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A Network Analysis of Sectoral Accounts: Identifying Sectoral Interlinkages in G-4 Economies

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Prepared by Luiza Antoun de Almeida[1]

Abstract

The recent financial crisis highlighted that balance sheet exposures can be a major shock transmission channel. Using sectoral accounts data in combination with data from the Coordinated Portfolio Investment Survey, International Investment Position, and BIS this paper estimates bilateral exposures between financial and non-financial sectors in three different financial instruments within and across G-4 economies (Euro Area, Japan, U.K. and U.S.). The generated financial networks represent a powerful tool for assessing financial stability, as they allow for the identification of systemically important sectors. The analysis suggests that after the financial crisis bilateral exposures in debt securities have increased, while exposures in loans and equities have declined. Shock simulations reveal that the vulnerability of the financial sector to the government sector has increased considerably since the outbreak of the financial crisis.

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Keywords: Balance sheet exposures, cross-border exposures, Data Gaps Initiative (DGI), financial networks, financial stability, sectoral accounts

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I. INTRODUCTION

The 2007–2009 financial crisis highlighted the importance of identifying balance sheet exposures and interconnectedness between sectors for assessing financial stability. Nonetheless, at the outbreak of the crisis essential information on bilateral exposures between sectors was largely lacking. Against this background, the International Monetary Fund (IMF) and the Financial Stability Board (FSB) launched the Data Gaps Initiative in 2009 with 20 recommendations to be implemented in the years to come. Recommendation 15 reads "the Inter-Agency Group (IAG),[2] which includes all agencies represented in the Inter-Secretariat Working Group on National Accounts, [shall] develop a strategy to promote the compilation and dissemination of the balance sheet approach (BSA), flow of funds, and sectoral data more generally, starting with the G-20 economies. Data on nonbank financial institutions should be a particular priority."[3]

This paper overcomes the partial non-availability of counterparty information (from-whom-to-whom data) in sectoral accounts data by estimating the missing information from aggregate balance sheets for G-4 economies (Euro Area, Japan, U.K., and U.S.). Furthermore, it combines sectoral accounts data with the IMF's Coordinated Portfolio Investment Survey (CPIS) and International Investment Position (IIP) dataset and BIS data in order to calculate cross-border exposures between country-sector pairs. The generated financial networks identify the structure of financial linkages between sectors within and across G-4 economies and how this structure changes over time. They diagnose in which financial instrument exposures are high, which sectors pose a threat to the system if they fail (the so-called systemically important sectors), and which sectors are the most vulnerable. In fact, the granularity of sectoral accounts data, with its breakdown by instrument and sector, provides a comprehensive framework to identify exactly in which instrument financial exposures are building up and which sectors play a key role in the propagation of shocks. Such an assessment of financial stability enables policymakers to recognize balance sheet exposure risks on time and formulate the necessary counteracting measures.

This paper is the first to compare sectoral interlinkages across G-4 economies and to estimate cross-border sectoral interlinkages broken down by instruments which go beyond the banking sector by combining different datasets. The results suggest that after the financial crisis exposures in debt securities have increased considerably at the country level in all G-4 economies, while cross-border exposures have remained stable. A deeper look demonstrates that exposures have increased above all vis-à-vis governments at the country and at the cross-border level. Shock simulations reveal that the exposure of the domestic financial sector to

[2] The IAG includes the BIS, ECB, IMF (chair), OECD, UN, and World Bank.

[3] "The Financial Crisis and Information Gaps. Report to the G-20 Finance Ministers and Central Bank Governors," prepared by the IMF Staff and FSB Secretariat, October 29, 2009. See also the progress reports on the implementation of the Data Gaps Initiative (DGI) from May 2010, June 2011, September 2012, September 2013, and September 2014.

the government sector has considerably increased after the financial crisis. There are also shifts in the exposure distribution, with cross-border exposures vis-à-vis the U.S. government increasing, while cross-border exposures vis-à-vis U.S. other financial intermediaries are decreasing.

On the other hand, exposures in loans and equities contracted sharply during the period of rising exposures to government debt securities after the financial crisis. While the decline in loan exposures was much larger at the cross-border level than at the country level, the decline in equity exposures was more accentuated at the country level than at the cross-border level. This pattern may be explained by the fact that a large share of cross-border equity exposure is made up of less volatile direct investments. Monetary financial institutions resident in the U.K. were the sector that reduced its national and cross-border loan exposures most, followed by U.S. monetary financial institutions, which substantially decreased their national exposures. In the Euro Area, while monetary financial institutions reduced their loan exposures, other financial intermediaries and nonfinancial corporations increased theirs, hinting at the emergence of alternative funding sources after the drying-up of bank credit. Unlike most countries, monetary financial institutions in Japan increased their cross-border exposures in loans after the crisis.

II. Brief Review of the Literature

Previous research has used information contained in sectoral accounts data in three related contexts. First, the data provide information on the borrowing and lending activities of different economic sectors and credit cycles have been found to have a major influence on economic performance and, thus, on monetary and fiscal policy. For example, Bonci (2012) shows estimating a VAR with euro area data that, after a contractionary monetary policy shock, the amount of bank loans to the real sector decreases while the amount of nonbank loans increases, households increase precautionary savings, and the government's budget deficit increases.

Second, sectoral accounts data have also been used to track balance sheets of different economic sectors, particularly the shadow banking industry (nonbank financial institutions). Bakk-Simon et al. (2012) use sectoral accounts data to measure the size of shadow banking and its interconnections with the traditional banking sector. Errico et al. (2014) go one step further by combining sectoral accounts data with IIP, CDIS, CPIS, and BIS data to analyze the U.S. shadow banking sector by breaking down its claims and liabilities by counterparty country and sector. Apart from shadow banking, Rusher and Wolff (2010) show that balance sheet adjustments can have a major impact on GDP growth, as aggregate demand is negatively affected when firms seek to increase their internal funds.

Third, some studies have used sectoral accounts in order to identify interconnections among economic agents and assess financial stability and systemic risk. Until recently, most network analysis research on financial stability has focused on interbank markets at the firm level or at the country level using cross-border banking flows data (e.g., Becher, Millard, and

Soromaki (2008), Upper and Worms (2004), and McGuire and Tarashev (2008), Moebert and Weistroffer (2010)). However, implications can be much stronger by focusing on the whole financial system and its main economic agents instead of individual institutions or country-specific aggregates. Several papers highlight the potential relevance of sectoral accounts data for financial stability surveillance (Allen et al (2002), Shrestha et al (2012), and Heath (2013)). Castrén and Kavonius (2009) use sectoral accounts data to demonstrate bilateral exposures between sectors in euro area countries via network analysis. They simulate how shocks propagate through the network via balance sheet exposures. Okuma (2012) does a similar analysis for Japan.

Furthermore, Castrén and Kavonius show that bilateral financial linkages have grown remarkably in euro area countries in the years previous to the financial crisis and that banks play a key role in the euro area financial systems. One caveat of their study is that the financial networks between sectors are restricted to the country level. Castrén and Rancan (2014) extend Castrén and Kavonius' study by connecting the EMU countries via the banking sector and considering thus also cross-border exposures. This is possible because the ECB provides data for banks' cross-border exposures broken down by instrument and counterparty country within the Euro Area. Their main findings are that the impact of a shock depends on its initial location in terms of the financial instruments, economic sector and country of origin. Moreover, they find that network statistics have predictive power of the impact of a shock in the system and that a more diversified cross-border exposure structure reduces the propagation of losses through the system.

This paper builds on the sectoral accounts network analysis literature by extending Castrén and Rancan's study of euro area countries to G-4 economies and by allowing cross-border exposures to exist beyond the banking sector. The breakdown of cross-border exposures by instrument and sector offers major advantages in comparison to using the BIS data of bank claims in all instruments, as developments in cross-border exposures vary across instruments and sectors, and such differences cannot be recognized using aggregate bank data. For example, while cross-border exposures in loans significantly decreased after the financial crisis, cross-border exposures in debt securities remained stable in general and increased vis-à-vis governments. The central motivation for extending the analysis is the interconnectedness of G-4 economies and the relevance of nonbank cross-border exposures. In fact, the financial crisis started in a small market segment in the U.S. and quickly spread to the rest of the world. Furthermore, global financial hubs, such as the U.S. and the U.K., are of particular importance for assessing global financial stability.

III. DATA: SCOPE AND LIMITATIONS

Data on financial balance sheets broken down by instrument and institutional sector come from the Principal Global Indicators (PGI) website, which also provides data on financial and non-financial transactions with the same breakdown. Deposits, securities other than shares, loans, and equity represent the largest instrument categories. The definition of the different transactions and institutional sectors as well as the overall framework is based on the System of National Accounts (SNA), a worldwide reference manual for the compilation of national

accounts. The SNA framework can be used to define seven main institutional sectors: nonfinancial corporations (NFC), the central bank and other monetary financial institutions (MFI), other financial intermediaries and financial auxiliaries (OFI), insurance corporations and pension funds (INS), general government (GOV), households and non-profit institutions serving households (HH), and the rest of the world (ROW). Ideally, the MFI sector would be divided into the central bank and other monetary financial institutions. This division becomes particularly appealing in times of quantitative easing and an increasing link between other monetary financial institutions and governments. However, separated information is not available for the Euro Area and U.K. on the PGI homepage, which provide internationally comparable data. The ECB and the Bank of England provide information on their balance sheets, but definition of instruments is not entirely consistent with the PGI framework.

With the inclusion of the ROW sector the system is closed in the sense that each transaction must have both a creditor and a debtor sector and each financial asset must have a counterparty liability item in another sector's balance sheet. Given that the sectoral accounts data constitute a closed system, these data seem to be particularly suitable for identifying linkages between financial and nonfinancial sectors and monitoring how these linkages evolve over time. However, the sectoral accounts dataset presents two main drawbacks which render a comprehensive analysis of counterparty risk exposures difficult. First, the vast majority of countries do not provide detailed information on the counterparty sector of a financial instrument issued by a given sector ("from-whom-to-whom" data). Even in the case of G-4 economies, only limited "from-whom-to-whom" data are available. Box 1 and Appendix I report which data are available for these economies. Second, the recent crisis showed that many risks to the global financial system arise from cross-border exposures and in the sectoral accounts data cross-border exposures fall all under the ROW sector without specifying the counterparty country and counterparty sector.

Box 1. Available From-whom-to-whom Sectoral Accounts Data in G-4 Economies

(See Appendix I)

Euro Area (ECB, Euro area accounts, MFI balance sheets):

- Sectoral breakdown for loans within countries and within the Euro Area.
- Sectoral breakdown for deposits within countries and within the Euro Area.
- MFI deposit liabilities with counterparty HH and NFC within countries and within the Euro Area as well as across euro area countries.
- MFI holdings of securities with counterparty MFI and GOV within countries and within the Euro Area as well as across euro area countries.
- MFI holdings of shares and other equity with counterparty MFI within countries and within the Euro Area as well as across euro area countries.

Japan (BOJ, Flow of Funds):

- Sectoral breakdown of holdings of government debt securities.
- Almost complete sectoral breakdown for loans (financial sector as a borrower sector is not broken down by MFI, OFI, and INS, but it is as a lender sector).

U.K. (ONS, U.K. Economic Accounts, the Blue Book):

- Sectoral breakdown of holdings of government debt securities.
- Sectoral breakdown of borrowings in loans from the ROW sector.
- Sectoral breakdown of holdings of deposits and equities from the ROW sector.

U.S. (FRB, Flow of Funds):

- Sectoral breakdown of holdings of government debt securities.
- Sectoral breakdown of holdings of agency and GSE debt securities (but not of the whole OFI sector debt securities).

In order to derive cross-border exposures, sectoral accounts data are combined with data from the Coordinated Portfolio Investment Survey (CPIS), the Bank for International Settlements (BIS) locational statistics,[4] and the International Investment Position (IIP) dataset. The CPIS data show countries' cross-border portfolio investments broken down by counterparty country and instrument type (debt securities and equities). The BIS statistics provide information on banks' total foreign claims not broken down by instruments but broken down by counterparty country and recently also by counterparty sector (banks, private nonbank, public). Finally, the IIP dataset shows countries' cross-border investments not broken down by counterparty country but broken down by instrument (debt securities, equities, and loans) and partly broken down by sector (deposit-taking corporations, general government, and other sectors (nonfinancial corporations, other financial intermediaries, insurances, and households)).

[4] The BIS offers three different datasets on banks' foreign claims: unconsolidated locational statistics, consolidated statistics on an immediate borrower basis, and consolidated statistics on an ultimate risk basis. Take as example a loan from a Deutsche Bank subsidiary in London to a Santander subsidiary in London. In the locational statistics no foreign claim will be compiled, on an immediate borrower basis this would be a claim from Germany vis-à-vis the U.K., and on an ultimate risk basis this would be a claim from Germany vis-à-vis Spain. Although the consolidated statistics on an ultimate risk basis convey a better picture of the risks at stake, in this paper it makes sense to use BIS locational statistics because sectoral accounts are also unconsolidated and by residence.

The advantage of the CPIS dataset over the BIS dataset is that it provides information not only on banks' foreign claims but also on the whole economy foreign claims, and it is broken down by financial instruments traded on markets. However, for the geographical breakdown of loan exposures the BIS banking statistics are used as a proxy and it is assumed that the whole economy loan foreign claims follow the same geographical breakdown as banks' total foreign claims.[5] The IIP dataset complements the CPIS and BIS datasets by providing sectoral information on who is holding foreign assets and who is issuing liabilities held by nonresidents.

Claims vis-à-vis the ROW in the sectoral accounts data include portfolio as well as direct investments. The share of direct investment could be taken from the IIP dataset, while its geographical breakdown could be taken from the Coordinated Direct Investment Survey (CDIS). However, this paper makes no distinction between portfolio and direct investments and assumes implicitly that the sectoral and geographical breakdown of direct investments follows the same distribution as the one of portfolio investments. This is done for several reasons. First, in the CDIS data outward investments are netted out in the sense that there exist negative values, which render the calculation of country shares in foreign investments impossible. Second, the CDIS is only available after 2009. Third, the IIP dataset does not provide information on the sectoral breakdown of direct investments.

IV. COMPARISON OF FINANCIAL BALANCE SHEETS AND NET LENDING ACROSS G-4 ECONOMIES

Despite the above-mentioned limitations, sectoral accounts data allow for an in-depth analysis of the saving, investment, and financing behavior of different economic sectors.

Box 2 displays the composition of the balance sheets of major economic sectors by country in 2012:Q2. A look at MFI's liabilities shows that the deposit funding base share of euro area and Japanese MFI is much larger than that of U.S. and U.K.[6] Moreover, in the Euro Area a relatively large share of MFI's funding comes via bond issuances, while U.S. MFI have a large share of equity funding. Equity shares, however, have to be interpreted with caution, as equity is valued at current market prices, i.e., at how much it would cost to buy all shares back. The forty percent of U.K. MFI's liabilities which are shown as "other" consists mainly

[5] According to the IIP data deposit taking corporations (the central bank and other monetary financial institutions) held 40% of the cross-border loans in the U.S. in 2007, 53 percent in Japan, 99.8 percent in the U.K., and 75 percent in the Euro Area.

[6] For a statement on the funding base to be totally precise, it would be necessary to split currency and deposits, separate central bank from other monetary financial institutions, and use consolidated data in order to exclude deposit that one MFI has in another. However, these modifications would probably not change the main message. The share of currency in "Currency and Deposits" is very small (0 percent in the U.K. and Euro Area, and around 5 percent in the U.S. and Japan). Second, central bank assets are relatively small compared to the unconsolidated assets of other monetary financial institutions (approx. 26 percent in the U.S., 17 percent in Japan, 7 percent in the Euro Area, and 4 percent in the U.K. by the end of 2014).

of financial derivatives that for the other three countries are given as “debt securities other than shares.”

Turning to how MFI invest their money, euro area MFI keep a larger share of their assets in safe currency and deposits. U.S. and Japanese MFI invest a large part of their assets in debt securities, probably reflecting the high issuance of sovereign bonds in both countries.

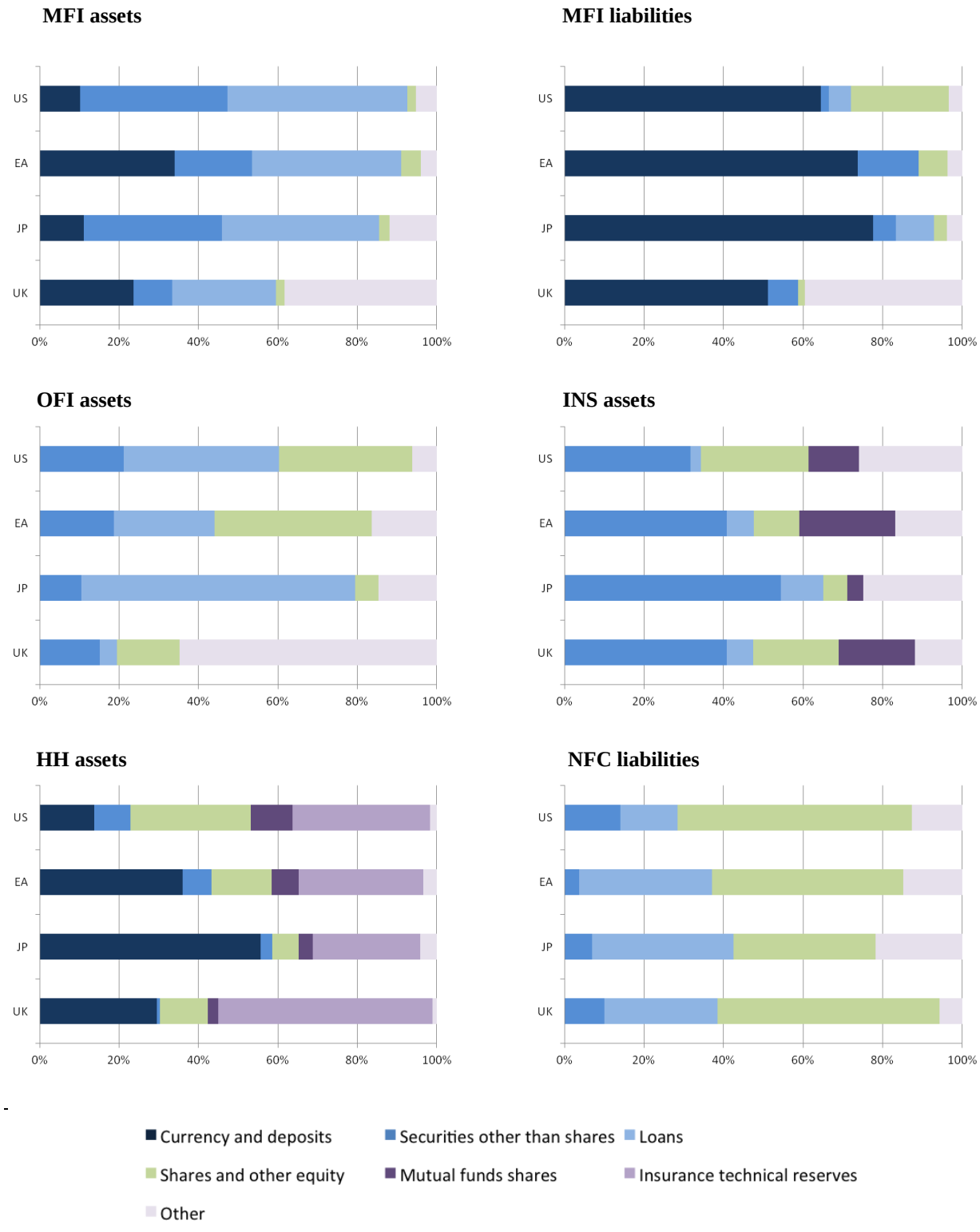
It is also interesting to analyze the asset portfolios of other financial intermediaries and insurance companies. In comparison to OFI in other G-4 economies, Japanese OFI invest a larger share of their assets in loans and a smaller share in debt securities and equities. By contrast, euro area and U.K. OFI invest only a very small share in loans. Japanese INS have the largest share invested in debt securities, reflecting the high issuance of bonds by the Japanese GOV which are held domestically. U.S. and U.K. INS have a relatively large share of their assets invested in equities, while euro area INS do not invest a large share in equities but compensate this with a larger share of investments in mutual funds shares. U.S. INS invest the smallest share in loans.

Until now, the focus lay on financial intermediaries but it is also interesting to have a look at the balance sheet of the biggest creditor in an economy, the HH sector, and of the biggest debtor next to the GOV sector, the NFC sector. Japanese HH keep the largest share of assets invested in currency and deposits, probably reflecting the low inflation (deflation) environment in Japan. U.S. HH are the ones who most diversify their assets across instruments. They invest a relatively small share of their assets in currency and deposits and a relatively high share in equities, reflecting the relatively high HH stock market participation in the U.S. In most G-4 economies, HH keep a very high share of their assets in insurance and pension reserves.

Sectoral accounts are also useful for tracking developments in balance sheets over time. Box 3 shows how the net worth (financial assets minus financial liabilities) of different sectors evolved between 2002:Q2 and 2013:Q2. Not surprisingly, the graphs show that HH are the biggest creditors in the economy, while NFC and GOV are the biggest debtors. The net worth of financial intermediaries is practically zero, reflecting their role as intermediaries. Moreover, the graphs show that after the outbreak of the financial crisis GOV indebtedness has increased considerably in G-4 economies. One can further see that the increase in GOV borrowing coincided with an increase in savings of the HH and NFC, probably deriving from precautionary savings due to economic uncertainty and the drying-up of bank lending. In other words, the GOV had to compensate the decrease in private sector demand.
The analysis of the development of balance sheets is also useful to gauge how some sectors have gained importance over time. The rise of the so-called shadow banking sector, often defined as nonbank financial intermediaries, has attracted a lot of attention in recent years. Box 3 depicts how the ratio of OFI's assets to MFI's assets has changed over time in G-4 economies. The U.S. has by far the largest OFI sector with assets at times amounting to almost double the size of the traditional banking sector. The OFI sector in Japan was also relatively big prior to the crisis with assets amounting to 50 percent of the traditional banking

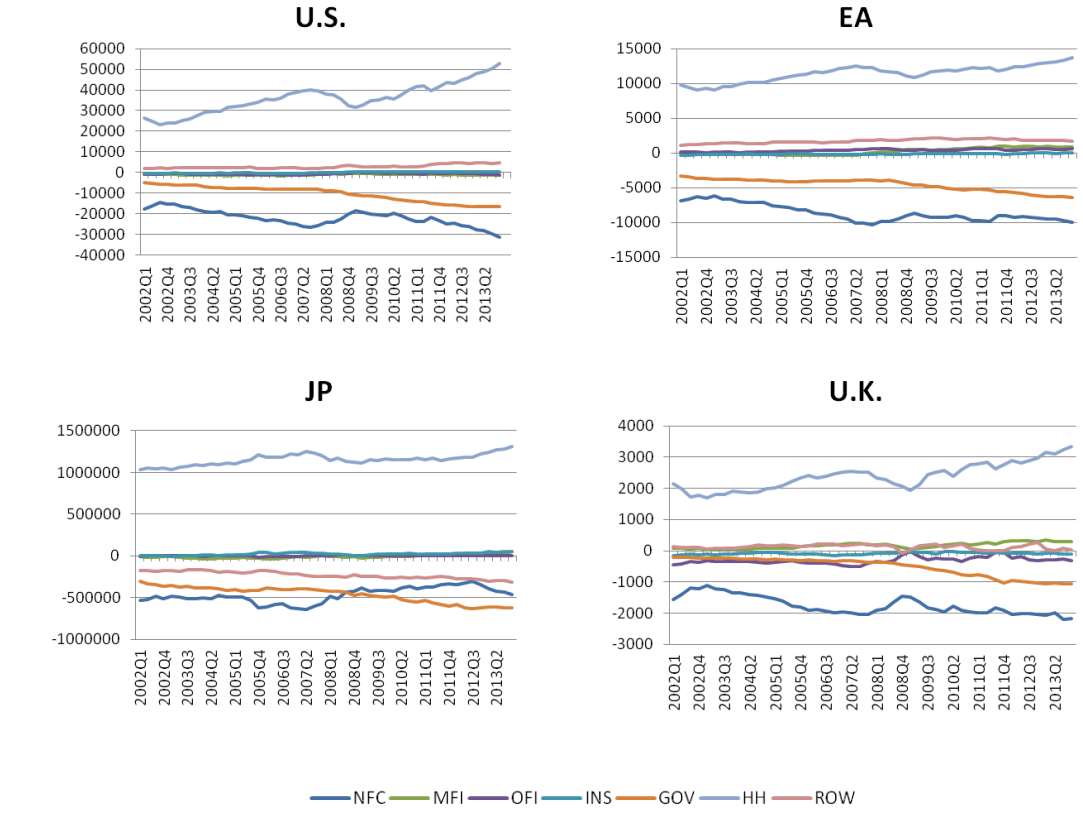
system sector. By contrast, the OFI sector in the Euro Area and in the U.K. corresponded to approximately 30–40 percent of the size of the traditional banking system. After the outbreak of the financial crisis the OFI sector in the U.S. and in Japan shrank relative to the traditional banking system, while it increased in the Euro Area and in the U.K.

Box 2. Composition of Financial Balance Sheets by Sector and Country (2012:Q2)



Source: IMF.

Box 3. Evolution of Financial Balance Sheets
(Net worth in USD bn.)



Ratio of OFIs' financial assets to MFIs' financial assets

Source: IMF.

Since sectoral accounts data are available for all seven institutional sectors in the G-4 economies over time from 1999:Q1 to 2012:Q4, it is possible to analyze how the economic behavior of different sectors correlates over time within and across countries. Table 1 reports the correlation across sectors in net acquisition of financial assets, net incurrence of liabilities, and net lending which is calculated by subtracting net incurrence of liabilities from net acquisition of financial assets. The matrix of each variable has the dimension 20x20 which corresponds to 5 sectors (GOV, HH, MFI, NFC, and ROW) from 4 countries. The variables are ordered by sectors instead of countries, and the diagonal of the matrix is filled with 1, the correlation of the variables with themselves. There are several observations that can be inferred from the correlation matrix for net lending. First, the main nonfinancial sectors (NFC, HH, GOV) seem to increase or decrease net lending at the same time within a sector across G-4 countries, as the cross-border correlations within these sectors are fairly positive. Second, the government acts countercyclically, compensating the increase in net lending elsewhere by increasing its budget deficit, as the correlation of government's net lending with HH and NFC's net lending is negative. Third, the data show that there must be common pull and push factors for capital flows in G-4 economies, as the net acquisition of assets and net incurrence of liabilities by the ROW sector is highly positively correlated across countries.

Table 1. Correlation of Borrowing and Lending across Country-sector Pairs Over Time

Net lending/borrowing (correlations 1991Q1-2012Q2)

	GOV_EA	GOV_JP	GOV_UK	GOV_US	HH_EA	HH_JP	HH_UK	HH_US	MFI_EA	MFI_JP	MFI_UK	MFI_US	NFC_EA	NFC_JP	NFC_UK	NFC_US	ROW_EA	ROW_JP	ROW_UK	ROW_US
GOV_EA	1.00	0.55	0.87	0.90	-0.71	-0.10	-0.58	-0.76	-0.31	-0.56	-0.51	0.50	-0.69	-0.48	-0.76	-0.32	0.02	-0.03	0.24	0.42
GOV_JP	0.55	1.00	0.46	0.63	-0.48	-0.58	-0.81	-0.56	-0.36	-0.35	-0.03	0.58	-0.53	-0.57	-0.28	-0.17	0.49	-0.55	0.01	0.61
GOV_UK	0.87	0.46	1.00	0.95	-0.69	-0.40	-0.31	-0.81	-0.31	-0.57	-0.56	0.27	-0.46	-0.19	-0.91	-0.04	0.07	0.10	0.04	0.15
GOV_US	0.90	0.63	0.95	1.00	-0.75	-0.29	-0.45	-0.87	-0.25	-0.42	-0.41	0.40	-0.49	-0.40	-0.86	-0.06	0.05	-0.12	0.20	0.28
HH_EA	-0.71	-0.48	-0.69	-0.75	1.00	0.15	0.44	0.63	0.32	0.32	0.41	-0.38	0.20	0.26	0.61	0.20	0.00	0.10	-0.30	-0.42
HH_JP	-0.10	-0.58	-0.40	-0.29	0.15	1.00	0.29	0.47	0.22	0.24	0.07	-0.20	0.04	-0.16	0.23	-0.30	-0.44	0.30	0.34	-0.23
HH_UK	-0.58	-0.81	-0.31	-0.45	0.44	0.29	1.00	0.43	0.17	0.44	0.10	-0.78	0.56	0.50	0.11	0.44	-0.16	0.43	-0.38	-0.61
HH_US	-0.76	-0.56	-0.81	-0.87	0.63	0.47	0.43	1.00	0.25	0.21	0.27	-0.37	0.29	0.33	0.67	-0.21	0.07	0.05	-0.16	-0.41
MFI_EA	-0.31	-0.36	-0.31	-0.25	0.32	0.22	0.17	0.25	1.00	0.17	0.56	0.04	0.26	0.38	0.24	0.10	-0.42	-0.10	0.40	-0.13
MFI_JP	-0.56	-0.35	-0.57	-0.42	0.32	0.24	0.44	0.21	0.17	1.00	0.56	-0.44	0.45	0.06	0.58	0.35	-0.07	-0.03	-0.09	-0.10
MFI_UK	-0.51	-0.03	-0.56	-0.41	0.41	0.07	0.10	0.27	0.56	0.56	1.00	0.01	0.28	-0.01	0.51	0.19	-0.02	-0.34	0.21	0.02
MFI_US	0.50	0.58	0.27	0.40	-0.38	-0.20	-0.78	-0.37	0.04	-0.44	0.01	1.00	-0.52	-0.23	-0.15	-0.52	0.09	-0.27	0.46	0.57
NFC_EA	-0.69	-0.53	-0.46	-0.49	0.20	0.04	0.56	0.29	0.26	0.45	0.28	-0.52	1.00	0.46	0.36	0.60	-0.49	0.22	0.04	-0.36
NFC_JP	-0.48	-0.57	-0.19	-0.40	0.26	-0.16	0.50	0.33	0.38	0.06	-0.01	-0.23	0.46	1.00	0.19	0.27	-0.15	0.09	-0.01	-0.31
NFC_UK	-0.76	-0.28	-0.91	-0.86	0.61	0.23	0.11	0.67	0.24	0.58	0.51	-0.15	0.36	0.19	1.00	0.04	-0.05	-0.37	-0.05	0.10
NFC_US	-0.32	-0.17	-0.04	-0.06	0.20	-0.30	0.44	-0.21	0.10	0.35	0.19	-0.52	0.60	0.27	0.04	1.00	-0.22	-0.11	-0.22	-0.26
ROW_EA	0.02	0.49	0.07	0.05	0.00	-0.44	-0.16	0.07	-0.42	-0.07	-0.02	0.09	-0.49	-0.15	-0.05	-0.22	1.00	-0.43	-0.56	0.06
ROW_JP	-0.03	-0.55	0.10	-0.12	0.10	0.30	0.43	0.05	-0.10	-0.03	-0.34	-0.27	0.22	0.09	-0.37	-0.11	-0.43	1.00	0.02	-0.39
ROW_UK	0.24	0.01	0.04	0.20	-0.30	0.34	-0.38	-0.16	0.40	-0.09	0.21	0.46	0.04	-0.01	-0.05	-0.22	-0.56	0.02	1.00	0.28
ROW_US	0.42	0.61	0.15	0.28	-0.42	-0.23	-0.61	-0.41	-0.13	-0.10	0.02	0.57	-0.36	-0.31	0.10	-0.26	0.06	-0.39	0.28	1.00

Net acquisition of financial assets (correlations 1991Q1-2012Q2)

	GOV_EA	GOV_JP	GOV_UK	GOV_US	HH_EA	HH_JP	HH_UK	HH_US	MFI_EA	MFI_JP	MFI_UK	MFI_US	NFC_EA	NFC_JP	NFC_UK	NFC_US	ROW_EA	ROW_JP	ROW_UK	ROW_US
GOV_EA	1.00	0.11	-0.10	0.26	0.39	0.29	-0.14	0.03	0.05	0.10	-0.35	0.14	-0.18	-0.37	0.00	-0.17	-0.19	-0.31	-0.37	-0.06
GOV_JP	0.11	1.00	0.22	-0.24	0.03	-0.46	-0.04	0.04	0.04	0.23	0.24	0.04	-0.12	0.23	0.00	0.01	0.23	-0.05	0.30	-0.04
GOV_UK	-0.10	0.22	1.00	0.21	-0.27	-0.50	-0.42	-0.17	0.02	0.02	0.20	0.26	-0.19	0.08	0.12	-0.21	0.00	-0.09	0.09	-0.23
GOV_US	0.26	-0.24	0.21	1.00	0.10	0.16	-0.16	-0.17	0.01	-0.10	-0.06	0.32	0.14	-0.22	-0.03	-0.15	-0.29	-0.25	-0.20	-0.11
HH_EA	0.39	0.03	-0.27	0.10	1.00	0.46	0.27	0.25	0.38	-0.31	0.04	-0.10	0.15	-0.36	-0.02	0.08	0.24	-0.15	-0.03	0.34
HH_JP	0.29	-0.46	-0.50	0.16	0.46	1.00	0.07	0.29	0.01	0.13	-0.42	-0.02	0.25	-0.15	-0.19	0.15	-0.29	-0.03	-0.45	0.18
HH_UK	-0.14	-0.04	-0.42	-0.16	0.27	0.07	1.00	0.12	0.02	-0.33	0.23	-0.15	0.09	-0.09	-0.03	0.31	0.30	0.07	0.23	0.43
HH_US	0.03	0.04	-0.17	-0.17	0.25	0.29	0.12	1.00	0.12	-0.09	0.23	0.00	0.10	-0.02	-0.28	0.09	0.27	0.39	0.20	0.22
MFI_EA	0.05	0.04	0.02	0.01	0.38	0.01	0.02	0.12	1.00	-0.20	0.33	0.25	0.39	-0.02	0.22	0.14	0.50	0.21	0.29	0.18
MFI_JP	0.10	0.23	0.02	-0.10	-0.31	0.13	-0.33	-0.09	-0.20	1.00	-0.37	0.12	-0.06	0.45	-0.15	-0.16	-0.31	0.20	-0.27	-0.17
MFI_UK	-0.35	0.24	0.20	-0.06	0.04	-0.42	0.23	0.23	0.33	-0.37	1.00	0.06	0.21	0.20	0.17	0.41	0.74	0.37	0.89	0.37
MFI_US	0.14	0.04	0.26	0.32	-0.10	-0.02	-0.15	0.00	0.25	0.12	0.06	1.00	0.44	0.05	0.42	-0.10	0.14	0.00	0.04	0.17
NFC_EA	-0.18	-0.12	-0.19	0.14	0.15	0.25	0.09	0.10	0.39	-0.06	0.21	0.44	1.00	0.30	0.30	0.44	0.42	0.18	0.28	0.54
NFC_JP	-0.37	0.23	0.08	-0.22	-0.36	-0.15	-0.09	-0.02	-0.02	0.45	0.20	0.05	0.30	1.00	0.03	0.21	0.14	0.16	0.21	0.09
NFC_UK	0.00	0.00	0.12	-0.03	-0.02	-0.19	-0.03	-0.28	0.22	-0.15	0.17	0.42	0.30	0.03	1.00	0.27	0.37	-0.05	0.30	0.23
NFC_US	-0.17	0.01	-0.21	-0.15	0.08	0.15	0.31	0.09	0.14	-0.16	0.41	-0.10	0.44	0.21	0.27	1.00	0.46	0.39	0.54	0.51
ROW_EA	-0.19	0.23	0.00	-0.29	0.24	-0.29	0.30	0.27	0.50	-0.31	0.74	0.14	0.42	0.14	0.37	0.46	1.00	0.46	0.81	0.60
ROW_JP	-0.31	-0.05	-0.09	-0.25	-0.15	-0.03	0.07	0.39	0.21	0.20	0.37	0.00	0.18	0.16	-0.05	0.39	0.46	1.00	0.54	0.37
ROW_UK	-0.37	0.30	0.09	-0.20	-0.03	-0.45	0.23	0.20	0.29	-0.27	0.89	0.04	0.28	0.21	0.30	0.54	0.81	0.54	1.00	0.45
ROW_US	-0.06	-0.04	-0.23	-0.11	0.34	0.18	0.43	0.22	0.18	-0.17	0.37	0.17	0.54	0.09	0.23	0.51	0.60	0.37	0.45	1.00

Net incurrence of liabilities (correlations 1991Q1-2012Q2)

	GOV_EA	GOV_JP	GOV_UK	GOV_US	HH_EA	HH_JP	HH_UK	HH_US	MFI_EA	MFI_JP	MFI_UK	MFI_US	NFC_EA	NFC_JP	NFC_UK	NFC_US	ROW_EA	ROW_JP	ROW_UK	ROW_US
GOV_EA	1.00	0.40	0.49	0.68	-0.30	-0.09	-0.47	-0.51	-0.15	0.26	-0.30	-0.06	-0.26	-0.25	-0.37	-0.28	-0.29	-0.33	-0.33	-0.12
GOV_JP	0.40	1.00	0.03	0.24	-0.16	-0.35	-0.29	-0.21	-0.07	0.26	-0.18	-0.24	-0.16	-0.14	-0.46	-0.11	-0.16	-0.06	-0.13	0.07
GOV_UK	0.49	0.03	1.00	0.85	-0.18	0.01	-0.47	-0.58	-0.09	0.18	-0.17	0.03	-0.21	0.07	-0.45	-0.30	-0.28	-0.16	-0.31	-0.17
GOV_US	0.68	0.24	0.85	1.00	-0.27	-0.15	-0.48	-0.60	-0.09	0.30	-0.22	-0.03	-0.30	-0.11	-0.56	-0.45	-0.37	-0.16	-0.36	-0.21
HH_EA	-0.30	-0.16	-0.18	-0.27	1.00	-0.09	0.63	0.51	0.47	-0.34	0.33	0.20	0.59	0.23	0.23	0.33	0.53	0.16	0.32	0.40
HH_JP	-0.09	-0.35	0.01	-0.15	-0.09	1.00	0.01	0.10	-0.12	0.30	0.35	0.08	-0.28	0.42	0.02	0.04	0.21	0.17	0.36	-0.17
HH_UK	-0.47	-0.29	-0.47	-0.48	0.63	0.01	1.00	0.80	0.31	-0.41	0.43	-0.16	0.36	0.03	0.23	0.34	0.54	0.20	0.40	0.38
HH_US	-0.51	-0.21	-0.58	-0.60	0.51	0.10	0.80	1.00	0.21	-0.42	0.59	0.04	0.25	0.00	0.27	0.37	0.57	0.30	0.58	0.39
MFI_EA	-0.15	-0.07	-0.09	-0.09	0.47	-0.12	0.31	0.21	1.00	-0.16	0.30	0.21	0.55	0.10	0.20	0.34	0.48	0.23	0.28	0.07
MFI_JP	0.26	0.26	0.18	0.30	-0.34	0.30	-0.41	-0.42	-0.16	1.00	-0.33	0.14	-0.20	0.37	-0.24	-0.07	-0.27	0.16	-0.24	-0.22
MFI_UK	-0.30	-0.18	-0.17	-0.22	0.33	0.35	0.43	0.59	0.30	-0.33	1.00	0.08	0.08	0.00	0.21	0.31	0.72	0.44	0.88	0.25
MFI_US	-0.06	-0.24	0.03	-0.03	0.20	0.08	0.16	0.04	0.21	0.14	0.08	1.00	0.38	0.17	0.40	0.21	0.06	-0.05	-0.01	-0.01
NFC_EA	-0.26	-0.16	-0.21	-0.30	0.59	-0.28	0.36	0.25	0.55	-0.20	0.08	0.38	1.00	0.24	0.38	0.57	0.42	0.14	0.13	0.40
NFC_JP	-0.25	-0.14	0.07	-0.11	0.23	0.42	0.03	0.00	0.10	0.37	0.00	0.17	0.24	1.00	-0.03	0.25	0.05	0.02	-0.05	0.03
NFC_UK	-0.37	-0.46	-0.45	-0.56	0.23	0.02	0.23	0.27	0.20	-0.24	0.21	0.40	0.38	-0.03	1.00	0.46	0.32	0.02	0.33	0.15
NFC_US	-0.28	-0.11	-0.30	-0.45	0.33	0.04	0.34	0.37	0.34	-0.07	0.31	0.21	0.57	0.25	0.46	1.00	0.58	0.50	0.44	0.51
ROW_EA	-0.29	-0.16	-0.28	-0.37	0.53	0.21	0.54	0.57	0.48	-0.27	0.72	0.06	0.42	0.05	0.32	0.58	1.00	0.57	0.81	0.52
ROW_JP	-0.33	-0.06	-0.16	-0.16	0.16	0.17	0.20	0.30	0.23	0.16	0.44	-0.05	0.14	0.02	0.02	0.50	0.57	1.00	0.61	0.31
ROW_UK	-0.33	-0.13	-0.31	-0.36	0.32	0.36	0.40	0.58	0.28	-0.24	0.88	-0.01	0.13	-0.05	0.33	0.44	0.81	0.61	1.00	0.39
ROW_US	-0.12	0.07	-0.17	-0.21	0.40	-0.17	0.38	0.39	0.07	-0.22	0.25	-0.01	0.40	0.03	0.15	0.51	0.52	0.31	0.39	1.00

V. METHODOLOGY: BUILDING THE NETWORKS

This section is divided into three subsections. The first explains how to estimate bilateral exposures between sectors within countries in order to construct country-specific financial networks. The second subsection describes how to reconcile the sectoral accounts data with CPIS, BIS, and IIP data in order to connect each country-level network to each other via cross-border exposures. Finally, the third subsection presents how the financial networks are constructed.

A. Estimating Bilateral Exposures within Countries

Although sectoral accounts data constitute a closed system in the sense that every asset item in one sector's balance sheet must have a counterparty liability item in another sector's balance sheet, the dataset does not provide counterparty information. In other words, although it is known how many loans the NFC sector received in a quarter or has accumulated in its balance sheet, one cannot know whether these loans are coming from monetary financial institutions, other financial intermediaries or other nonfinancial corporations. However, bilateral exposures on an instrument-by-instrument basis can be estimated from aggregate data using maximum entropy techniques in a first step and the RAS algorithm in a second step. The application of these methodologies is common in input-output analysis and in interbank networks (e.g., Sheldon and Maurer (1998), Upper and Worms (2004), and Wells (2004)). The maximum entropy approach distributes assets and liabilities as evenly as possible among the counterparty sectors yielding dense and almost complete exposure networks. Since the danger usually lies in extreme, not diversified exposures and these are underestimated by the maximum entropy approach, the exposures estimated by this technique represent risk lower bounds.[7]

[7] Maximum entropy is the leading method for estimating unknown bilateral exposures, but there are alternative methods. The minimum density approach (Anand, Craig, and von Peter (2014)) works in the opposite direction distributing bilateral exposures across counterparties by minimizing the numbers of linkages and thus providing a risk upper bound. There are also methods which lie in between these two. For a more comprehensive discussion on matching algorithms see Aldasoro, Delli Gatti and Faia (2015). Matching algorithms are primarily developed for replicating interbank networks, which are characterized by a large number of banks and sparse concentrated relationships. In sectoral accounts networks there are few sectors and the network is almost always complete with each sector having exposures to all others so that it seems preferable to use maximum entropy.

More specifically, bilateral exposures across N sectors in a financial instrument k can be expressed in a NxN matrix in which the element x_{ij} denotes a claim of sector i vis-à-vis sector j. So, the sum of each row i denotes the aggregate holdings of assets of sector i in instrument k ($a_{i,k}$) and the sum of each column j denotes the aggregate holdings of liabilities of sector j in instrument k ($l_{j,k}$). Aggregate assets ($a_{i,k}$) and liabilities ($l_{j,k}$) per sector are observed, but bilateral exposures x_{ij} need to be estimated.

$$X_k = \begin{pmatrix} x_{11} & \dots & x_{1N} \\ \vdots & \ddots & \vdots \\ x_{N1} & \dots & x_{NN} \end{pmatrix} \text{ with } \sum_{j=1}^{N} x_{ij} = a_{i,k} \text{ and } \sum_{i=1}^{N} x_{ij} = l_{j,k}$$

Since there are N^2 unknown elements in matrix X_k and 2N known elements (total assets and liabilities for each sector), it is not possible to estimate X_k without additional restrictions. In this case, it is sensible to assume a distribution for X_k which maximizes the entropy (i.e., uncertainty) of the bilateral exposures. The marginal distributions of the sum elements $a_{i,k}$ and $l_{j,k}$ are used to calculate the individual elements x_{ij}. Assuming that the marginal distributions of assets and liabilities are independent, their joint distribution in X_k can be easily calculated by multiplying both marginal distributions. For example, if sector i holds 30 percent of the assets in instrument k, and sector j has issued 20 percent of the liabilities outstanding in instrument k, then a good first guess would be that the element x_{ij} corresponds to 6 percent (0.3 x 0.2= 0.06) of the assets (liabilities) outstanding in instrument k. Since the sectoral accounts data form a closed system, assets outstanding in instrument k must equal liabilities outstanding in instrument k. Considering that sectoral accounts data are not consolidated (i.e., they include intra-sector claims), the diagonal elements of the estimated matrix $X_k^{(0)}$ must not be restricted to zero. The only exception is the diagonal element of the ROW sector, as in this case, by construction of the dataset, the intrasector claims are zero.

After this first step of estimating bilateral exposures via maximum entropy techniques, it must not necessarily hold that the sum of rows and columns in matrix $X_k^{(0)}$ corresponds to the observed $a_{i,k}$ and $l_{i,k}$, respectively. Therefore, in a second step, the RAS algorithm is used in order to find a matrix X_k^* which is sufficiently close to $X_k^{(0)}$, but does satisfy the adding-up and zero constraints. The RAS algorithm iteratively changes the elements of $X_k^{(0)}$ until the adding up constraints are satisfied.

The accuracy of the bilateral exposure estimations is assessed in the Appendix II using some actual "from-whom-to-whom" data from the Euro Area. As mentioned in section III, some limited "from-whom-to-whom" data are available for G-4 economies. In principle, one could restrict some estimated bilateral exposures to equal actual exposures, in the cases in which the latter is available. However, it seems preferable not to mix observed bilateral exposures with estimated bilateral exposures. There are two main reasons for this. First, the whole point of using PGI data is that they provide internationally comparable data. The available "from-whom-to-whom" data from national statistics do not follow completely the PGI framework in

some cases (sectoral and instrument breakdowns are sometimes more comprehensive, sometimes less). Second, a particular "from-whom-to-whom" information is usually available only for a certain country and countries would be treated differently if for some observed bilateral exposures are used, while for others estimated bilateral exposures are used.

After estimating bilateral exposures between sectors within a country, it becomes possible to construct financial networks at the country level. It is then interesting to connect the country-level financial networks to each other via cross-border exposures. For that, it is necessary to combine sectoral accounts data with CPIS, BIS, and IIP data.

B. Combining Sectoral Accounts Data with CPIS, BIS, and IIP Data

Claims of sector i in country A vis-à-vis sector j in country B are calculated by multiplying country A's foreign claims (ROW liabilities in country A) by the share of country B in country A's foreign claims, the share of sector i's holdings of foreign assets in country A, and the share of sector j's issuances of liabilities held by nonresidents in country B. These data are available on an-instrument-by-instrument basis.

For example, foreign claims of Japanese MFI vis-à-vis the U.S. GOV in debt securities are calculated as

$$X_{MFI\ JP \rightarrow GOV\ US} = ROW^{L}_{JP} \times S_{JP \rightarrow US} \times S^{H}_{MFI\ JP} \times S^{I}_{GOV\ US},$$

where ROW^{L}_{JP} is the amount of the Japanese ROW sector's liabilities in debt securities coming from the sectoral accounts data, $S_{JP \rightarrow US}$ is the share of the U.S. in Japanese foreign debt security claims coming from the CPIS data, $S^{H}_{MFI\ JP}$ is the MFI's share in the holdings of foreign debt securities in Japan according to the IIP data, and $S^{I}_{GOV\ US}$ is the GOV's share in U.S. liabilities in debt securities held by nonresidents according to the IIP dataset. It is noteworthy that the sectoral accounts data, CPIS data, and IIP data are consistent among themselves in the sense that their compiled foreign claims by country and instrument are virtually equal.

C. Networks Visualization

Financial networks[8] displaying linkages between sectors are constructed on an instrument-by-instrument basis for the quarters 2007:Q2 and 2012:Q2, i.e., right before the outbreak of the financial crisis and five years afterwards. The analysis focuses on the following financial instruments: debt securities, loans, and equities. The networks are constructed using stock data instead of flow data, since interest lies in total exposures of a sector vis-à-vis other sectors and flow data can be very volatile.

[8] Financial networks in this paper are constructed with the FNA networks map software, www.fna.fi.

A network is merely an alternative representation of a matrix, in which the graphical representation allows for a faster interpretation of the interconnectedness among sectors. A network consists of nodes and links connecting them. Nodes in the financial networks below represent different sectors and a link going from sector i to sector j represents sector i's claims (exposure) vis-à-vis sector j. The position of nodes is arbitrary, but their size is proportional to a sector's holdings of liabilities in a given instrument, in order to facilitate the identification of systemically important sectors. For example, if the U.S. GOV is represented by a large node in the financial network depicting exposures in debt securities that means that the U.S. GOV is a large issuer of debt securities. Likewise, the width of the links is also proportional to the size of each sector's exposure to another sector. Since networks are constructed to assess financial stability, it does not make sense to draw the links proportional to the absolute value of a bilateral claim but to relativize this value by the capacity of the creditor sector to absorb a potential loss of this claim. A smaller sector will be less able to absorb the loss of a claim than a larger sector. In this sense, links' widths are proportional to the ratio of a bilateral claim to the creditor sector's total consolidated assets.[9] Representing claims relative to the size of a sector is also a novelty of this paper in relation to previous papers using networks analysis with sectoral data, which consider absolute claims.

Regarding cross-border exposures, the IIP data do not split "other sectors" into HH, NFC, OFI, and INS. For illustration purposes, the HH sector's node represents other sectors as a foreign creditor and the NFC's node represents other sectors as a foreign debtor. Other sectors' cross-border claims going from the HH node are, however, relativized by the sum of the total financial assets of the HH, OFI, and INS sectors and not only by the HH's financial assets.

This paper compares financial networks in 2007:Q2 with that in 2012:Q2. The size of nodes and links are comparable across countries and in different years in networks showing claims in the same financial instrument but not across financial instruments. If in a network showing loan exposures the size of the HH sector's node and the link going from the MFI to the HH sector decreases from 2007:Q2 to 2012:Q2 that means that in 2012:Q2 the HH sector has less liabilities in loans and MFIs were less exposed to the HH sector. Similarly, if the HH sector in the U.S. has a bigger node than the HH sector in the Euro Area in a loan network in 2007:Q2 that means that the HH sector in the U.S. has more loan liabilities in absolute terms than the HH sector in the Euro Area. However, if the U.S. NFC sector has a bigger node in the loan network than in the debt security network that does not necessarily mean that the U.S. NFC sector has more liabilities in loans than in debt securities. The same holds for the comparison of links' width across financial instruments.

Another point is that since cross-border exposures are much smaller than national exposures, another reference base for links' width is used for cross-border links so that one can visualize

[9] Total assets of the ROW sector are calculated by summing up the total assets of the ROW sector in all G-4 economies.

differences in exposures to different countries. In this sense, one cannot compare the thickness of a link showing cross-border exposures with that of a link showing national exposures. Each financial network reports which are the values of the three strongest links in national networks and in cross-border exposures so that one can get an idea of how they relate to each other. For the sake of clarity, only linkages which are above the median exposure (there is one median for intra-country exposures and another for inter-country exposures) are drawn in the network.

After this short introduction to the construction of financial networks, we are able to explore all information contained in the sectoral accounts data.

VI. Interpreting Financial Networks

As the networks below show, differences in interconnectedness between 2007:Q2 and 2012:Q2 depend on the financial instrument, sector, and country under consideration. For a broader understanding, the networks below should be interpreted in conjunction with the tables in the Appendix III showing the largest increases and decreases in financial exposures between 2007:Q2 and 2012:Q2 by sector.

A. Debt Securities

A first look at the debt security financial network for 2007:Q2 shows that governments in the U.S., Euro Area, and Japan as well as U.S. OFI are the largest issuers of debt securities, as these sectors have the largest nodes. The high amount of debt securities being issued by U.S. OFI partly reflects the activities of government-sponsored enterprises (GSEs). Two other points also stand out. First, the amount of debt securities outstanding of the U.S. NFC sector is much larger than that of other G-4 NFC sectors, reflecting how corporate financing in the U.S. is market-based. Second, in comparison to other G-4 MFI sectors, euro area banks finance themselves relatively more via debt securities, as shown by the size of this sector's node.

The largest exposures at the country level are from the Japanese INS and MFI sectors vis-à-vis the Japanese GOV. As a matter of fact, the lending activities of INS and MFI to the Japanese GOV comprise 31 percent and 25 percent of their total assets, respectively. In the U.S. the MFI sector, the INS sector and particularly the GOV sector were highly exposed to the OFI sector, once again reflecting the activities of GSEs. In the Euro Area the strongest lending activities in debt security markets are from the MFI and INS sectors to the GOV and from the INS sector to the MFI sector. In the U.K. the strongest lending exposure is from the INS sector to the ROW sector, revealing the importance of the U.K. as a financial hub.

In terms of cross-border exposures, U.K. MFI show the largest vulnerabilities, namely vis-à-vis U.S. other sectors (NFC, OFI, INS, and HH, represented in the network by the NFC sector), euro area MFI and GOV. These exposures amount to 2.1 percent, 1.8 percent, and 1.8 percent of U.K. MFI's total assets, respectively. Japanese other sectors (represented in the network by the HH sector) are also highly exposed to the U.S. other sectors.

A couple of changes stand out when comparing the G-4 financial network in debt securities of 2012:Q2 with that of 2007:Q2. The size of all GOV nodes increased meaning that after the crisis governments have considerably increased their amount of debt outstanding. In these five years the Japanese and U.K. GOV more than doubled their amount of debt securities outstanding.[10] At the same time, the amount of debt securities outstanding of U.S. OFIs decreased.

Looking at the network for 2012:Q2 as well as at the table in the Appendix II showing differences in exposures, it becomes clear that national exposures in debt securities have on average increased (+0.3pp). This increase happened mainly for exposures vis-à-vis governments (+2.4pp), and particularly in Japan (+4.0pp) and in the U.S. (+3.1pp). More precisely, in Japan, the already large exposures of the INS and MFI sectors vis-à-vis the GOV increased even more to, respectively, 43 percent and 35 percent of these sectors' total assets. At the same time the largest decreases in national exposures happened vis-à-vis the OFI sector in the U.S. (-3.5pp) and in Japan (-0.6pp) and vis-à-vis the MFI sector in the U.K. (-0.2pp) and in the Euro Area (-0.2pp).

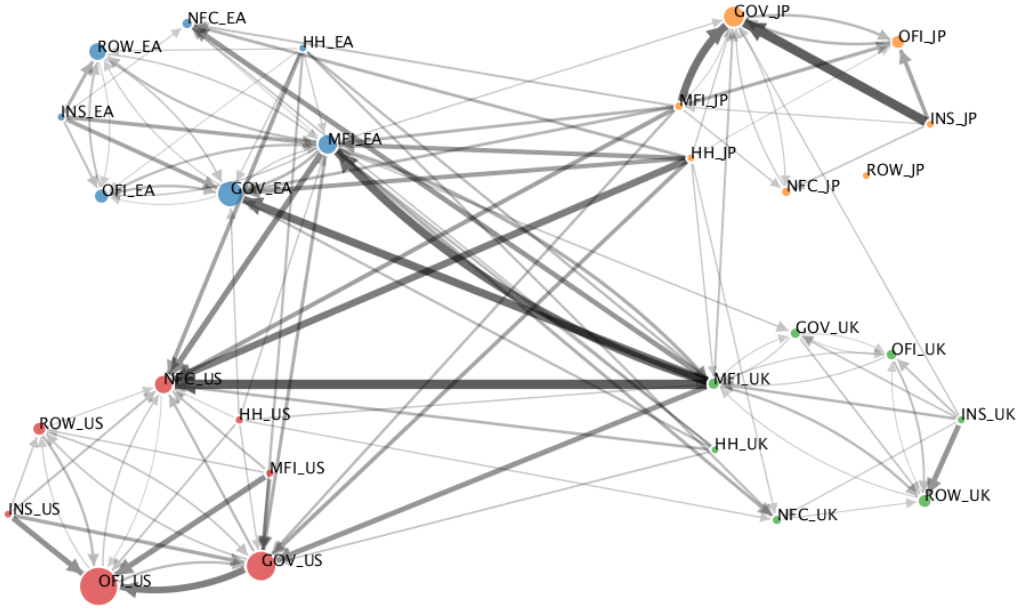
Comparing cross-border exposures before and after the financial crisis shows that previous to the crisis foreign sectors held many debt securities from U.S. other sectors, which include OFI, providing funding for HH's growing mortgage liabilities and fueling the house price bubble. However, after the crisis, foreign sectors sold OFI issued debt security and moved to government debt. In fact, on the one hand, exposure increased mainly vis-à-vis the U.S. GOV (+0.3pp). Particularly the Japanese MFI sector and other sectors increased their exposures to the U.S. GOV (+0.7pp and +1pp, resp.), which is a likely consequence of Japanese economic stimulus packages. On the other hand, cross-border exposures to U.S. other sectors were the most reduced (-0.5pp), followed by exposures to euro area MFI (-0.3pp). The U.K. MFI sector was the sector which most reduced its cross-border exposures (-0.5pp). However, while U.K. and euro area MFI decreased their exposures to foreign GOV (-0.2pp), U.K. and euro area other sectors increased theirs (+0.3pp).

All in all, national exposures in debt securities vis-à-vis GOV increased between 2007 and 2012. Regarding cross-border exposures, the most noticeable difference is the increase of Japanese sectors' claims vis-à-vis the U.S. GOV.

[10] Since debt values are expressed in USD and between 2007 and 2012 the USD appreciated vis-à-vis the EUR, JPY, and GBP, this paper likely underestimates the increase in GOV debt in the Euro Area, Japan, and U.K.

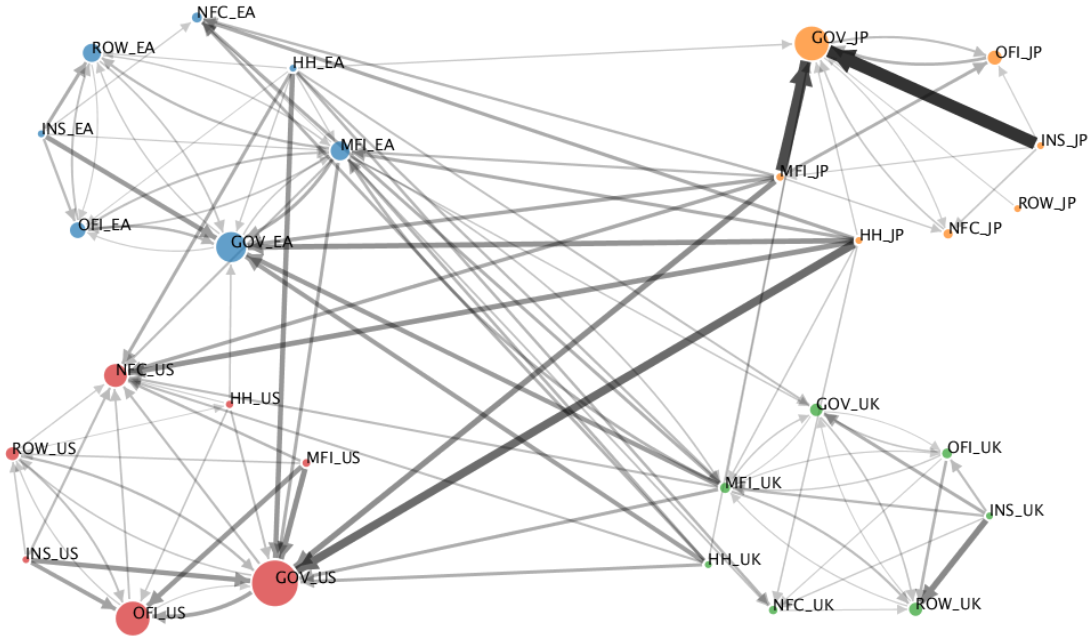
Figure 1. Debt Security Network

Debt Securities 2007:Q2



Top 3 bilateral national exposures:
INS_JP -> GOV_JP 30.7%, MFI_JP -> GOV_JP 25.1%, GOV_US -> OFI_US 21.7%.
Top 3 bilateral cross-border exposures:
MFI_UK -> NFC_US 2.11%, MFI_UK -> MFI_EA 1.82%, MFI_UK -> GOV_EA 1.76%.

Debt Securities 2012:Q2



Top 3 bilateral national exposures:
INS_JP -> GOV_JP 42.6%, MFI_JP ->GOV_JP 35.1%, INS_UK -> ROW_UK 19.0%.
Top 3 bilateral cross-border exposures:
HH_JP -> GOV_US 1.84%, MFI_JP -> GOV_US 1.23%, HH_JP -> GOV_EA 1.12%.

B. Loans

The financial network in loans for 2007:Q2 shows that the biggest debtors in this financial instrument are the NFC and HH sectors in the U.S. and in the Euro Area, with the HH sector in the U.S. being the biggest. Again, one can sense the difference between a market-based corporate financing in the U.S. and bank-based system in the Euro Area by noticing that euro area NFC have a larger amount of loans outstanding.

The largest national exposures are from the U.S. MFI sector and OFI sector vis-à-vis the HH sector and amounts to 32.1 percent and 28.2 percent of their assets, respectively. The large quantity of HH's loans owned by OFI in the U.S. stems from securitization. Also in Japan and in the Euro Area the MFI sector has strong lending activities relative to their assets to the HH sector, with the difference that in these two regions MFI are even more exposed to the NFC sector than to the HH sector. In Japan, where as in the U.S., OFI lending plays a big role, the OFI sector is also more exposed to NFC than to HH. The same does not hold for the Euro Area, where OFI lending activities are not very large in relation to OFI's total assets. In the U.K. the strongest lending activities of the MFI sector are vis-à-vis the OFI, ROW and HH sectors.

The most vulnerable sector in cross-border exposures is the U.K. MFI sector with exposures to euro area MFI and U.S. other sectors amounting to 5.7 percent and 2.8 percent of its assets, respectively. The euro area MFI sector is also highly exposed to U.K. other sectors (4.0 percent of its assets).

When comparing the financial networks in loans for 2007:Q2 with that for 2012:Q2, the first thing that stands out is that cross-border exposures in loans decreased considerably. Both, national and cross-border exposures in loans, decreased on average by -0.1pp between 2007:Q2 and 2012:Q2, but the relative decrease in cross-border exposures were larger because cross-border exposures are much smaller than national exposures.

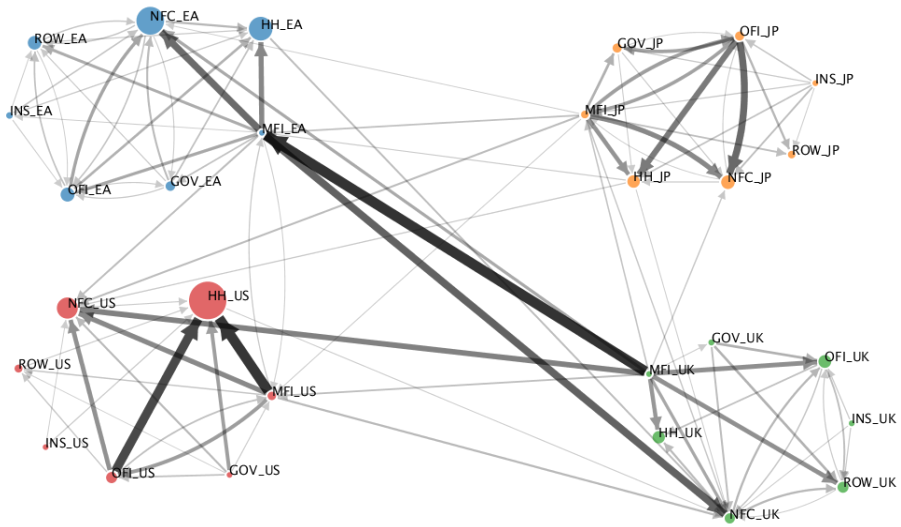
Regarding national exposures, GOV in the U.S. and in the Euro Area were the sectors which most increased their exposures (+1.9pp and +0.2pp, resp.), particularly vis-à-vis NFC (+3.0pp and +1.4pp, resp.) and HH (+6.1pp and +1.0pp, resp.). In the Euro Area, also OFI and NFC increased their loan exposures (+0.8pp and +0.7pp, resp.), showing the emergence of alternative sources of funding after the drying-up of bank credit. At the same time, MFIs in the U.K., U.S., and Euro Area were the sectors which most reduced their loan exposures, next to OFI in the U.S. and U.K. No major changes in loan exposures vis-à-vis the HH and NFC sectors happened in Japan. The largest decreases in national loan exposures happened towards U.K HH (-1.2pp), ROW (-0.9pp), OFI (-0.8pp), and NFC (-0.6pp), as well as U.S. HH (-0.7pp).

The Japanese MFI sector was the only sector which increased its cross-border exposures (+0.1pp) and to which cross-border exposures were increased (+0.01pp). At the same, cross-border exposures to and from the U.S. MFI sector remained broadly unchanged. By contrast,

the U.K. MFI sector reduced its cross-border exposures considerably (-0.9pp). This is in line with findings by Forbes (2014) who shows that the decline in U.K. MFI cross-border lending was the largest in absolute values for all countries for which data are available. According to her, this comes probably from the fact that many international banks are resident in the U.K. serving as intermediaries between foreign investors and savers. With the outbreak of the financial crisis cross-border banking activity contracted sharply due to an increasing home bias driven by rising risk aversion, deleveraging and reduced wholesale funding. For these same reasons banks resident in the UK also scaled down their international presence by ending many of their consumer banking operations abroad. In general, cross-border exposures in loans were mainly reduced towards euro area MFI (-0.6pp) and U.S. other sectors (-0.1pp), which include U.S. OFI.

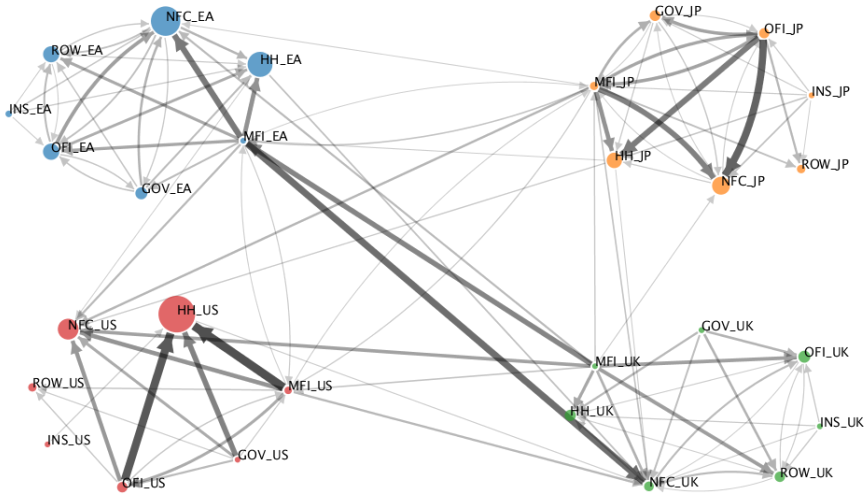
Figure 2. Loan Network

Loans 2007:Q2



Top 3 bilateral national exposures:
MFI_US -> HH_US 32.1%, OFI_US -> HH_US 28.2%, OFI_JP -> NFC_JP 21.4%.
Top 3 bilateral cross-border exposures:
MFI_UK -> MFI_EA 5.7%, MFI_EA -> NFC_UK 4.0%, MFI_UK -> NFC_US 2.8%.

Loans 2012:Q2



Top 3 bilateral national exposures:
MFI_US -> HH_US 26.7%, OFI_US -> HH_US 24.9%, OFI_JP -> NFC_JP 22.8%.
Top 3 bilateral cross-border exposures:
MFI_EA -> NFC_UK 3.5%, MFI_UK -> MFI_EA 2.7%, MFI_UK -> NFC_US 1.6%.

C. Equities

As expected, the G-4 financial network in equities shows that the biggest issuers of equities are NFC in the U.S. and in the Euro Area, particularly NFC in the U.S. The equity holders with the largest exposures are INS and HH in the U.S. vis-à-vis U.S. NFC, reflecting the high stock market participation of U.S. HH. In the Euro Area INS and OFI have the largest holdings of NFC equities relative to assets. In the U.K. INS' exposure in equities to NFC is also high but so it is INS and NFC's exposure to the ROW. Governments in the Euro Area and in Japan have also large holdings relative to their assets of NFC equities, reflecting the high number of public companies in these countries.

The highest cross-border exposure is from euro area other sectors, which include NFC, HH, OFI, and INS, vis-à-vis U.S. other sectors and amounts to 3.6 percent of their assets. U.K. other sectors have also relatively high exposures vis-à-vis other sectors in the U.S. and in the Euro Area.

When comparing equity exposures in two different points in time, it is important to bear in mind that equity liabilities are valued at market value, i.e., at how much would it cost to buy all the outstanding shares back. In 2012:Q2 the Eurostoxx 50 and the Nikkei 225 stock indices were still 50 percent below their value in 2007:Q2, while the S&P 500 and FTSE 100 indices were only 10–15 percent below their value in 2007:Q2.

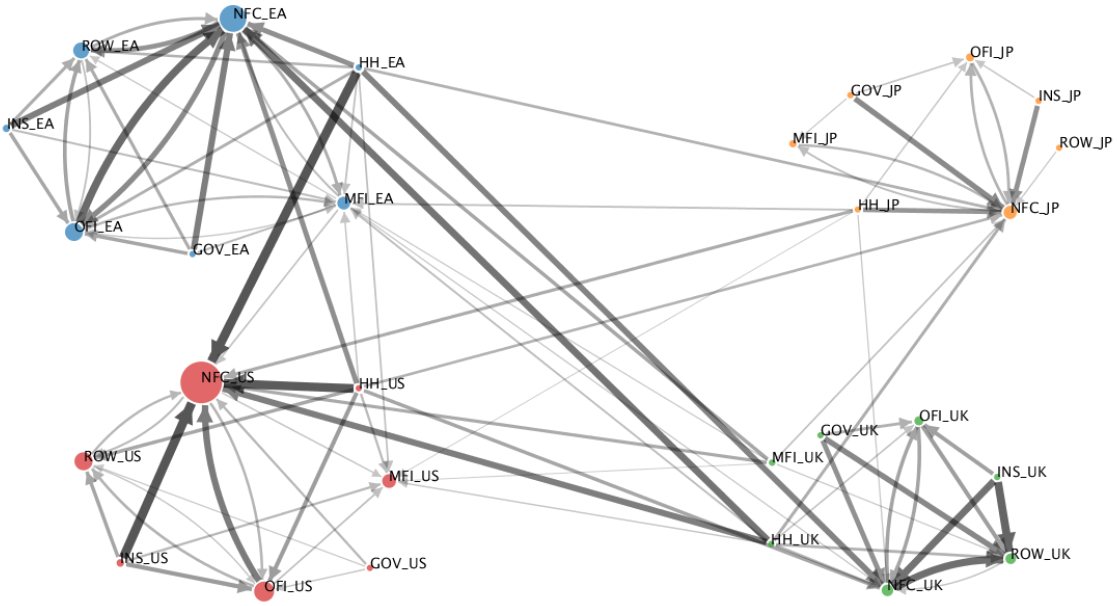
It sticks out that cross-border exposures have been less reduced from 2007 to 2012 than national exposures. In fact, national exposures decreased on average by -0.9pp, while cross-border exposure decreased on average by -0.1pp. This is probably due to the fact that equity foreign investments are made up of a large share of less volatile direct investments. As a matter of fact, IIP data confirm that on average the share of direct investments in equity foreign investments increased by 10pp between 2007 and 2012 for G-4 economies.

Regarding national exposures, INS in the U.K., Japan, and U.S. were the sectors which most decreased their equity exposures (-3.6pp, -2.9pp, -2.4pp, resp.). Equity exposures were most reduced vis-à-vis NFC in the Euro Area (-3.8pp), Japan (-3.6pp), U.K. (-3.0pp), U.S. (-2.3pp), as well as vis-à-vis MFI in the Euro Area (-2.1pp). Moreover, in the Euro Area and in the U.S. there was an increase in equity exposure vis-à-vis the ROW sector (1.0pp and 0.6pp, resp.), which may reflect companies registered offshore.

Turning to cross-border exposures, euro area other sectors was the sector which most increased its exposures (+0.1pp). Their exposure to U.S. and U.K. other sectors increased to 4.7 percent and 2.5 percent of their assets, respectively. This increase is likely a consequence of the uncertainty caused by the European sovereign debt crisis and of the fact that U.S. and U.K. stock markets outperformed the euro area stock market in this period. Again, U.K. other sectors and MFI were the sectors which most reduced their exposures (approx. -0.35pp each). Cross-border exposures were mainly reduced vis-à-vis other sectors in the Euro Area (-0.3pp) and in Japan (-0.2pp).

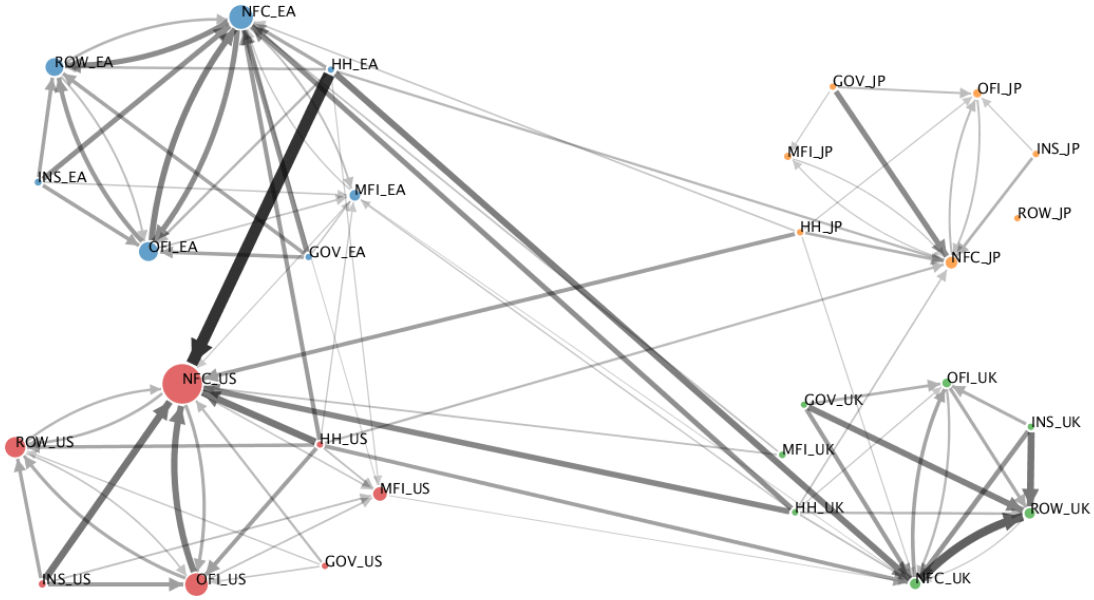
Figure 3. Equity Network

Equities 2007:Q2



Top 3 bilateral national exposures:
INS_US -> NFC_US 27.3%, HH_US -> NFC_US 26.2%, INS_UK -> ROW_UK 23.9%.
Top 3 bilateral cross-border exposures:
HH_EA -> NFC_US 3.62%, HH_UK -> NFC_EA 2.75%, HH_UK -> NFC_US 2.44%.

Equities 2012:Q2



Top 3 bilateral national exposures:
NFC_UK -> ROW_UK 24.9%, INS_US -> NFC_US 20.3%, INS_UK -> ROW_UK 20.0%.
Top 3 bilateral cross-border exposures:
HH_EA -> NFC_US 4.65%, HH_EA -> NFC_UK 2.41%, HH_UK -> NFC_US 2.18%.

VII. SHOCK SIMULATIONS

The financial networks for G-4 economies are estimated for all quarters between 2002:Q2 and 2012:Q2. After the construction of the networks, it is possible to simulate how shocks propagate through the system and if their effects vary over time and across countries. In network analysis of interbank claims it is common to study shock propagation as a function of the network structure (e.g., Allen and Gale (2000)). However, sectoral networks differ in particular ways from the common network of individual banks.

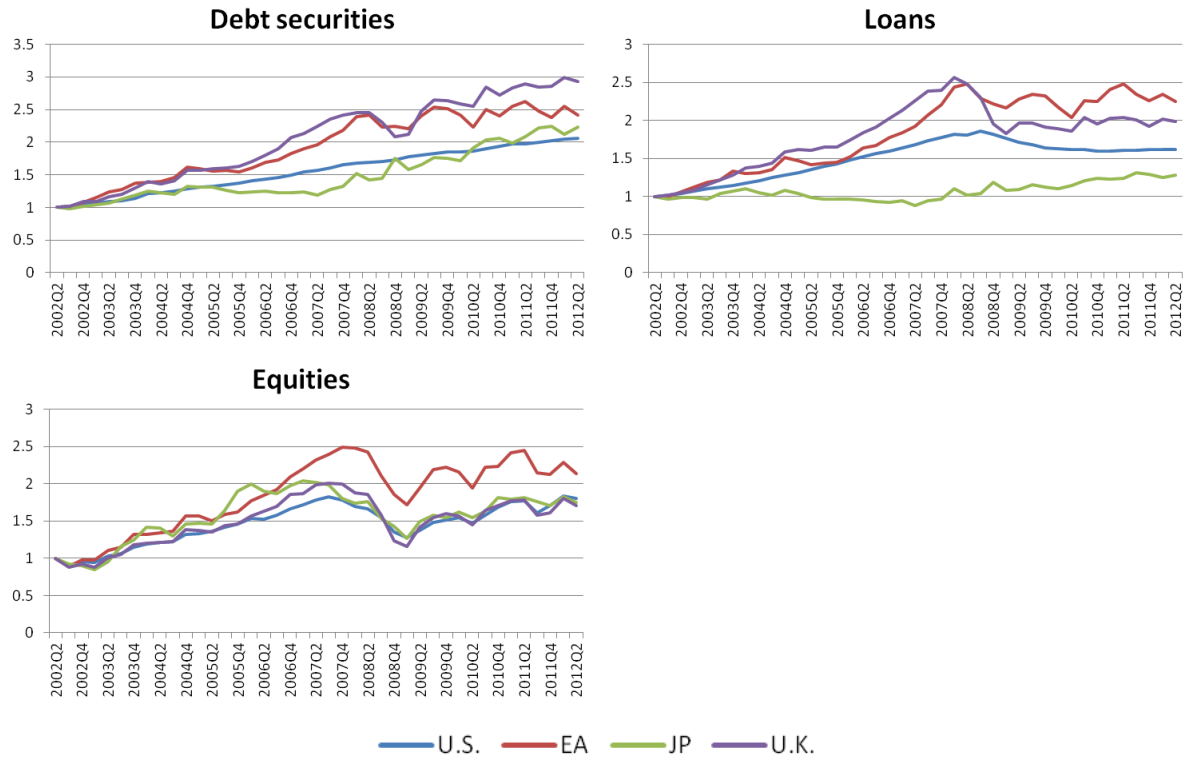
First, by construction, the number of links in the G-4 financial networks does not vary over time, only their strength. The national networks are almost always complete, with every sector having claims vis-à-vis all other sectors, and cross-border exposures are only allowed to exist between MFI and other sectors vis-à-vis foreign MFI, other sectors, and GOV. Network measures consist of centrality and connectivity measures, which can be binary (number of links) or weighted (by links' strength). Centrality measures refer to node's importance in the system, while connectivity measures refer to interconnectedness. By construction, binary network measures do not change in the G-4 sectoral financial networks over time and for the same reason connectivity measures do not change much either. In this sense, the focus lies on how weighted node degrees, a centrality measure, changes over time.

Second, since whole sectors and not individual institutions are analyzed, it is unlikely that a sector as a whole is going to be so exposed to another sector that it could default if it loses its claims. In common network analysis shock propagation only starts upon default of an institution (when equity is not enough to buffer claim losses) and this is not possible in the sectoral framework. Another possible shock propagation channel is to assume mark-to-market valuation and that the shocks propagate via cross-sector equity holdings (Castrén and Rancan (2014)). For example, assume that a credit loss (e.g., a loan loss) has to be deducted from sector A's equity, causing a mark-to-market drop in the value of sector A's equity. Then, every sector holding sector A's equity as an asset will have also to mark down its assets, which will cause a drop in its own equity value. The propagation process continues for several rounds until it finally converges, as the HH and GOV sectors do not transmit the shock because they do not issue equity. There are then two determinants of shock propagation and amplification in this setting: 1) the connections of the sector, in which the shock originates (claim losses); and 2) the cross-sector equity holdings.

Figure 4 shows the average node degree over time per country and instrument, defined as average sum of link values going from (claims) and coming to (liabilities) a sector. The average node degree is standardized at one in 2002. From Figure 4, one can see that the node degree increased the most for debt securities between 2002 and 2012, being between 2 to 3 times larger in 2012 than in 2002. Most node degrees in all instruments under consideration increased considerably from 2002 until the outbreak of the financial crisis in mid-2008, decreasing shortly thereafter, and then remaining relatively stable, as in the case of loans, or increasing, as in the case of debt securities and equities. Japan is an exception in the sense that its sector node degrees for loans remained relatively stable between 2002 and

2012, while its node degrees for debt securities remained stable until the outbreak of the crisis and started to rise thereafter. Node degrees in the Euro Area and in the U.K. seem to have increased more than in the U.S. and Japan for the instruments under consideration. It is important to bear in mind that the framework does not differentiate changes in exposures coming from volumes (transactions) from that coming from valuation, and this, for instance, should explain why equity exposures are more volatile.

Figure 4. Average Weighted Node Degree Over Time (per country and instrument, (2002=1)**)**



In the sequence, three different shock scenarios are analyzed. First, it is assumed that government debt securities in each country lose 20 percent of their value, and the impact (first-round effect) that this shock causes on the equity of domestic financial sectors is analyzed. Second, the just mentioned shock is allowed to propagate (as many rounds as necessary for the shock to converge) through the domestic sectors via cross-sector holdings of equities. Third, it is assumed that the debt securities of U.S. other sectors and GOV lose 20 percent of their value, and the impact on other G-4 economies is calculated.[11]

Figure 5 shows the impact (first-round effect) of a 20 percent value drop in GOV debt securities on the domestic financial sectors (MFI, OFI, and INS) as a share of their equity

[11] These shocks serve as an illustration. The same shocks can be simulated for loan losses from HH, or a drop in NFC equity value, for example.

over time. It is straightforward to see that after the financial crisis the impact of a value loss in GOV debt securities on the financial sectors has increased considerably in all G-4 economies. This is in line with Figure 4 which shows that node degrees in debt security networks have been increasing since the outbreak of the financial crisis. According to Figure 5, in 2002 a 20 percent devaluation in GOV debt securities in the U.S., Euro Area, and U.K. would cause a mark-to-market drop of approx. 15 percent in the value of the domestic financial sectors' equity. By mid 2012 this same shock would lead to a devaluation of the financial sectors' equity by 30 percent in the U.S. and in the U.K., and by 20 percent in the Euro Area. According to the estimations, Japanese financial sectors could not buffer a devaluation of 20 percnt in the Japanese GOV debt securities before 2004 and after 2008, as the losses caused would be higher than their equity value (>1). The impact caused by a devaluation of Japanese GOV debt securities in 2012 has a similar magnitude as in 2002, but it has decreased in the meantime.

Figure 5. Impact on Domestic Financial Sectors of a 20 Percent Value Drop in GOV Debt Securities
(ratio claim losses of financial domestic sectors over their equity)

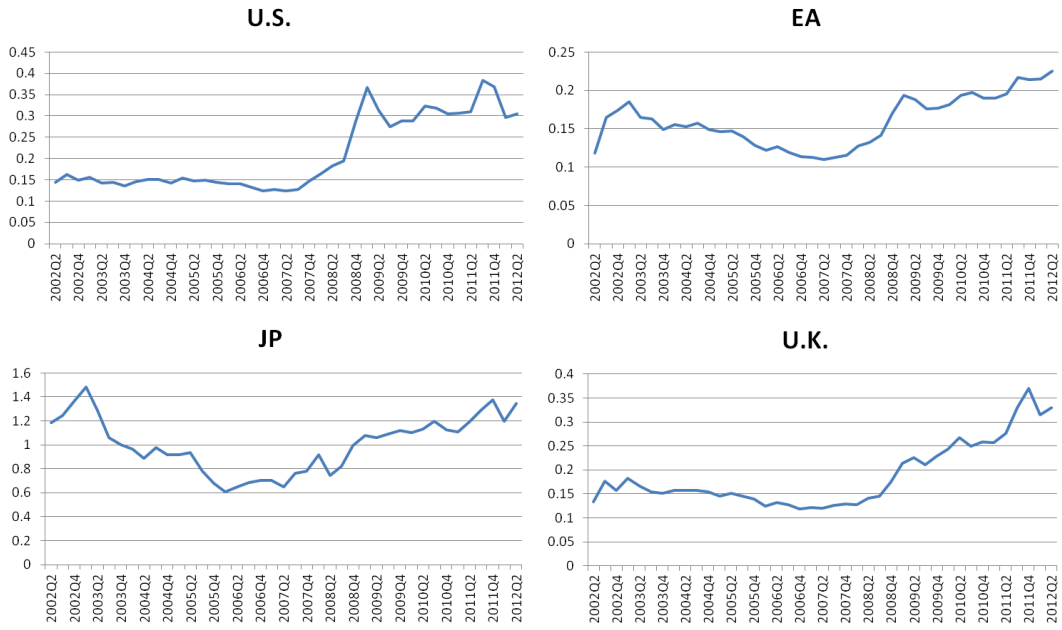
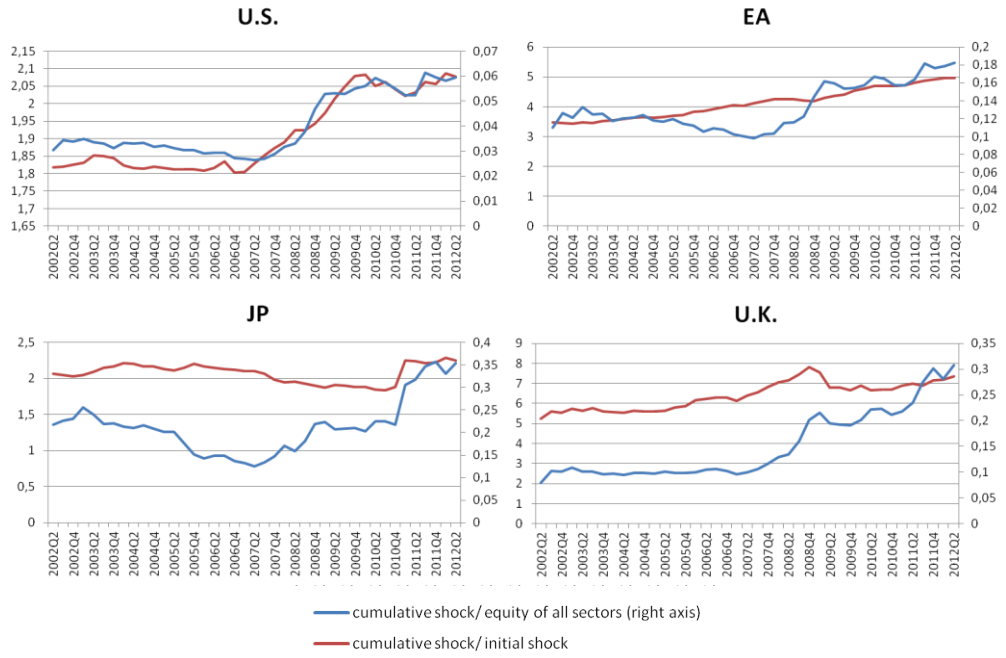


Figure 5 shows the impact effect of a 20 percent devaluation in GOV debt securities, but it is also interesting to let this shock propagate through the network via cross-sector equity holdings as explained above. Figure 6 depicts the final total loss of a 20 percent devaluation in GOV debt securities over time. The final total loss of domestic financial sectors is expressed both as the ratio over their equity and the ratio over the initial shock (amplification factor). When interpreting the ratio over equity it is once again important to keep in mind that equity is valued at market value and this influences changes in this ratio. For all countries the ratio of total loss of domestic financial sectors over their equity and the amplification factor have increased after the financial crisis, although Japan experienced the steepest increase in these variables by the end of 2010, coinciding with QE2 in Japan. The U.S. presents the

smallest loss as a share of equity and the smallest amplification factor. Before the outbreak of the crisis a 20 percent devaluation of GOV debt securities would cause losses to the financial sectors in the size of 3 percent of their equity and the final total loss after the propagation via equity-holdings would be 1.8 times larger than the initial shock (amplification factor). After the crisis, the same devaluation of GOV debt would cause claims losses to the financial sectors which amount to 6 percent of their equity and the amplification factor increased to approximately 2. In our framework HH and GOV do not transmit shocks because they do not issue equity. The high HH stock market participation in the U.S. may explain why the initial shock is not very amplified. Japan presents also a small amplification factor of 2. By contrast, the U.K. seems to have the highest amplification factor with final total loss being eight times as high as the initial loss by mid 2012. The Euro Area has also a high amplification factor which increased from 3 to 5 between 2002 and 2012. In Japan and in the U.K. financial sectors' losses due to a 20 percent devaluation of GOV debt amounted to approximately one third of their equity by mid 2012, while in the Euro Area it amounted to 18 percent. This ratio of claim losses to equity has tripled in the U.K. between 2002 and 2012.

Figure 6. Final Total Loss for Domestic Financial Sectors after a 20 Percent Value Drop in GOV Debt Securities (ratio)



The network graphs on debt securities showed that the U.S. other sectors (HH, INS, OFI, and NFC) and U.S. GOV are systemically important sectors in G-4 financial networks. They also show that, after the crisis, while cross-border exposures to U.S. other sectors have decreased, cross-border exposures to U.S. GOV have increased. Figure 7 shows the impact that a 20 percent devaluation in U.S. other sectors and GOV debt securities has on all other sectors of the Euro Area, Japan, and U.K. Under the assumptions of section V, after 2009 all sectors in the other G-4 economies were more exposed to the U.S. government than to U.S. other

sectors. And, while exposure to U.S. GOV increased after the crisis, exposures vis-à-vis U.S. other sectors decreased in the Euro Area and in the U.K., and remained stable in Japan.

Figure 7. Impact on Foreign Countries of a 20 Percent Value Drop in the Debt Securities of U.S. Other Nonbank Sectors and GOV, (USD m)

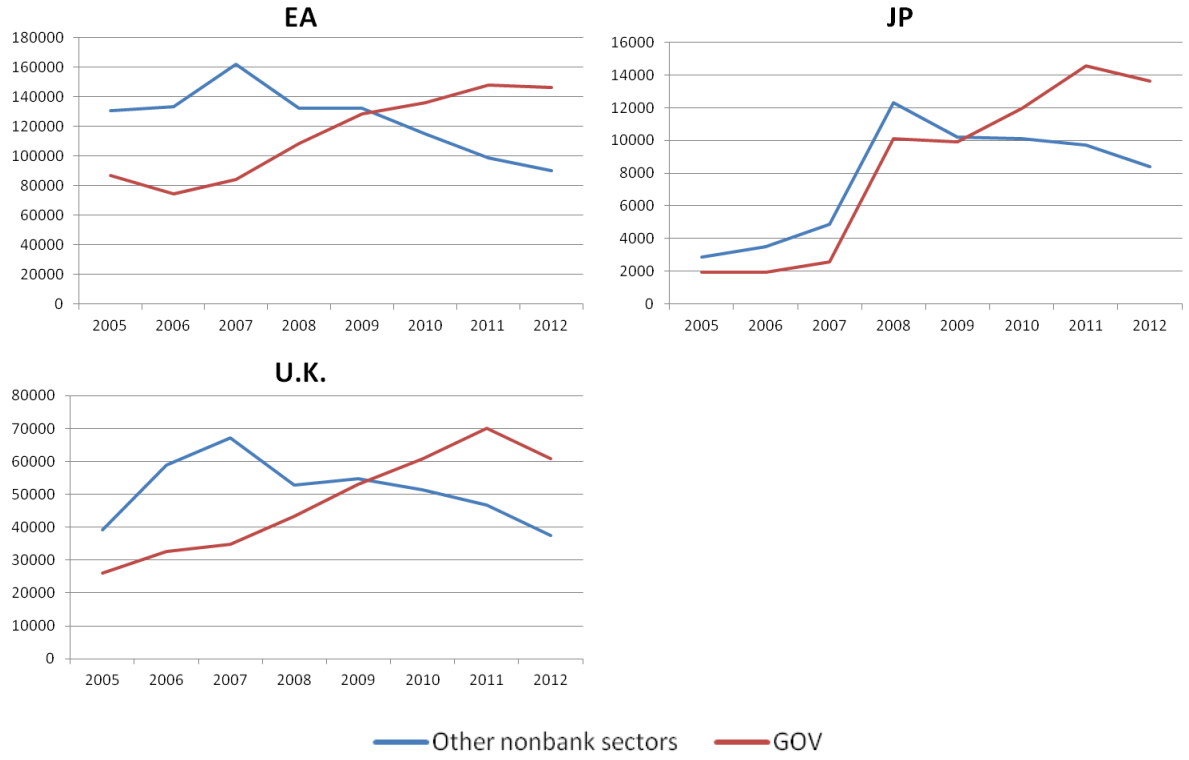


Figure 7 exemplifies the advantages of combining sectoral accounts, the IIP and the CPIS. The breakdown of cross-border claims by country and sector is not possible by using the datasets separately. Sectoral accounts deliver information on whether ROW debt security claims vis-à-vis the U.S. have increased but not vis-à-vis which sectors and not from which countries. The IIP dataset reports which U.S. sectors have increased their debt security liabilities vis-à-vis the ROW but not vis-à-vis which countries. The CPIS dataset, on the other hand, contains information on which countries have increased their debt security claims vis-à-vis the U.S. but not vis-à-vis which sectors. For example, if the increase in foreign claims vis-à-vis the U.S. GOV offsets the decrease in foreign claims vis-à-vis U.S. OFI, no change is observed in the CPIS data.

VIII. Conclusion

This paper uses sectoral accounts data to estimate bilateral financial exposures between sectors in G-4 economies. Furthermore, it connects national financial networks to each other via cross-border exposures, which are calculated by merging information from sectoral accounts with that from the CPIS, BIS, and IIP datasets. The contributions of this paper are twofold. First, this is the first paper to compare national financial exposures across G-4 economies. Second, it considers cross-border interconnections beyond the banking sector.

The findings on how interconnectedness between sectors has changed after the financial crisis depend on the financial instrument, sector, and country under consideration. National exposures in debt securities vis-à-vis governments have increased, particularly in the U.S. and in Japan. Cross-border exposures in debt securities vis-à-vis governments, in general, have also increased, particularly exposures of Japanese sectors vis-à-vis the U.S. government. While the decrease in cross-border exposure in loans was much more pronounced than the decrease in national exposures, the opposite is true for exposures in equities. This likely derives from the fact that a large share of equity foreign investments is made up of less volatile direct investments. In general, exposures in the U.K., particularly in the MFI sector, and, to a lesser extent, in the Euro Area seem to have decreased more than exposures in the U.S. and in Japan. This fact may reflect the different responses to the financial crisis, fiscal stimulus vs. austerity.

There are several potential interesting extensions of this paper which are left for future work. First, once data are available, financial networks could be estimated for a wider range of countries. Second, changes in exposures between 2007 and 2012 could be decomposed into volume and valuation changes. Third, from the bilateral claims one could calculate the debt service flows between sectors.

To sum up, the paper shows that sectoral accounts data can serve as a powerful tool for assessing financial stability. The broad compilation of "from-whom-to-whom" sectoral accounts data would provide an even more accurate picture of interconnectedness between sectors and financial vulnerabilities.

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APPENDIX I. AVAILABLE ACTUAL FROM-WHOM-TO-WHOM DATA

U.S. (FRB, Flow of Funds)

Securities

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC					x		
CB					x		
MFI					x		
OFI					x		
INS					x		
GOV					x		
HH					x		
ROW					x		0

Loans

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC							
CB							
MFI		x					
OFI							
INS							
GOV							
HH							
ROW							0

Equities

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC							
CB							
MFI							
OFI							
INS							
GOV							
HH							
ROW							0

EA (ECB, Euro area accounts, MFI balance sheets)

Securities

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC							
CB							
MFI		x			x		
OFI							
INS							
GOV							
HH							
ROW							0

Loans

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC	x		x	x	x	x	x
CB							
MFI	x	x	x	x	x	x	x
OFI	x		x	x	x	x	x
INS	x		x	x	x	x	x
GOV	x		x	x	x	x	x
HH	x	0	0	0	0	x	0
ROW	x		x	x	x	x	0

Equities

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC							
CB							
MFI		x					
OFI							
INS							
GOV							
HH							
ROW							0

JP (BOJ, Flow of Funds)

Securities

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC					x		
CB					x		
MFI							
OFI							
INS							
GOV					x		
HH					x		
ROW					x		0

Loans

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC							
CB							
MFI	x				x	x	x
OFI	x				x	x	x
INS	x				x	x	x
GOV							
HH							
ROW							0

Equities

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC							
CB							
MFI							
OFI							
INS							
GOV							
HH							
ROW							0

U.K (ONS, U.K. Economic Accounts, the Blue Book

Securities

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC		x			x		x
CB							
MFI		x			x		x
OFI		x			x		x
INS		x			x		x
GOV		x			x		x
HH		x			x		x
ROW		x			x		0

Loans

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC							
CB							
MFI	x		x	x	x	x	x
OFI							
INS							
GOV							
HH							
ROW	x		x	x	x	x	0

Equities

	NFC	MFI	OFI	INS	GOV	HH	ROW
NFC							x
CB							
MFI							x
OFI							x
INS							x
GOV							x
HH							x
ROW							0

APPENDIX II. ESTIMATED VS. ACTUAL FINANCIAL LINKAGES

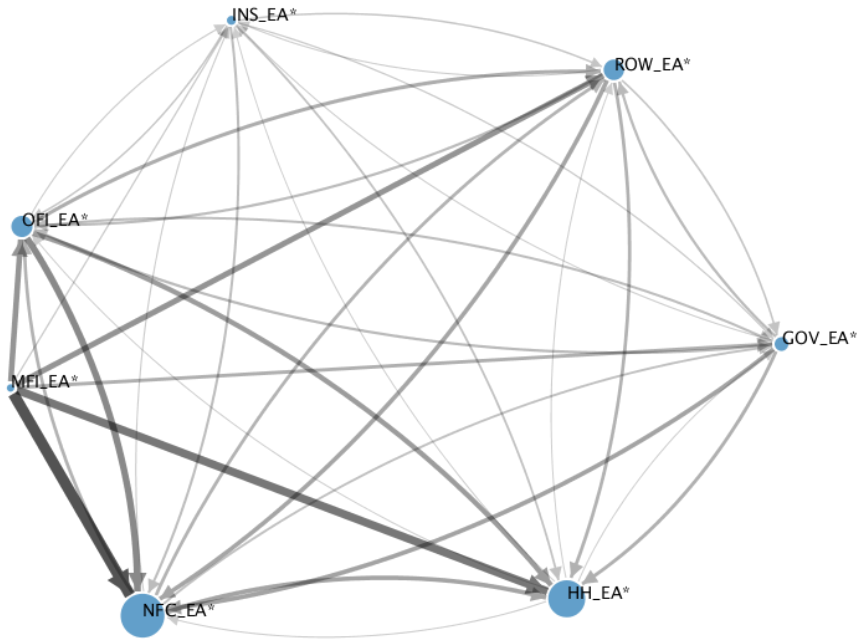
The ECB provides data with complete from-whom-to-whom information for loans in the Euro Area, what makes it possible to assess the accuracy of estimated bilateral exposures. By construction, maximum entropy techniques tend to spread financial exposures evenly across all sectors. This has the potential of underestimating extreme exposures and overestimating small exposures, thereby the approach is likely to underestimate risk. The logic is that if one can show large exposures with estimated links, the actual exposures are likely to be even larger. In this sense, estimated links represent risk lower bounds.

Box 4 compares estimated with actual loan bilateral exposures between euro area sectors in 2007:Q2. Both networks look similar, but some differences in line with the considerations above stand out. For instance, the strongest links, the exposures from MFI to the HH and NFC sectors, are weaker in the estimated network than in the actual observed network. In the observed network MFI's exposure to the NFC sector relative to their assets is 20 percent, while exposure to the HH sector is 23 percent. These same measures are, respectively, 18 percent and 13 percent, in the estimated network. In this case the algorithm performs better in estimating MFI's exposure to NFC than to HH. Since the HH sector is a large loan issuer and the OFI and INS sectors are big loan holders, the algorithm tends to allocate a larger exposure of the OFI and INS sector to the HH sector than in reality and this diminishes MFI's exposure. This effect is smaller for the NFC sector because OFI and INS do hold a considerable amount of NFC loans in reality. Similarly, the ROW's exposure to the OFI sector is underestimated. Since the ROW sector is not a large holder of loans, the algorithm underestimates the fact that OFI receive most loans from abroad. Moreover, the algorithm tends to identify some inexistent links, although it does not give much weight to them. For instance, it identifies some inexistent exposures of the HH sector vis-à-vis the OFI, INS, and GOV sectors. This could have been avoided by imposing a zero exposure when calculating the algorithm, as we did with the intrasector exposures of the ROW sector. Often inexistent bilateral exposures are correctly estimated as zero because the sector under consideration has zero aggregate assets/liabilities in an asset class. For instance, the HH sector does not have aggregate liabilities in debt securities and equities so that the estimated bilateral exposures to HH in these assets are zero. When inexistent bilateral exposures are estimated as non-zero, they do not receive much weight in most cases because the aggregate assets/liabilities of at least one of the sectors under consideration are small.

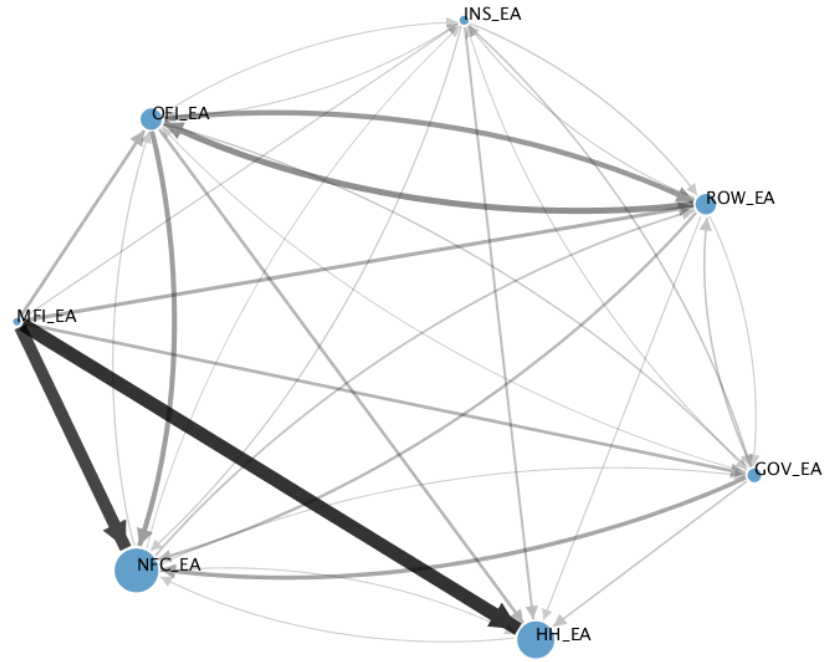
All in all, the accuracy of estimated loan bilateral exposures in the Euro Area can be considered satisfactory, since the mean absolute error in the estimation of exposures relative to total assets is only of 1.5 pp.

Box 4. Estimated vs. Actual Bilateral Exposures (Euro Area, exposure in loans, 2007:Q2)

Estimated bilateral exposures



Actual bilateral exposures



APPENDIX III. LARGEST INCREASES AND DECREASES IN EXPOSURES

Debt securities other than shares

Largest increases in creditor's exposure between 2007:Q2 and 2012:Q2 (pp)			
National exposures			
By creditor		By debtor	
INS_JP	2.63	GOV_JP	4.00
MFI_JP	2.31	GOV_US	3.10
INS_UK	1.84	GOV_UK	1.65
OFI_US	1.49	GOV_EA	0.84
MFI_US	1.26	ROW_UK	0.75
Cross-border exposures			
By creditor		By debtor	
HH_UK	0.14	GOV_US	0.39
MFI_JP	0.12	GOV_UK	0.06
HH_JP	0.10	MFI_US	0.03
HH_EA	0.09	NFC_EA	0.03
MFI_US	0.02	GOV_EA	0.03
Largest decreases in creditor's exposure between 2007:Q2 and 2012:Q2 (pp)			
National exposures			
By creditor		By debtor	
GOV_US	-2.76	OFI_US	-3.53
GOV_JP	-0.43	OFI_JP	-0.55
HH_JP	-0.18	MFI_UK	-0.23
NFC_US	-0.18	MFI_EA	-0.22
GOV_UK	-0.15	MFI_JP	-0.14
Cross-border exposures			
By creditor		By debtor	
MFI_UK	-0.54	NFC_US	-0.57
MFI_EA	-0.19	MFI_EA	-0.27
HH_US	-0.02	MFI_UK	-0.08
MFI_US	0.02	NFC_UK	-0.03
HH_EA	0.09	NFC_JP	-0.01
Average differences in creditor's exposure between 2007:Q2 and 2012:Q2 (pp)			
National exposures		0.34	
Cross-border		-0.03	

Loans

Largest increases in creditor's exposure between 2007:Q2 and 2012:Q2 (pp)			
National exposures			
By creditor		By debtor	
GOV_US	1.89	ROW_EA	0.66
GOV_EA	0.92	NFC_JP	0.58
OFI_EA	0.81	GOV_EA	0.54
NFC_EA	0.70	OFI_EA	0.43
GOV_JP	0.34	ROW_US	0.12
Cross-border exposures			
By creditor		By debtor	
MFI_JP	0.06	MFI_JP	0.01
MFI_US	0.01	MFI_US	0.00
HH_US	0.01	NFC_JP	-0.01
HH_UK	0.00	NFC_UK	-0.06
HH_JP	-0.01	NFC_EA	-0.10
Largest decreases in creditor's exposure between 2007:Q2 and 2012:Q2 (pp)			
National exposures			
By creditor		By debtor	
MFI_UK	-2.06	HH_UK	-1.16
MFI_US	-1.76	ROW_UK	-0.86
OFI_UK	-1.08	OFI_UK	-0.84
OFI_US	-0.97	HH_US	-0.65
MFI_EA	-0.65	NFC_UK	-0.62
Cross-border exposures			
By creditor		By debtor	
MFI_UK	-0.88	MFI_EA	-0.55
MFI_EA	-0.02	NFC_US	-0.13
HH_EA	-0.01	NFC_EA	-0.10
HH_JP	-0.01	NFC_UK	-0.06
HH_UK	0.00	NFC_JP	-0.01
Average differences in creditor's exposure between 2007:Q2 and 2012:Q2 (pp)			
National exposures		-0.12	
Cross-border		-0.12	

Equity

Largest increases in creditor's exposure between 2007:Q2 and 2012:Q2 (pp)			
National exposures			
By creditor		By debtor	
NFC_US	0.94	ROW_EA	1.03
NFC_UK	0.89	ROW_US	0.60
GOV_JP	0.39	OFI_US	0.35
ROW_US	0.23	MFI_UK	0.12
OFI_US	0.14	INS_JP	-0.06
Cross-border exposures			
By creditor		By debtor	
HH_EA	0.12	NFC_US	0.06
MFI_US	0.05	NFC_UK	0.03
HH_JP	0.01	MFI_UK	0
MFI_JP	0	MFI_JP	-0.01
MFI_EA	-0.08	MFI_EA	-0.09
Largest decreases in creditor's exposure between 2007:Q2 and 2012:Q2 (pp)			
National exposures			
By creditor		By debtor	
INS_UK	-3.57	NFC_EA	-3.80
INS_JP	-2.92	NFC_JP	-3.59
INS_US	-2.40	NFC_UK	-2.99
HH_EA	-1.98	NFC_US	-2.30
HH_JP	-1.90	MFI_EA	-2.07
Cross-border exposures			
By creditor		By debtor	
HH_UK	-0.36	NFC_EA	-0.33
MFI_UK	-0.35	NFC_JP	-0.22
MFI_EA	-0.08	MFI_US	-0.12
HH_US	-0.08	MFI_EA	-0.09
MFI_JP	0	MFI_JP	-0.01
Average differences in creditor's exposure between 2007:Q2 and 2012:Q2 (pp)			
National exposures		-0.87	
Cross-border		-0.09	