomberg at $423 billion between Q2 2007 and Q1 2009) were related to their US dollar-denominated non-bank assets, then their US dollar funding gap at end-Q1 2009 would be in the neighbourhood of $880 billion (dashed green line) – still down from the pre-crisis peak, but considerably higher than the estimated $583 billion gap which results when the funding positions are assumed to have been closed.

[31] Only in the period *prior to the crisis*, when asset writedowns were zero, will the sum of the three components of net short-term liabilities be identically equal to the (negative of) the US dollar funding gap (net claims on non-banks).

5. The international policy response

The severity of the US dollar shortage among banks outside the United States called for an *international* policy response. While European central banks adopted measures to alleviate banks' funding pressures in their domestic currencies, they could not provide sufficient US dollar liquidity. Thus they entered into temporary reciprocal currency arrangements (swap lines) with the Federal Reserve in order to channel US dollars to banks in their respective jurisdictions (Figure 7). Swap lines with the ECB and the Swiss National Bank were announced as early as December 2007. Following the failure of Lehman Brothers in September 2008, however, the existing swap lines were doubled in size, and new lines were arranged with the Bank of Canada, the Bank of England and the Bank of Japan, bringing the swap lines total to $247 billion. As the funding disruptions spread to banks around the world, swap arrangements were extended across continents to central banks in Australia and New Zealand, Scandinavia, and several countries in Asia and Latin America, forming a global network (Figure 7). Various central banks also entered regional swap arrangements to distribute their respective currencies across borders.

Central bank network of swap lines

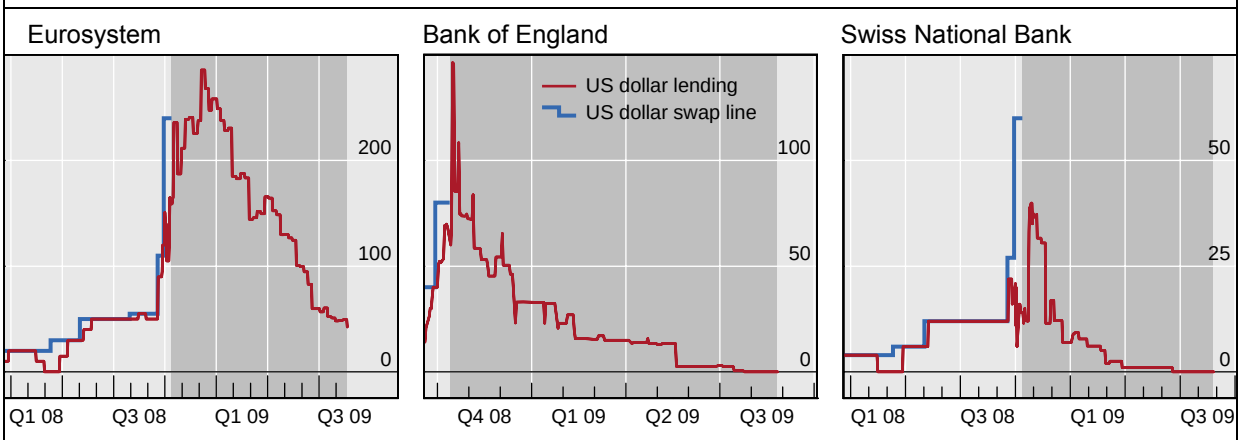


The arrows indicate the direction of flows (where known); light shaded arrows represent US dollars provided to other central banks, dark arrows represent other currencies (evaluated at the average exchange rate during Q4 2008). The thickness of the arrows is proportional to the size of central bank swap lines, as announced; where swap lines are unlimited, the figure shows maximum usage instead, derived from auction allotments (Figure 8). The ASEAN swap network is not shown.

Source: Central banks. Figure 7

Central banks' US dollar swap lines[1]

In billions



[1] Amounts outstanding are constructed by cumulating US dollar auction allotments, taking into account the term to maturity. The shaded area indicates the period of unlimited swap lines (as of 13 October 2008).

Source: Central banks. Figure 8

On 13 October 2008, the swap lines between the Federal Reserve and the Bank of England, the ECB and the Swiss National Bank became unlimited to accommodate *any* quantity of US dollar funding demanded. The swap lines provided these central banks with ammunition beyond their existing foreign exchange reserves (Obstfeld et al (2009)), which in mid-2007 amounted to $294 billion for the euro area, Switzerland and the United Kingdom combined, an order of magnitude smaller than our lower-bound estimate of the US dollar funding gap.[32]

In providing US dollars on a global scale, the Federal Reserve effectively engaged in *international lending of last resort*. The swap network can be understood as a mechanism by which the Federal Reserve extends loans, collateralised by foreign currencies, to other central banks, which in turn make these funds available through US dollar auctions in their respective jurisdictions.[33] This made US dollar liquidity accessible to commercial banks around the world, including those that have no US subsidiaries or insufficient eligible collateral to borrow directly from the Federal Reserve System.

The quantities of US dollars actually allotted through US dollar auctions in Europe provide an indication of European banks' US dollar funding shortfall at any point in time (Figure 8). Most of the Federal Reserve's international provision of US dollars was indeed channelled through central banks in Europe, consistent with the finding that the funding pressures were particularly acute among European banks. Once the swap lines became unlimited, the share provided through the Eurosystem, the Bank of England and the Swiss National Bank combined was 81% (15 October 2008), and it has remained in the range of 50–60% since December 2008.

How successful has the international policy response been? While it is too soon for conclusive answers, the immediate effects have been largely positive. Reflecting

[32] Line "Foreign currency reserves (in convertible foreign currencies)" from the IMF Template on International Reserves and Foreign Currency Liquidity, which includes reserves disclosed by central government and monetary authorities (Eurosystem, Swiss National Bank and Bank of England).

[33] The Federal Reserve press release of 13 October 2008 explicitly stated that the swap lines are to provide US dollar funding via the central banks to financial institutions abroad. The foreign currencies pledged to the Federal Reserve in exchange are best regarded as collateral. A new set of swap arrangements (announced on 6 April 2009) was necessary to authorise the Federal Reserve, should the need arise, to obtain and disburse the foreign currencies to US banks.

considerable demand in the aftermath of the Lehman bankruptcy, the amount of US dollars provided globally through international dollar swap lines surged in October 2008, and peaked at $583 billion in December 2008 (Federal Reserve Statistical Release H.4.1). Since then, the use of swap lines has gradually subsided, to $50 billion by early October 2009. In tandem, the level and spreads of US dollar interest rates, notably Libor, have receded from their historical peak in autumn 2008. Baba and Packer (2009b) find evidence that the US dollar auctions reduced the level and volatility of swap spreads. The policy also helped avert more extensive distress-selling of dollar-denominated assets, and possibly mitigated interbank rate volatility and upward pressure on the US dollar. [34]

Beyond addressing the immediate exigencies, however, the international swap arrangements are of broader interest from an institutional perspective.[35] The structure of the arrangements appears to overcome two challenges commonly associated with international lending of last resort. First, the Federal Reserve and its foreign counterparts have the power, in principle, to create any amount of money, in contrast with international financial institutions administering limited resources.[36] Demands in other currencies can similarly be met by including the respective currency-issuing central banks in the network of swap lines. Second, the swap network does not compound the informational problems that can give rise to moral hazard. By lending against collateral to foreign central banks that intermediate those funds to banks in their jurisdictions, the Federal Reserve assumes no credit risk vis-à-vis the ultimate borrowers, and delegates the task of monitoring the banks (or collateralising the loans) to the national authorities closer to the bank supervision process.[37]

6. Concluding remarks

The recent financial crisis has highlighted just how little is known about the structure of banks' international balance sheets and their interconnectedness. The globalisation of banking over the past decade and the increasing complexity of banks' international positions have made it harder to construct measures of funding vulnerabilities that take into account currency and maturity mismatches. This paper partially fills this void, investigating how banks funded their international positions across currencies and counterparties. The analysis shows that between 2000 and mid-2007, the major European banking systems built up long US dollar positions vis-à-vis non-banks and funded them by interbank borrowing, borrowing from central banks and FX swaps. We argue that this greater transformation across *counterparties* in fact reflected greater *maturity* transformation across these banks' balance sheets, exposing them to considerable funding risk. When heightened credit risk compromised

---

[34] At the same time, banks' increased reliance on the public availability of US dollar funding may have delayed the necessary restructuring of their balance sheets.

[35] The international swap arrangements are not unprecedented. A network of swap lines, also centred on the Federal Reserve Bank of New York, was set up in 1962 to support dollar parities in the Bretton Woods system of fixed exchange rates (Kindleberger (1996)).

[36] Effective lending of last resort requires sufficient resources to reassure markets that the means of payment will remain available in all circumstances (Bagehot (1873)). As the ultimate issuers of currencies, central banks are the natural lenders of last resort, which some take to imply that an international financial institution cannot play an analogous role internationally (Capie (1998), Schwartz (1999)). The recent literature on the design of the IMF or its lending policies takes into account its limited resources and focuses on moral hazard issues (Fischer (1999), Lerrick and Meltzer (2003)).

[37] The regulation and supervision of banks remains decentralised, and vested with domestic authorities at the national level. An international institution may find it difficult to contain moral hazard when lending to banks outside its regulatory and supervisory reach (Jeanne and Wyplosz (2003)).

sources of short-term funding during the crisis, the chronic US dollar funding needs became acute, particularly in the wake of the Lehman Brothers bankruptcy.

In contrast to many previous international financial crises, it was banks' international exposures to other industrialised countries that deteriorated, and the global interbank and FX swap funding structure which seized up. The build-up of such stresses at the global level can only be identified by tracking the extent of cross-currency funding, and by implication, banks' reliance on short-term interbank and FX swap positions. What pushed the system to the brink was not cross-currency funding per se, but rather too many large banks employing funding strategies *in the same direction*, the funding equivalent of a "crowded trade". Only when examined at the aggregate level can such vulnerabilities be identified. By quantifying the US dollar overhang on non-US banks' global balance sheets, this paper contributes to a better understanding of why the extraordinary international policy response was necessary, and why it took the form of a global network of central bank swap lines.

A broader message of this paper is that vulnerabilities in the international financial system are best measured along the contours of banks' consolidated balance sheets, rather than along national borders. This is because (i) stresses build up *across* the balance sheet – as mismatches between the maturity, currency and counterparty of assets *and liabilities* – and (ii) the consolidated balance sheets of the relevant decision-making units (ie banks) transcend national borders. The dataset constructed for this paper provides a fairly comprehensive picture of banks' funding patterns at the level of national banking systems. The macroprudential perspective afforded by these data shows that (i) stresses can build up in a national banking system that cannot be identified with the home country's residency-based statistics alone, and (ii) banks' cross-border positions are large relative to countries' external positions, clouding the interpretation of what the "national balance sheet" implies for domestic residents.

Data appendix: Reconstructing banks' global balance sheets

The analysis in this paper requires estimates of banks' consolidated asset and liability positions broken down by currency and counterparty sector. This data appendix describes how we construct these estimates, and highlights known data limitations.

The BIS international banking statistics

Table A shows the relevant balance sheet components (first column) and how the required breakdowns are captured in the BIS international banking statistics. The underlying data are taken from the *BIS consolidated banking statistics on an immediate borrower basis* (CBS) and the *BIS locational banking statistics by nationality* (LBSN).

The CBS are organised on the principle of bank *nationality*. They provide reporting banks' worldwide consolidated foreign claims (*FC*), which comprise cross-border claims (*XBC*) booked by all offices worldwide, and local claims (*LC*), or positions booked by banks' foreign offices vis-à-vis residents of the host country. Local claims are denominated in either "local currencies" (*LCLC*), ie the domestic currency of the host country, or in foreign currencies (*LCFC*). The statistics record cross-border claims and local claims in foreign currencies as a joint item called international claims (*INTC* = *XBC* + *LCFC*). These claims can be broken down by the country of residence of the counterparty. Therefore, banking system *b*'s foreign claims on borrowers in country *c* are

$$FC_{bc} = LCLC_{bc} + INTC_{bc} \quad \Rightarrow \quad FC_b = \sum_c FC_{bc}$$

While the counterparty sector (bank, non-bank private sector and public sector) is known for international claims, there is no currency breakdown for these positions nor information about the location of the booking office. Moreover, the CBS data contain no information on *international liabilities* (*INTL*). In contrast to international positions, both the currency and the location of the booking office are known for *LCLC* by definition. In addition, banks report their locally booked liabilities in local currencies (*LLLC*).

In contrast to the CBS, the LBSN are collected on the principle of bank *residence*. The "reporting unit" in the LBSN is any bank office (head office, branch or subsidiary) in a particular country or jurisdiction – including major offshore financial centres. Each bank office reports its cross-border claims *and* liabilities (*XBC* and *XBL*) as well as foreign currency claims and liabilities vis-à-vis residents of that country (*LCFC* and *LCFL,* if a foreign office; *DCFC* and *DLFC* if the home office). Importantly, these positions are broken down by *bank nationality* (ie the parent country of the booking office) as well as by *currency* and counterparty sector.[38] For instance, $XBC^{\$}_{rb}$ represents US dollar cross-border claims booked in reporting country *r* by banks headquartered in parent country *b*. The LBSN do not include information on the location (country) of the counterparty, nor do they include local claims and liabilities (ie vis-à-vis residents) in the domestic currency of the reporting country (*LCLC* and *LLLC*).

Construction of the dataset

The two sets of statistics contain *complementary* information on banks' global balance sheets. We merge these statistics to construct the required balance sheet components as

[38] The sectoral breakdown distinguishes positions vis-à-vis non-banks, vis-à-vis official monetary authorities and vis-à-vis banks. The interbank positions are further divided into inter-office positions (within the same bank group) and positions vis-à-vis other (unaffiliated) banks.

shown in Table A. The key step is to aggregate the LBSN data across the 40 reporting countries to obtain total international claims *and international liabilities* for each bank nationality (ie banking system), along with the currency and counterparty sector breakdowns that are unavailable in the CBS. As shown in the last column of Table A, combining these pieces from the LBSN with those from the CBS splice yields a complete breakdown by currency of all foreign positions. The only remaining missing pieces of the balance sheet are banks' "strictly domestic" positions, or their domestic currency assets and liabilities booked by home offices vis-à-vis residents of the home country (*DCLC* and *DLLC*). While their gross "strictly domestic" positions are unknown, their *net* position can be inferred as a residual from the balance sheet identity, as illustrated in equation (1) in the main text.

Table A

A breakdown of banks' consolidated worldwide positions

		Totals	**Breakdowns by**			
			Booking office location	**Residence of counterparty**	**Sector of counterparty**	**Currency of positions**
ASSETS	Domestic claims (DC)[1]					
	in foreign currency (DCFC)	LBSN	LBSN	LBSN	LBSN	LBSN
	in local currency (DCLC)					
	Foreign claims (FC)	CBS		CBS		
	Cross-border claims (XBC)	LBSN	LBSN		LBSN	LBSN
	International claims (INTC)[2]	CBS LBSN	LBSN	CBS	CBS LBSN	LBSN
	Local claims (LC)[3]					
	in foreign currency (LCFC)	LBSN	LBSN	LBSN	LBSN	LBSN
	in local currency (LCLC)	CBS	CBS	CBS		CBS
LIABILITIES	Domestic liabilities (DL)[1]					
	in foreign currency (DLFC)	LBSN	LBSN	LBSN	LBSN	LBSN
	in local currency (DLLC)					
	Foreign liabilities (FL)					
	Cross-border liabilities (XBL)	LBSN	LBSN		LBSN	LBSN
	International liabilities (INTL)[2]	LBSN	LBSN		LBSN	LBSN
	Local liabilities (LL)[3]					
	in foreign currency (LLFC)	LBSN	LBSN	LBSN	LBSN	LBSN
	in local currency (LLLC)	CBS	CBS	CBS		CBS

CBS = consolidated banking statistics on an immediate borrower basis; LBSN = locational banking statistics by nationality.

[1] Domestic claims (liabilities including equity) in the home country. [2] International claims INTC ≡ XBC + LCFC, and international liabilities INTL ≡ XBL + LLFC. [3] Local positions booked by banks' foreign offices *outside* the home country.

Consider, for example, UK-headquartered banks. Summing across all reporting countries (indexed by *r*) in the LBSN where UK banks have offices gives UK banks' international claims and liabilities on a global consolidated basis, or

$$INTC_b = \sum_r \left(XBC_{rb} + LCFC_{rb} \right).$$

This aggregate compares to *INTC* in the CBS, but now comes with detailed breakdowns by currency and counterparty sector. To match worldwide consolidated foreign claims (*FC* from the CBS), the only missing balance sheet components are UK banks' local claims and liabilities in the domestic currencies of various host countries (*LCLC* and *LLLC*). This information is available in the CBS reported by the United Kingdom.

The combined dataset thus yields, for 19 banking systems, foreign claims and liabilities on a worldwide consolidated basis both broken down by (i) the currency of the position, (ii) the location of the booking office and (iii) the counterparty type (bank, non-bank, central bank), and with partial information on the residency (country) of the counterparty (ie for local positions, the residency of the counterparty is known by construction; for cross-border positions, the residency of the counterparty is unknown).

Consistency check and data limitations

In principle, for each banking system, total $INTC_b$ (summed across reporting countries in the LBSN) plus *LCLC* (summed across borrowing countries in the CBS) should correspond to total foreign claims reported in the CBS. That is,

$$\sum_r \left(XBC_{rb} + LCFC_{rb} \right) + \sum_c LCLC_{bc} = FC_b.$$

This serves as a consistency check across the two datasets for the asset side of the balance sheet. There is no corresponding check on the liability side since banks do not report foreign liabilities (*FL*) in the CBS.

In practice, some statistical discrepancies arise because the two sets of statistics are collected in fundamentally different ways. For many banking systems (Belgian, Canadian, Dutch, French, German, Italian, Spanish and UK banks) the match is fairly close. The match is not as satisfactory for Swiss and US banks. Discrepancies arise for three main reasons. First, the set of reporting banks in the CBS differs from that reporting LBSN in various reporting countries.[39] Second, some banking systems have offices in countries that do not report in the LBSN, yet those offices are included in the worldwide consolidated positions reported in the CBS. In addition, some countries report incomplete positions in the LBSN; the United States, for example, does not report foreign currency positions vis-à-vis US residents.

A third problem that affects the calculations is that the residency, counterparty sector and currency of a portion of banks' liabilities are unknown. These "unknown" liabilities are typically *debt securities* issued by banks. Once these securities are traded on secondary markets, reporting banks no longer know the residency or the counterparty sector of the entity that holds these securities. Unfortunately, when the data are reported to the BIS, the currency of these "unallocated" positions is not reported, even though, in principle, this is known by the reporting banks. While these positions are small on a gross basis (Figure 2), they are large on a net basis (Figures 3 and 4), and thus should not be excluded from the analysis.

Across all reporting countries, the United Kingdom reports by far the largest "unallocated" liability positions (roughly $800 billion in mid-2007 for the major European banks' offices located there). The currency denomination of these liabilities can be estimated by using the

[39] This is problematic in the case of US banks, since the major US investment banks are generally included in the LBSN (reported by all countries), but were not included in the CBS reported by the United States until Q1 2009, the last quarter of our sample.

BIS international debt securities database, which provides information on issuance of debt securities by banks located in various countries around the world. In Figure 2, the unknown positions are plotted in their raw form, whereas in Figures 3, 4 and 5 the positions are allocated by currency by applying the currency split from the debt securities database. Because the counterparty sector of these positions, needed for Figures 4 and 5, remains unknown, we make the conservative assumption that all unallocated US dollar liabilities are held by *non-banks*. This assumption biases downwards the net positions vis-à-vis non-banks (our lower-bound estimate of the US dollar funding gap) in Figure 4 and Figure 5 (bottom panels).

Finally, the breakdowns by sector and currency in the LBSN are in some cases incomplete. For each banking system *b*, total interbank claims (*IBC*) in a particular currency are the sum of claims on other (unaffiliated) banks (*OTHBC*) and inter-office claims (*IOC*). That is,

$$IBC_b = \sum_r IBC_{rb} = \sum_r \left(OTHBC_{rb} + IOC_{rb}\right),$$

with a corresponding equation for interbank liabilities. The inter-office asset and liability positions must be stripped out of total foreign claims in order to make the LBSN and CBS data comparable on a gross basis, as in Figures 2 and 5. Some LBSN-reporting countries/regions, however, do not provide a complete currency breakdown (eg Singapore, Hong Kong SAR and the Channel Islands), while others provide only limited currency information for inter-office positions (eg France, Germany, Italy and Japan split inter-office activity into domestic and foreign currencies). To the extent possible, we estimate the missing inter-office components, although some uncertainty still remains in the overall interbank positions for some banking systems. This makes it difficult to pin down the extent of reliance on interbank financing, as shown by the two alternative estimates presented in Figures 4 and 5. On a *net* basis (claims minus liabilities), inter-office positions should, in principle, sum to zero across all reporting office locations. This implies that net "interbank" claims (*IBC* – *IBL*) should equal net claims on "other banks", both of which are observable in the data:

$$\sum_r \left(IOC_{rb} - IOL_{rb}\right) = 0 \;\Rightarrow\; \sum_r \left(IBC_{rb} - IBL_{rb}\right) = \sum_r \left(OTHBC_{rb} - OTHBL_{rb}\right).$$

The solid blue lines in Figures 4 and 5 track $\sum_r \left(IBC_{rb} - IBL_{rb}\right)$, or net interbank positions calculated without stripping out inter-office positions, while the dashed blue line tracks $\sum_r \left(OTHBC_{rb} - OTHBL_{rb}\right)$, or the reported positions vis-à-vis unaffiliated banks only. The dashed black lines in Figures 4 and 5 track the implied reliance on FX swaps which corresponds to this alternative estimate of interbank positions. Which set of estimates is more accurate depends on the relative sizes of observed versus missing inter-office positions, and whether banks have offices with (unobserved) offsetting positions in non-reporting countries.

References

Allen, F and D Gale (1998): "Optimal financial crises", *Journal of Finance*, 53(4), pp 1245–84.

Baba, N and F Packer (2009a): "Interpreting deviations from covered interest parity during the financial market turmoil of 2007–08", *Journal of Banking and Finance*, forthcoming.

——— (2009b): "From turmoil to crisis: dislocation in the FX swap market before and after the failure of Lehman Brothers", *Journal of International Money and Finance*, forthcoming.

Baba, N, R McCauley and S Ramaswamy (2009): "Dollar money market funds and non-US banks", *BIS Quarterly Review*, March.

Bagehot, W (1873): *Lombard Street: a description of the money market*, New York: Scribner, Armstrong & Co.

Bank for International Settlements (2009a): "Highlights of international banking and financial market activity", *BIS Quarterly Review*, June.

——— (2009b): "An assessment of financial sector rescue programmes", *BIS Papers*, no 48, July.

Bernanke, B (2008): "Policy coordination among central banks", speech at the Fifth European Central Bank central banking conference, Frankfurt, 14 November.

Capie, F (1998): "Can there be an international lender of last resort?", *International Finance*, 1(2), pp 311–25.

Cetorelli, N and L Goldberg (2008): "Banking globalization, monetary transmission, and the bank lending channel", *NBER Working Papers*, no 14101.

Chang R and A Velasco (2000): "Financial fragility and the exchange rate regime", *Journal of Economic Theory*, 92, pp 1–34.

——— (2001): "A model of financial crises in emerging markets", *Quarterly Journal of Economics*, 116, pp 489–517.

Devereux, M and A Sutherland (2009): "Valuation effects and the dynamics of net external assets", *Journal of International Economics*, forthcoming.

Diamond, D and R Rajan (2001): "Liquidity risk, liquidity creation, and financial fragility: a theory of banking", *Journal of Political Economy*, 109(2), pp 287–327.

——— (2006): "Money in a theory of banking", *American Economic Review*, 96(1), pp 30–53.

European Central Bank (2009): *EU banks' funding structures and policies*, May.

Faria, A and P Mauro (2009): "Institutions and the external capital structure of countries", *Journal of International Money and Finance*, 28, pp 367–91.

Fischer, S (1999): "On the need for an international lender of last resort", *Journal of Economic Perspectives*, 13(4), pp 85–104.

Flannery, M and C. James (1984): "Market evidence on the effective maturity of bank assets and liabilities", *Journal of Money, Credit and Banking*, 16(4,1), pp 435–45.

Forbes, K (2008): "Why do foreigners invest in the United States?", *NBER Working Papers*, no 13908.

Fukao, M (1991): "Exchange rate movements and capital-asset ratio of banks: on the concept of structural positions", *BOJ Monetary and Economic Studies*, 9(2), September.

Goodhart, C (1995): *The central bank and the financial system,* MIT Press.

Jeanne, O and C Wyplosz (2003): "The international lender of last resort: how large is large enough?", in M Dooley and J Frankel (eds), *Managing currency crises in emerging markets*, University of Chicago Press, pp 89–118.

Kindleberger, C (1950): *The dollar shortage*, MIT Press and John Wiley & Sons, Inc.

——— (1996): *Manias, panics, and crashes – a history of financial crises*, John Wiley & Sons, Inc.

Lane, P and G M Milesi-Ferretti (2001): "The external wealth of nations: measures of foreign assets and liabilities for industrial and developing countries", *Journal of International Economics*, 55(2), pp 263–294.

Lane, P and J Shambaugh (2009a): "Financial exchange rates and international currency exposures", *American Economic Review*, forthcoming.

——— (2009b): "The long of short of it: determinants of foreign currency exposure in external balance sheets", *NBER Working Papers*, no 14909.

Lerrick, A and A Meltzer (2003): "Blueprint for an international lender of last resort", *Journal of Monetary Economics*, 50, pp 289–303.

McCauley, R (1984): "Maturity matching in the euromarkets", *New York Federal Reserve Quarterly Review*, 9(1), pp 33–5.

Mishkin, F (1999): "Global financial instability: framework, events, issues", *Journal of Economic Perspectives*, 13(4), pp 3–20.

Morgan, G and S Smith (1987): "Maturity intermediation and intertemporal lending policies of financial intermediaries", *Journal of Finance*, 42(4), pp 1023–34.

Obstfeld, M, J Shambaugh, and A Taylor (2009): "Financial instability, reserves, and central bank swap lines in the panic of 2008", *American Economic Review*, 99(2), pp 480–86.

Peek, J and E Rosengren (2001): "Determinants of the Japan premium: actions speak louder than words", *Journal of International Economics*, 53, pp 283–305.

Rajan, R and I Tokatlidis (2005): "Dollar shortages and crises", *International Journal of Central Banking*, 1(2), pp 177–220.

Schwartz, A (1999): "Is there a need for an international lender of last resort?", *Cato Journal*, 19(1), pp 1–6.

Stigum, M and A Crescenzi (2007): *Stigum's Money Market*, fourth edition, McGraw Hill.

Taylor, J and J Williams (2009): "A black swan in the money market", *American Economic Journal: Macroeconomics*, 1(1), pp 58–83.

Tille, C and E van Wincoop (2007): "International capital flows", *NBER Working Papers*, no 12856.

Triffin, R (1957): *Europe and the money muddle – from bilateralism to near-convertibility 1947–1956*, Yale University Press.