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Jonas Heipertz, Romain Rancière, Natacha Valla

Domestic and external sectoral portfolios: network structure and balance-sheet contagion

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Abstract

This paper uses a unique comprehensive database on French security assets and liabilities to study the dynamics of domestic and external sectoral portfolios, their network structure, and their role in the propagation of shocks. We first show how the sharp deterioration of the net external portfolio position of France between 2008 and 2014 was driven by sectoral patterns such as the banking sector retrenchment and the increase in foreign liabilities of the public and corporate sectors, but was mitigated by the expansion of domestic and foreign asset portfolios of insurance companies. We also provide a network representation of the links between domestic sectors and the rest of the world, and document their evolution between 2008 and 2014. Second, we put forward and estimate a model of balance-sheet contagion through inter-sectoral security linkages. The estimation of the model shows that the financial sectors of the economy (banking, mutual fund, and insurance sector) are affected by balance-sheet contagion.

JEL Codes: F30, G11, G20

Keywords: Sectoral Inter-Linkages, Portfolio Investments, Asset Demand and Supply

Non-technical summary

This paper uses a unique comprehensive database on French security assets and liabilities to study the dynamics of domestic and external sectoral portfolios, their inter-linkages, and their role in the propagation of shocks. The sectors include banking, mutual funds, insurance, corporate, households and public sector. The data covers the period 2008-2014.

We first highlight specific sectoral patterns that echoed the 2008 sudden-stop: the banking sector severed its international activities; foreign liabilities of the public and corporate sectors gained prominence; by contrast, the insurance sector expanded massively its domestic and foreign asset portfolios. These patterns were behind the sharp deterioration of the net external portfolio position of France between 2008 and 2014.

We then analyze the inter-linkages between the assets and liabilities of domestic sectors and those of the rest of the world, and document their evolution. Over time, the banking sector rebalanced its asset portfolios away from public sector securities into corporate securities. Meanwhile, its liabilities became increasingly held abroad. Finally, the insurance sector took up a much larger role in the financing of the economy by increasing its holdings of securities issued by all sectors.

Finally, we propose and estimate a model in which financial contagion between sectors occurs through inter-sectoral security linkages. The estimation of the model shows that the financial sectors of the economy (banking, mutual fund, and insurance sector) are affected by balance-sheet contagion but not the real sectors (households, corporations, and public sector).

1 Introduction

Large shocks, such as the 2007-2008 financial crisis, can trigger sizable changes in countries' external portfolios, and in the dynamics of their net foreign assets positions. Such aggregate changes result from trade in financial assets undertaken by different sectors of the economy (banking, mutual funds, insurance, corporate, household and public sector) as well as valuation changes experienced by the corresponding sectoral portfolios. Using a unique security-level database covering the universe of asset and liability positions, valuation changes and flows of domestic and foreign security portfolios of French sectors between 2008 and 2014, this paper documents how sectoral portfolio patterns shape the dynamics of a country's external portfolio investment position. An estimated model of balance-sheet contagion exposes the role played by network linkages, in the form of domestic and foreign security cross-holdings, in the transmission of real and financial shocks.

While there is a vast literature on cross-border bank holdings and flows, there is so far limited evidence on international asset and liability holdings for other sectors of the economy. Data limitations might explain this gap. For example, the Coordinated Portfolio Investment Survey (CPIS) of the IMF only reports security holdings at the sector-level for some countries. The survey does not report any information on sector-level liabilities, nor any information on flows and valuations. In addition, the CPIS does not integrate external and domestic portfolios.

The ability to trace the institutional sector of the holding and issuing entity at the security-level makes the data uniquely suitable for the analysis of balance-sheet contagion at the sectoral level. We refer to balance-sheet contagion in a broad sense as a phenomenon where a shock to one sector also affects balance-sheets of other sectors through bilateral exposures (Kiyotaki and Moore, 2002). For example, the value of A's claim on B depends on the value of B's claims on C, who itself might have a claim on A. In focusing on balance-sheet contagion, the paper relates to a large literature on shock propagation through networks of firms and banks. For example, in the seminal paper by Eisenberg and Noe (2001), banks hold debt claims on each other and an outside asset. A sufficiently large shock to a bank's outside asset wipes out its equity and induces a default on its debt pro-rata, therefore affecting creditor banks.

The paper has three objectives. First, we document in a number of stylized facts the evolution of domestic and foreign portfolio assets and liabilities of French sectors between 2008 and 2014. Second, we analyze the network structure of cross-holdings among domestic sectors and the foreign sector. Third, we propose and structurally estimate a model of transmission of sectoral shocks through the network implied by bilateral asset

and liability positions. The model allows identifying the critical financial linkages that play a disproportionate role in the propagation of domestic and foreign sectoral shocks.

The main results are as follows: First, the net external portfolio position of France over the 2008-2014 period evolves from a positive net external position of 4.7 percent of GDP to a large negative net position of −35.7 percent of GDP. This large deterioration (−40.4 ppts) resulted mostly from the deterioration of the net external position of the public sector (−24.1 ppts), the banking sector (−15.1 ppts), and the corporate sector (−7.9 ppts), and was only partly compensated by an improvement of the net external position of the insurance sector (+7.6 ppts). The deterioration of the net external portfolio position came entirely from the external liability side of the aggregate balance-sheet, the external asset side remained constant (at about 100 percent of GDP), a reduction of the external assets of the banking sector (−9.8 ppts) being compensated by an increase in the external assets of the insurance sector, and of mutual funds. The deterioration was three times larger vis-à-vis non-Eurozone countries (−30.7 ppts) than vis-à-vis the Eurozone (−9.7 ppts), and five times larger for public sector liabilities (−19.8 vs. −4.3 ppts). Within the Eurozone, the French sectors, and chiefly the banking sector, exhibited a large retrenchment from GIPS countries (−11.3 ppts).

The analysis of cross-sectoral international portfolios reveals that the exposure of French sectors to Eurozone sectors changed dramatically over the period: a large reduction of the exposure to the Eurozone banking sector (−4.3 ppts) and Eurozone corporate sector (−9.6 ppts) was mirrored by a large increase in the exposure to the Eurozone mutual fund and insurance sector (+16.0 ppts).

Second, we discuss the joint evolution of the domestic and external sectoral portfolios. The banking sector exhibited a severe retrenchment with an amelioration of +11.4 ppts of its net domestic position coinciding with a −15.1 ppts deterioration of its net external position. The insurance sector increased significantly its net position in both domestic (+15.0 ppts) and external assets (+7.6 ppts). Consolidating the domestic and external sectoral net position reveals that the insurance sector is the largest net security creditor (+89.9 percent of GDP), while the public sector (−77.0 percent of GDP) and the corporate sector (−62.9 percent of GDP) are the largest net security debtors.

Third, we provide a network representation of bilateral asset and liability positions of sectors. Between 2008Q1 and 2014Q1, the banking sector substituted public sector securities with corporate securities and its liabilities became increasingly held by the rest of the world. The insurance sector ended up playing a much larger role in the financing of the economy through securities by increasing its holdings of securities issued by all sectors.

Fourth, the estimation of our balance-sheet contagion model shows that only the financial sectors of the economy propagate shocks on their security asset position, i.e. the banking sector, the insurance sector, and mutual funds. That is the impact of portfolio returns on the price of real sector securities through balance-sheet mechanisms comes out as insignificant. This is consistent with the intuition that the price of securities issued by the real sector is mostly driven by real shocks rather than financial contagion. We also show that consistent with the evolution of inter-sectoral linkages, the exposure of the banking and insurance sectors to public sector shocks has increased over the 2008 to 2014 period. All financial sectors are vulnerable to foreign sector shocks, consistent with their substantial external asset positions.

The descriptive section of the paper contributes to the literature on cross-sector balance-sheet exposures. Castrén and Kavonius (2009) use flow-of-funds data for the Eurozone and resort to entropy methods to estimate bilateral sectoral linkages due to data limitations. We do not have such limitations since our database allows us to observe inter-sectoral exposures in the data. Our main contribution is to integrate the analysis of domestic and international sectoral portfolios. Galstyan et al. (2016) also focus on international sectoral portfolios. Their analysis covers a cross-section of countries but is constrained by the limitations of the CPIS data as discussed in Section 2.

The estimated model of balance-sheet contagion explores how changes in the value of a sector's assets propagate through the re-pricing of its liabilities which are held as assets by other sectors. The estimated model makes three contributions to the literature. First, we show how balance-sheet contagion can be structurally derived and identified from an equilibrium model of asset demand and supply building on Koijen and Yogo (2018). We can, therefore, relate the magnitude of contagion to the sensitivity of demand and supply schedules to changes in security returns. Second, we obtain inter-sectoral linkages directly from the data and estimate the sector-specific link between the price of assets and liabilities. Third, we provide estimates of sectors' vulnerability to shocks originating in any part of the financial system rather than in the banking sector only.

The model builds on Koijen and Yogo (2018) who show how asset demand can be represented using a logit model, where portfolio shares depend on asset prices and characteristics. Under additional assumptions, such a representation can be derived from a mean-variance optimal portfolio allocation. We extend this model to incorporate both demand and supply decisions, and further derive and estimate implied balance-sheet contagion. The key contagion channel emphasized by our model is the endogenous response of asset demand and supply to changes in returns and vice-versa.

Other models test other channels of network contagion. Shin (2008) constructs a

model of balance-sheet contagion incorporating value-at-risk constraints. Contagion in Greenwood et al. (2014) works through the price impact of fire-sales. Allen and Gale (2000) focus on the interbank market and analyze how a financial crisis in one region spreads to other regions analyzing how different network structures affect the resilience or proneness of the network to contagion (see also Acemoglu et al. 2012).

2 Data Description

We use data on French portfolio investments collected by the Banque de France at quarterly frequency since 2008 through the exhaustive survey PROTIDE (PROduction de statistiques de TItres en DÉtention) among French resident custodians and financial institutions. Therefore, foreign asset portfolios also include holdings by French resident entities of liabilities issued by their foreign affiliates**.** Indeed, it contains the totality of portfolio investments, as they appear in the French international investment position and balance of payments statistics. The latter are constructed through aggregation of the security-level data contained in PROTIDE. Security accounts held by French residential households in non-residential custodial accounts are not recorded.[1]

The data is collected security-by-security and provides a wide range of information on the security itself, the sector of the holder and the issuer. At the most dis-aggregated level it distinguishes a security in the portfolio of a specific institutional sector. The security holdings data has been complemented by the security issuance survey of the Banque de France in order to obtain the complete coverage of French resident liabilities. Indeed, this is crucial since PROTIDE only records security holdings and does therefore not cover securities issued by French residents that are held by non-resident financial institutions or custodians.

The dataset is unique in the landscape of the literature on capital flows for at least two reasons: First, it provides a complete whom-to-whom mapping of portfolio assets and liabilities between domestic sectors and between domestic sectors and the rest of the world from 2008Q1 until today. The information on foreign portfolio investments by domestic residents indicates the type of the security (τ), the sector of the French holder (k), and the country (n) and sector of the issuer (j). Information on holdings of domestic assets by foreign residents includes the type of the security (τ), and the sector of the French issuer (j). In addition, it includes for the Eurozone the country (n) and sector of the security

[1]This omission, however, applies to many statistics on residential financial transactions. It might partly be addressed by the recent aggregation of national securities holding statistics by the ECB into the Securities Holding Statistics (SHS) database.

holder (k). Thus, an asset or liability security-level position can be expressed as $a_{\tau jkn}$ and $l_{\tau jkn}$ in which the country subscript n is dropped for domestic securities. To the best of our knowledge, this paper is the first to use such comprehensive portfolio cross-holdings of security assets and liabilities to analyze domestic and international financial linkages over the 2008-2014 period. Second, the data has a high degree of dis-aggregation (i.e. security-by-security at holding sector level) and covers all sectors of the economy.

Cross-border portfolio investments represent about one-third of the total international investment positions of France, followed by other investments, and foreign direct investments (Figure 2 (a)). Even more significant is the role of portfolio investments as a key driver of the net foreign asset position of France over the period (Figure 2 (b)). Between 2008 and 2014, one observes a large trend increase in the net negative position in portfolio investments and a large trend decrease in the net negative position in other investments. The increase in net portfolio liabilities exceeds the decrease in net liabilities of other investments, the difference explaining the deterioration of the overall net international investment position.

The breakdown of the change of the net foreign asset position into flows and valuation shows that flows dominate the dynamics and clearly confirms the substitution of other investments by portfolio investments as the driver of the change in the net position. However, portfolio investment valuation still plays a sizable role for the aggregate foreign asset and liability positions (Figure 3). This is consistent with the fact that other investments (of which a large part are bank loans) exhibit smaller valuation effects than securities do. Aggregate valuation effects, therefore, reflect, to a large extent, portfolio valuation effects.

3 Domestic and External Sectoral Portfolios

The objective of this section is first to describe the construction of domestic and external sectoral portfolios and then to show how the analysis of these portfolios helps to understand, for the period 2008-2014, (*i*) the deterioration of the net external portfolio position of France, (*ii*) the joint evolution of domestic and external sectoral portfolios, and (*iii*) the evolution of the financial network structure implied by bilateral asset and liability positions.

3.1 Constructing Sectoral Portfolios

Sectoral portfolios are obtained by aggregating security-level asset and liability positions of each sector. The underlying data are the security-level PROTIDE data which report,

at quarterly frequency, the issuer and the holder of a security, and allows to decompose the change of asset and liability positions into flows and valuations. We consider the following six institutional sectors defined in the European System of National and Regional Accounts (ESA 2010):

1. Banks and money market funds referred to as the *banking sector*
2. Other financial corporations, which are (mostly) mutual funds and thus referred to as *mutual funds*[2]
3. Non-financial corporations referred to as the *corporate sector*
4. The *insurance sector*
5. Households and non-profit institutions serving households referred to as the *household sector*
6. The *public sector*

For each sector, we report the portfolio assets (A_t) and liabilities (L_t) in equity (E_t) and debt (B_t). The portfolio of each sector is divided between the domestic portfolio (domestic assets and liabilities held by other domestic agents), and the foreign portfolio (indexed by $*$). Net asset positions are obtained as the difference between assets and liabilities.

By construction, the sum of domestic assets equals the sum of domestic liabilities,

$$\sum_{i=1}^{6} \left(B_{it}^{A} + E_{it}^{A}\right) = \sum_{i=1}^{6} \left(B_{it}^{L} + E_{it}^{L}\right),$$

which does not prevent each individual sector to have a positive or negative net domestic position. The sum of net foreign asset positions of each sector equals the country's net external portfolio (NEP_t):

$$NEP_t = \sum_{i=1}^{6} NEP_{it} = \sum_{j=1}^{6} \left(B_{it}^{A*} + E_{it}^{A*}\right) - \sum_{j=1}^{6} \left(B_{it}^{L*} + E_{it}^{L*}\right).$$

[2]The sector *other financial corporations* comprises all institutional units whose principal activity is the production of financial services for the market other than banks, money-market funds, insurance corporations or pension funds. The largest subcategory of this sector are non-money market investment funds (OPCVM in French), that is collective investment schemes issuing fund shares that are not close substitutes to deposits (contrary to money-market funds) and might invest in long-term financial assets or real estate. It also includes other financial intermediaries (e.g. security and derivative dealers, leasing and factoring corporations), financial auxiliaries (e.g. brokers and consultants) and captive financial institutions and money lenders.

Further, the evolution of any position between two periods can be decomposed into new flows and changes in the market value of existing positions. The change in the net foreign position of sector i can thus be written as

$$NEP_{it} - NEP_{it-1} = F_{it} + \triangle Val\left(NEP_{it-1}\right),$$

where F_{it} measures the net new flows during period t and $\triangle Val\left(NEP_{it-1}\right)$ measures the change in valuation of the portfolio hold at time $t-1$. The latter can be further decomposed into a price effect and an exchange rate effect.

3.2 Stylized Facts on French Domestic and External Sectoral Portfolios

3.2.1 *External Portfolios*

Table 1 decomposes external assets and liabilities in percent of French GDP of each sector in 2008Q1 and 2014Q1. Table 1, Panel A aggregates debt and equity positions which are dis-aggregated in Panel B and Panel C. Changes in assets and liabilities between 2008Q1 and 2014Q1 are measured in percentage point (ppt) changes of their share of GDP. The analysis of sectoral portfolios allows to understand the role played by each sector in the large deterioration of the external portfolio position of France from a net positive position in 2008Q1 (+4.7 percent of GDP) to a large net negative position (−35.7 percent of GDP) in 2014Q1:

Stylized Fact 1 ***[Net External Position]****: The sharp deterioration of the net external position between 2008Q1 and 2014Q1 (−40.4 ppts) is explained by the deterioration of the external position of: the public sector (−24.1 ppts), the banking sector (−15.1 ppts), and the corporate sector (−7.9 ppts). The insurance sector is the only sector whose net external position improved (+7.6 ppts).*

Between 2008Q1 and 2014Q1, the external asset position barely changed from 100.3 to 101.3 percent of GDP while the external liability position deteriorated sharply from 95.6 to 137.0 percent of GDP, thus explaining entirely the deterioration of the net external position. Underlying those aggregates are large re-shufflings in sectoral positions both on the asset and the liability side.

Stylized Fact 2 ***[External Assets and Liabilities]****: The stability in aggregate external asset portfolio between 2008Q1 and 2014Q1 has been associated with a sharp reduction*

in the external assets of the banking sector (−9.3 ppts) largely compensated by an increase in the external assets of the insurance sector (+6.3 ppts) and of mutual funds (+1.5 ppts). The deterioration of the net external position (Stylized Fact 1) is due to a deterioration in the liability positions.

Breaking down positions between debt and equity (Table 1, Panel A and Panel B) reveals that the net external position in 2008Q1 was positive in debt (+12.8 percent of GDP) and negative in equity (−8.1 percent of GDP). By 2014Q1, the net external position in equity barely changed (−6.6 percent of GDP), but the net position in debt became strongly negative (−29.1 percent of GDP). This implies that the sharp deterioration in the net external portfolio (−40.4 percent of GDP) can be explained by that of the debt liability position. The underlying sectoral patterns can be summarized as:

Stylized Fact 3 ***[Debt versus Equity Portfolios****]: The deterioration in the net external position (−40.4 ppts) is mostly explained by the increase of debt liabilities (+39.2 ppts) and is mostly driven by the increased debt liabilities of the public sector (+24.2 ppts), the banking sector (+6.5 ppts), and the corporate sector (+6.5 ppts). On the asset side, banks reduce sharply their external debt holdings (−9.8 ppts), while the insurance sector increased them significantly (+4.9 ppts).*

Table 2 summarizes the stylized facts described above by showing the contribution of each sector and each balance-sheet item to the change in the net external portfolio position of France between 2008Q1 and 2014Q1.

Table 3 contrasts the role of Eurozone and non-Eurozone countries in external portfolios. The net position of France vis-à-vis the Eurozone deteriorated from 23.3 to 13.6 percent of GDP. Vis-à-vis non-Eurozone countries, the net position of France deteriorated three times more, from −18.6 to −49.3 percent of GDP. The related sectoral patterns can be summarized as follows:

Stylized Fact 4 ***[Eurozone versus ROW]:*** *The deterioration of the net portfolio position vis-à-vis the non-Eurozone countries has been three times larger than vis-à-vis the Eurozone countries (−30.7 ppts vs. −9.7 ppts). The banking sector shifted from being a net portfolio creditor to becoming a net debtor vis-à-vis non-Eurozone countries. The deterioration in the public sector liability position has been about five times larger vis-à-vis the non-Eurozone countries than vis-à-vis Eurozone countries (−19.8 ppts vs. −4.3 ppts).*

Table 4 decomposes the Eurozone asset portfolios further into assets held on GIPS

countries (Greece, Italy, Portugal, Spain) versus asset held on non-GIPS countries.[3] As expected the reduction in the exposure to GIPS countries has been massive between 2008Q1 and 2014Q1, from 23.5 to 12.2 percent of GDP, and especially so in the banking sector (from 10.5 to 4.7 percent of GDP). By contrast the external asset position towards non-GIPS countries has increased slightly from 39.2 to 43.4 percent of GDP, with the largest contribution coming from the insurance sector (+3.2 ppts).

Stylized Fact 5 ***[GIPS versus Non-GIPS]:*** *The asset exposure of French sectors to Eurozone countries exhibited a retrenchment from GIPS countries (−11.3 ppts), with a large contribution of the banking sector (−5.9 ppts), and a more modest expansion towards the non-GIPS countries (+4.2 ppts).*

Table 5, Panel A decomposes the evolution of international sectoral portfolios between 2008Q1 and 2014Q1 between *flows and valuations*. Panel B and Panel C provide the same decomposition for debt and equity portfolios. Overall, exchange rate fluctuations play a modest role compared to changes in asset prices and portfolio flows. As previously discussed, most of the change in the country's external net portfolio position came from the debt liability side, and since the valuation losses on the liability side were, to a large extent, compensated by valuation gains on the asset side, net flows contributed seven times more to the change in the net portfolio position than net valuation effects (−36.2 ppts vs. −5.1 ppts). The relative role of flows and valuations varies however substantially across sectors as summarized below.

Stylized Fact 6 ***[Valuations versus Flows]:*** *Valuation effects account for about* 12 *percent of the change in the net external portfolio position between 2008Q1 and 2014Q1. The increase in the assets portfolio of the insurance sector is balanced between flows and valuation effects while the banking sector mostly experienced negative net asset flows. Valuation effects account for* 15 *to* 20 *percent of the deterioration of the liability position of the public sector, corporate sector, and the banking sector. Net valuation effects are about equally divided between equity and debt portfolios.*

3.2.2 *External Cross Sectoral Portfolios*

Table 6 describes the asset and liability linkages between French sectors and the Eurozone sectors. The table shows how much a French sector is exposed to each of the four Eurozone sectors, i.e. the banking sector, the corporate and household sector, the mutual funds and insurance sector, and the public sector.

[3]For such decomposition, the information contained in PROTIDE is restricted on the asset side.

Looking at the total assets combined of French sectors reveals a striking fact: while the overall exposure stays nearly constant, the distribution of that exposure across the different Eurozone sectors changes dramatically between 2008Q1 and 2014Q1: the exposure of French sectors to the Eurozone banking sector was reduced from 16.6 to 12.2 percent of GDP, and that to the Eurozone corporate and household sectors was halved from 20.3 to 10.7 percent of GDP; meanwhile the exposure to the mutual funds and insurance sectors more than tripled from 6.7 percent of 22.7 percent of GDP. Turning to specific French sectors, the French banking sector reduced its exposure to the Eurozone banking sector substantially (from 7.7 to 4.7 percent of GDP), but it reduced exposure to the Eurozone corporate and household sector even more (from 7.9 to 1.3 percent of GDP). The insurance sector expanded its asset position in Eurozone mutual funds and insurances (from 0.9 to 7.5 percent of GDP).

On the liability side, French sectors combined increased their liabilities to Eurozone sectors from 39.1 to 51.5 percent of GDP, an increase which is almost entirely due to larger holdings of French assets by the Eurozone banking sector.

Stylized Fact 7 ***[Eurozone Sectors]:*** *During the period 2008Q1-2014Q1, the exposure of French sectors to Eurozone sectors changed dramatically: a large reduction of the exposure to the Eurozone banking sector (−4.3 ppts) and Eurozone corporate and household sector (−9.6 ppts) was mirrored by a large increase in the exposure to the Eurozone mutual funds and insurance sector (+16.0 ppts). The increase in French liabilities towards the Eurozone (+12.3 ppts) has been almost entirely absorbed by the Eurozone banking sector.*

3.2.3 *Domestic versus Foreign Portfolios*

Table 7 contrasts the evolution of the domestic and the foreign portfolio between 2008Q1 and 2014Q1. Panel A presents the domestic positions, Panel B the external positions, and Panel C the consolidated positions. While the aggregate domestic portfolio is balanced, by construction, there are internal imbalances at the sector-level as well as external and consolidated imbalances. The comparison of the domestic, foreign and consolidated portfolios across sectors can be summarized as follows:

Stylized Fact 8 ***[Domestic and Foreign Portfolios]:*** *The banking sector improves its domestic net portfolio position (+11.4 ppts) while its foreign net portfolio position deteriorates (−15.1 ppts), as a result of a shift of its liabilities from foreign to domestic, and of its assets from foreign to domestic. The banking sector's consolidated net position*

deteriorated modestly (−3.8 ppts). The public sector increased its external liabilities significantly more than its domestic liabilities (−24.2 ppts vs. −10.4 ppts). The insurance sector increased its domestic assets (+13.2 ppts) significantly more than its foreign assets (+6.3 ppts).

Consolidating the domestic and external net positions (Panel C) reveals that in 2014Q1 the insurance sector is the largest net security creditor (+89.9 percent of GDP) while the public sector (−77.0 percent of GDP) and the corporate sector (−62.9 percent of GDP) are the largest net debtors.

By looking at the share of foreign assets in total portfolios in 2008Q1 and 2014Q1 (Table 8), one can assess the relative role of p*ortfolio growth vs. portfolio re-balancing*, as discussed by Kraay and Ventura (2000). An implication of portfolio growth is that the share of foreign assets in the portfolio must remain roughly constant over time. Interestingly, the portfolio growth hypothesis works very well for the aggregate assets position - a constant share of about 37 percent of foreign assets over total assets - despite large heterogeneity across sectors, with the retrenchment of the banking sector being compensated by the outwards expansion of other sectors, mostly the household sector. On the liability side, the aggregate portfolio liability position became increasingly international, reflecting re-balancing towards foreign liabilities in all sectors. These findings can be summarized as follows:

Stylized Fact 9 ***[Portfolio Growth versus Re-balancing]:*** *The share of the aggregate foreign asset portfolio remained constant between 2008Q1 and 2014Q1 despite large heterogeneity across sectors, with the banking sector exhibiting retrenchment, and the household sector foreign expansion. On the asset side, the evolution of the portfolio of the insurance sector and that of mutual funds are consistent with the portfolio growth hypothesis. The share of foreign liabilities in total liabilities increased sharply over the period and all sectors re-balanced their liabilities towards international liabilities. Only the insurance sector exhibits a behavior consistent with portfolio growth on the liability side.*

3.3 The Network Structure of Domestic and External Portfolios

The cross-sectoral asset and liability positions between domestic sectors, and between domestic sectors and the rest of the world form a weighted network whose weights are determined by the size of cross-sectoral exposures. Figure 4 graphs the network of domestic

sectors. An arrow pointing from sector i to sector j indicates the amount of liabilities issued by sector j which are held in the asset portfolio of sector i. Cross-holdings are normalized by GDP and positions amounting to less than 1 percent of GDP are omitted to keep the graph easily readable. Each node represents a sector and the size of each node is proportional to the sum of total security assets of the sector. The position of sectors in the graph is based on the number of links (exceeding one percent of GDP) through which a sector is connected with other sectors. The intensity of cross-sector links is captured by the thickness of the arrows.

Figure 4 compares the domestic network in 2008Q1 and 2014Q1. From Table 7, we know that the total of domestic security assets positions (which by construction is also the total of domestic security liabilities) barely changes (from 167.1 to 170.8 percent of GDP), but the network graph reveals that the *distribution of domestic cross-sectoral asset and liability position did change substantially.* A large fraction of the increase in the asset position of the insurance sector (from 44.9 to 58.1 percent of GDP) corresponds to a change in its holdings of public sector securities (+6.2 ppts). The banking sector slightly increased its domestic asset position (from 38.8 to 43.2 percent of GDP) as a result of a reduction in its holdings of corporate sector securities (from 5.6 to 3.5 percent of GDP), and an *increase* in its holdings of public sector securities (from 7.9 to 12.9 percent of GDP). The banking sector also reduced its liability positions (from 56.1 to 49.1 percent of GDP), which is reflected in the reduction of the holdings of banking sector securities in the portfolio of corporations, households, and mutual funds. Finally, the government reduces its holding of securities issued by corporations (through privatization of government's assets) and households reduce their holdings of mutual funds liabilities. These findings can be summarized as follows:

Stylized Fact 10 ***[Domestic Network]:*** *The banking and insurance sectors increase their holdings of public sector securities. The banking sector did so by reducing its holdings of corporate sector securities and the insurance sector by increasing its overall asset position. The reduction of banking sector liabilities has been associated with a reduction in the holdings of banking sector liabilities by corporations, mutual funds, and households.*

Figure 5 adds the rest of the world (ROW) as an additional node to the network, and thus the network graph maps both external and domestic sector portfolios. In 2008Q1, the ROW accounted for 37.5 percent of French security assets, and 36.4 percent of French security liabilities. By 2014Q1, the foreign share of assets was about the same, but that of foreign liabilities increased to 44.5 percent of GDP. The graph shows the reversal in the banking sector net external portfolio through a sharp reduction in external assets

and a sharp increase in external liabilities. Securities issued by the French corporate sector became also increasingly held by the ROW. Indeed, the liabilities of the corporate sector held in domestic portfolios remain constant at about 47 percent of GDP, while corporate liabilities held in foreign portfolios increased from 30.8 to 38.8 percent of GDP. Figure 3 breaks down the ROW between Eurozone and non-Eurozone countries. The increase in foreign liabilities of the most externally indebted French sectors (banking sector, corporate sector, and public sector) has been disproportionately tilted towards non-Eurozone countries, which thus experienced an increase in their holdings of French assets by 29.1 ppts vs. 12.3 ppts for Eurozone countries. These findings can be summarized as follows:

Stylized Fact 11 ***[International Network]:*** *Between 2008Q1 and 2014Q1, France experienced an increase in its international financial integration driven by the increase in liability exposure of the banking sector, the corporate sector, and the public sector. Such international financial integration has been disproportionately tilted towards liability exposure to non-Eurozone countries. The insurance sector is the only sector that significantly increased its foreign assets.*

4 An Estimated Model of Sectoral Balance-Sheet Contagion

In this section, we put forward and estimate a simple equilibrium model of balance-sheet contagion. The central idea is that the value of liabilities issued by a sector depends on the value of assets held on the asset side of the sector's balance-sheet. The transmission of value changes from the asset to the liability side of the balance-sheet is called *balance-sheet contagion*.

From a structural point of view, such balance-sheet contagion is, in fact, the result of demand and supply decisions taken by market participants and a price discovery mechanism that leads to market clearing. Indeed, the steps from a change in the value of sector's assets to a change in the value of its liabilities are as follows: *First*, a change in the value of assets induces the sector to rebalance its asset portfolio and to adjust its liabilities. This, *second*, generates partial disequilibria on asset markets and therefore leads to partial price changes, which, *third*, induce further portfolio rebalancings and liability adjustments by other sectors until eventually, a new market clearing price vector emerges. In equilibrium, there is thus a specific comovement of the value of a sector's assets and

liabilities. A change in the value of assets of one sector can, through equilibrium price changes, propagate to all sectors of the economy.

Fundamentally, the degree of balance-sheet contagion depends on the shape of sectoral demand and supply function for financial assets, and in particular on the sensitivity of sectors' demand and supply of a given asset to price changes. Demand and supply are in turn determined by sector-specific balance-sheet management objectives, return beliefs, and constraints. Here, instead of deriving optimal demand and supply schedules from balance-sheet optimization problems, we build on Koijen and Yogo (2018) and model asset demand and supply directly as functions of asset characteristics.

In this framework, balance-sheet contagion has a simple form and is captured by a function of (i) sector-specific balance-sheet contagion coefficient and (ii) the network of bilateral sectoral exposures.

4.1 The Model

There is a set of domestic institutional sectors indexed by $i \in \{1, 2, \ldots, I\}$. The set of assets available for investment to sector i is noted by $\mathcal{P}_i^A$. It comprises securities issued by domestic sectors indexed by $j(i')$, $i' \in \{1, 2, \ldots, I\}$, and securities that are issued by foreign entities. The foreign portfolio of each sector is different and is summarized by one bundled *sector-specific foreign asset* denoted by $f(i)$. It thus allows to capture the heterogeneity of returns on foreign asset portfolios across sectors highlighted by Galstyan and Velic (2018) for the case of Germany. Similarly, all other types of instruments that are not part of portfolio investments, such as loans, cash or real assets are bundled into a *sector-specific outside asset* noted $o(i)$. Each sector i can also raise funds through issuing either securities denoted by $j(i)$ or other financial instruments which are again bundled into the outside asset $o(i)$. The set of assets available to sector i for raising funds is denoted $\mathcal{P}_i^L$.

Figure 1: Sector i's Asset and Liability Allocation

	Assets	Liabilities
Domestic Securities	ω^A_{i1t}	
	$\omega^A_{ij(i)t}$	$\omega^L_{ij(i)t}$
	$\ldots$	
	ω^A_{iJt}	
Foreign Portfolio Investments	$\omega^A_{if(i)t}$	
Other Assets, e.g. loans, cash, ...	$\omega^A_{io(i)t}$	$\omega^L_{io(i)t}$
	$= 1$	$= 1$

Figure 1 summarizes notations and illustrates the complete allocation of sector i's assets and liabilities across the different assets, where ω^s_{ikt} is the share of asset k in sector i's assets ($s = A$) or liabilities ($s = L$) in period t.[4]

In the following, we model equilibrium returns on the domestic securities issued by the different sectors, taking as given returns on foreign portfolio investments and outside assets.

4.1.1 *Asset Demand and Supply*

We build on the approach followed by Koijen and Yogo (2018) and model a sector's optimal portfolio allocation as a logit model of asset characteristics. Compared to the mean-variance case, where the optimal allocation depends on the full variance-covariance matrix of returns, this might seem an over-simplification. However, when it is additionally assumed that (i) returns follow a factor structure, *and* that (ii) the factor loadings depend on asset characteristics, the optimal mean-variance allocation and the characteristics-based logit model can be shown to be approximately equivalent. In this case, asset characteristics are sufficient to capture expected returns and their variance-covariance.

With $s \in \{A, L\}$ noting assets or liabilities, the share of sector i's balance-sheet invested in (or raised through) asset k in period t is modeled as

$$\omega^s_{ikt} = \frac{\exp\left(b^s_{i0} + b^s_i \log P_{kt} + \log U^s_{ikt}\right)}{1 + \sum_{l \in \mathcal{P}^s_i} \exp\left(b^s_{i0} + b^s_i \log P_{lt} + \log U^s_{ilt}\right)}, \tag{1}$$

where b^s_{i0} and b^s_i are sector-specific intercept and coefficient on the log-price, $\log P_{kt}$, respectively, that determine the shape of sector i's demand and supply function. Asset characteristics other than the price that generate latent demand or supply for asset k are captured by the term $\log U^s_{ikt}$. Equation 1 and the budget constraint imply that the share of the outside asset is $\omega^s_{io(i)t} = 1/1 + \sum_{l \in \mathcal{P}^s_i} \exp\left(b^s_{i0} + b^s_i \log P_{lt} + u^s_{ilt}\right)$ and we derive the growth factors of balance-sheet shares from period $t-1$ to t as

$$\frac{\omega^s_{ikt}}{\omega^s_{ikt-1}} = \left(\frac{P_{kt}}{P_{kt-1}}\right)^{b^s_i} \cdot \frac{U^s_{kt}}{U^s_{kt-1}} \cdot \frac{\omega^s_{io(i)t}}{\omega^s_{io(i)t-1}}. \tag{2}$$

Taking logs of Equation 2 and using a first-order approximation, the growth rate of the

[4]The share of assets invested in own liabilities is generally different from zero, because entities within the sector can invest in securities issued by an entity that is part of the same sector.

share of asset k in sector i's balance-sheet,

$$z^s_{ikt} \approx b^s_i r_{kt} + \Delta u^s_{ikt} + z^s_{o(i)t}, \tag{3}$$

is approximately linear in the contemporaneous return on asset k, r_{kt}, the log-difference of latent demand (or supply), Δu^s_{ikt}, and the growth rate of the share of the outside asset, $z^s_{o(i)t}$. The coefficient on the log-price, b^s_i, is therefore simply the *sensitivity of balance-sheet share growth rates to contemporaneous returns.*

4.1.2 *Sectoral Balance-Sheet Equilibrium*

Sectoral balance-sheet identities are used to determine the equilibrium vector of returns. Indeed, in equilibrium not only must markets clear, but also the value of assets must be the same as the value of liabilities for each sector:

$$A_{it} = L_{it}. \tag{4}$$

Now, using the linear expression for the growth rate of asset shares from Equation 3, sectoral balance-sheet identities can be decomposed as

$$\sum_{l \in \mathcal{P}^s_i} \omega^A_{ilt-1} \left[b^A_i r_{lt} + \Delta u^A_{ilt} \right] + z^A_{o(i)t} = \omega^L_{ij(i)t-1} \left[b^L_i r_{j(i)t} + \Delta u^L_{ij(i)t} \right] + z^L_{o(i)t}. \tag{5}$$

Returns on domestic securities must thus move to equalize asset- and liability side of the balance-sheet given the balance-sheet allocation in $t-1$, and exogenous changes in the allocation of the rest of the balance-sheet. Stacking balance-sheet identities (one for each domestic sector) in matrix notation, the I-column vector of equilibrium returns on domestic securities is shown to be

$$\mathbf{r}_t = \underbrace{\left(I - \text{diag}(\boldsymbol{\beta}) \widetilde{\Omega}_{t-1} \right)^{-1}}_{\equiv C(\boldsymbol{\beta})_{t-1}} \cdot \left(\underbrace{\text{diag}(\boldsymbol{\alpha}) \tilde{\boldsymbol{z}}_{ot}}_{(i)\ Outside\ Assets} + \underbrace{\text{diag}(\boldsymbol{\beta}) \text{diag}(\widetilde{\boldsymbol{\omega}}_{ft-1}) \mathbf{r}_{ft}}_{(ii)\ Foreign\ Assets} + \underbrace{\boldsymbol{\epsilon}_t}_{(iii)\ Shocks} \right), \tag{6}$$

where *tilde* denotes normalization by the shares of a sector's liabilities raised through securities, $\omega^L_{ij(i)t-1}$. Equilibrium returns thus crucially depend on the ratio $\beta_i \equiv \frac{b^A_i}{b^L_i}$, that we call *balance-sheet contagion coefficient*, which is the relative sensitivity of sector i's asset demand over asset supply to contemporaneous returns. Importantly, given that β_i is a ratio, its value is unrestricted and, in particular, can be either smaller or larger than one. Further, we defined $\alpha_i \equiv 1/b^L_i$, the vector $\tilde{\boldsymbol{z}}_{ot} \equiv \tilde{z}^A_{o(i)t} - \tilde{z}^A_{o(i)t}$ as the asset-liability

difference in growth rates of the share of outside assets in sectors' balance-sheets, and $\boldsymbol{\epsilon}_t$ the vector of shocks that contains sectors' latent demand and supply for domestic securities and foreign portfolio investments.

As shown in Equation 6, equilibrium returns are determined by the endogenous reaction of balance-sheet shares of domestic securities to exogenous changes in the allocation of the rest of the balance-sheet, i.e. exogenous changes in (i) the outside asset share, (ii) the return on foreign portfolio investments, and (iii) the net of latent demand and supply. The matrix $C(\boldsymbol{\beta})_t$, called *contagion matrix*, captures how exogenous changes in sectoral balance-sheets propagate to changes in equilibrium returns.

4.1.3 *Balance-Sheet Contagion*

To illustrate how an exogenous change in sectoral balance-sheets propagates to equilibrium returns, consider a shock $d\boldsymbol{\epsilon}_t$. Total differentiation of Equation 6,

$$d\mathbf{r}_t = C(\boldsymbol{\beta})_{t-1} \cdot d\boldsymbol{\epsilon}_t, \tag{7}$$

shows that the contagion matrix, $C(\boldsymbol{\beta})_{t-1}$, maps sectoral shocks to changes in equilibrium returns. The rows of the contagion matrix correspond to returns on securities issued by a sector and the columns to the sectors in which the shock originated. The elements of the contagion matrix are sector-specific multipliers that measure the strength of the full transmission of sectoral shocks through the network.

To understand how shocks propagate through sectoral balance-sheets, we decompose the full return change (Equation 7) into a sequence of partial return adjustments

$$d\mathbf{r}_t = \underbrace{d\boldsymbol{\epsilon}_t}_{d\mathbf{r}_t|_1} + \underbrace{\operatorname{diag}(\boldsymbol{\beta})\,\widetilde{\Omega}_{t-1} d\mathbf{r}_t|_1}_{d\mathbf{r}_t|_2} + \underbrace{\left(\operatorname{diag}(\boldsymbol{\beta})\,\widetilde{\Omega}_{t-1}\right)^2 d\boldsymbol{\epsilon}_t}_{d\mathbf{r}_t|_3} + \dots, \tag{8}$$

where Equation 8 follows from expanding the contagion matrix as infinite sum $C(\boldsymbol{\beta})_{t-1} = \sum_{p=0}^{\infty} \left(\operatorname{diag}(\boldsymbol{\beta})\,\widetilde{\Omega}_{t-1}\right)^p$. Under this sequential representation, in each step returns move such as to revalue a sector's liabilities to match the value of its assets and restore the balance-sheet identity. In particular, the chain from the shock to the full change in returns is as follows: First, the shock leads to a discrepancy between sectors' assets and liabilities of magnitude $d\boldsymbol{\epsilon}_t$. In order to restore balance-sheet identities, returns thus initially move one-for-one, $d\mathbf{r}_t|_1 = d\boldsymbol{\epsilon}_t$, with the shock in order to revalue liabilities and match assets. This initial partial change of returns, however, leads to rebalancings of demand and supply and value changes on the asset side, which again generate balance-sheet disequilibria of

magnitude diag $(\boldsymbol{\beta})\,\widetilde{\Omega}_{t-1}d\mathbf{r}_t|_1$. These, in turn, require a *second* change in returns, $d\mathbf{r}_t|_2$, and so forth until the shock is fully propagated and a new balance-sheet equilibrium is reached.

The role of sectors in the propagation of shocks depends on the balance-sheet contagion coefficients $\boldsymbol{\beta}$ and the time-varying matrix of normalized asset shares $\tilde{\Omega}_{t-1}$. Indeed, ceteris paribus, the role of a given sector i for shock propagation increases, the stronger the sensitivity of its asset shares to returns (b_i^A high) and the weaker the reaction of its liability shares to returns (b_i^L low). Further, the more a sector is exposed to a given asset k (the higher the asset share ω_{ikt-1}^A), the stronger the effect on the value of sectoral assets for a given change in returns. Similarily, the lower the share of securities in total sectoral liabilities (the lower the liability share $\omega_{ij(i)-1}^L$), the more returns must move in order to revalue liabilities and restore balance-sheet equilibria.

4.2 Identification and Estimation

The model as specified in Equation 6 can be identified and estimated through two-step GMM. For the identification of the parameters of the model, we need to make assumptions on the distribution of the residual $\boldsymbol{\epsilon}_t$. In particular, we assume that residuals have zero-mean,

$$\mathbb{E}\left[\boldsymbol{\epsilon}_t\right] = \mathbf{0}, \tag{9}$$

and are uncorrelated across sectors. We do, however, allow for heteroscedasticity across sectors, such that

$$\mathbb{V}ar\left[\boldsymbol{\epsilon}_t\right] \equiv \Sigma_\epsilon = \text{diag}\left(\sigma_1, \sigma_2, ..., \sigma_S\right). \tag{10}$$

The assumptions on the distribution of the I-column vector of residuals provide $I + I(I + 1)/2$ moment conditions, corresponding to I first order moments and $I(I + 1)/2$ second order moments from the variance-covariance matrix of the sectoral shocks. There are $3I$ parameters, corresponding to the I-column vectors $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$, and the number of variances in the variance-covariance matrix of $\boldsymbol{\epsilon}_t$. The model is exactly identified if there are as many moment conditions as parameters. The model is over-identified if the number of sectors I is larger than 3.

The baseline estimation is performed until the assumption of no correlation of residuals across sectors. We complete this baseline by allowing for various common shock structures: a global shock that affects all the sectors simultaneously, a financial shock that affects all the financial sectors of the economy (banking, mutual funds, insurance), and a real shock that affects the real sectors of the economy (corporate and public). A global shock with

variance σ_g, for example, changes the variance-covariance matrix to

$$\Sigma_\epsilon^g = \begin{pmatrix} \sigma_g + \sigma_1 & \sigma_g & \sigma_g & \sigma_g & \sigma_g \\ \sigma_g & \sigma_g + \sigma_2 & \sigma_g & \sigma_g & \sigma_g \\ \sigma_g & \sigma_g & \sigma_g + \sigma_3 & \sigma_g & \sigma_g \\ \sigma_g & \sigma_g & \sigma_g & \sigma_g + \sigma_4 & \sigma_g \\ \sigma_g & \sigma_g & \sigma_g & \sigma_g & \sigma_g + \sigma_5 \end{pmatrix}. \tag{11}$$

Similarly, the financial and the real shock introduce covariance between the financial and real sectors, respectively.

4.2.1 *Moment Conditions*

Equation 9 implies first-order moments,

$$m_1(\boldsymbol{\alpha}, \boldsymbol{\beta}) \equiv \mathbb{E}\left[\mathbf{r}_t - \text{diag}(\boldsymbol{\beta})\left(\widetilde{\Omega}_{t-1}\mathbf{r}_t - \text{diag}(\widetilde{\boldsymbol{\omega}}_{ft-1})\mathbf{r}_{ft}\right) - \text{diag}(\boldsymbol{\alpha})\tilde{\boldsymbol{z}}_{ot}\right], \tag{12}$$

and second order moments,

$$\begin{aligned} M_2(\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon) \equiv \mathbb{E}\Big[&\left(\mathbf{r}_t - \text{diag}(\boldsymbol{\beta})\left(\widetilde{\Omega}_{t-1}\mathbf{r}_t - \text{diag}(\widetilde{\boldsymbol{\omega}}_{ft-1})\mathbf{r}_{ft}\right) - \text{diag}(\boldsymbol{\alpha})\tilde{\boldsymbol{z}}_{ot}\right) \cdot \\ &\left(\mathbf{r}_t - \text{diag}(\boldsymbol{\beta})\left(\widetilde{\Omega}_{t-1}\mathbf{r}_t - \text{diag}(\widetilde{\boldsymbol{\omega}}_{ft-1})\mathbf{r}_{ft}\right) - \text{diag}(\boldsymbol{\alpha})\tilde{\boldsymbol{z}}_{ot}\right)'\Big] - \Sigma_\epsilon. \end{aligned} \tag{13}$$

We stack the $I(I+1)/2$ independent second-order moment conditions into the vector $m_2(\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon)$ and define the vector of empirical moment conditions as $\bar{m}(\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon)' \equiv (\bar{m}_1', \bar{m}_2')'$.

4.2.2 *Two-Step GMM*

In the first step, we obtain the minimizer of the sum of squared empirical moment conditions

$$\widehat{(\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon)}_{GMM1} = \text{argmin}_{\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon}\left\{\bar{m}(\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon) \cdot I \cdot \bar{m}(\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon)'\right\}.$$

In the second step, the inverse of the estimate of the variance-covariance matrix of moment conditions obtained in the first step, $S_T = \frac{1}{T}\sum_{t=1}^{T} \widehat{m_t}\big|_{GMM1} \widehat{m_t}\big|_{GMM1}'$, is used as a weighting matrix for the empirical moments and final estimates are obtained as

$$\widehat{(\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon)}_{GMM2} = \text{argmin}_{\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon}\left\{\bar{m}(\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon) \cdot S_T^{-1} \cdot \bar{m}(\boldsymbol{\alpha}, \boldsymbol{\beta}, \Sigma_\epsilon)'\right\}.$$

The variance-covariance matrix of the estimates results from the gradient of the empirical moment conditions and the updated estimate of the variance-covariance matrix of moments.

4.3 Results

The estimates of the model's parameters are presented in Table 9. First, balance-sheet contagion coefficients are significantly different from zero only for the financial sectors, i.e. for the banking sector, the insurance sector, and for mutual funds, while they are statistically insignificant for the real sectors. This result is consistent with our prior that decisions on the balance-sheet structure of the real sectors (corporate and public sector) are much more driven by factors such as demand for goods and services or the general macroeconomic outlook, rather than the return on the security portfolio. Further, public sector investments might rather be motivated by stabilization concerns and issuance of government bonds by public spending.

Second, the contagion coefficients for the financial sectors are all positive, which is consistent with the intuition that the value of securities issued by the financial sectors increases with the return of the securities held on the asset side. Third, we find that the balance-sheet contagion coefficient is highest for mutual funds (1.56), followed by banks (0.71) and insurances (0.06), which is consistent with the mutual funds and banking sector managing portfolios more actively, while insurances follow long-term passive investment strategies.

These results are robust to the introduction of common shocks across sectors and the magnitude of the coefficient are very similar, with at most a slight decline. Indeed, as shown in columns (2)-(4) of Table 9, allowing for a global shock (common to all sectors) or a real shock decrease the estimates slightly. Allowing for a shock common to all financial sectors leaves balance-sheet contagion coefficients virtually unchanged.

We now turn to how balance-sheet contagion varies over time. As shown in Equation 7, the multipliers mapping shocks to equilibrium returns are given by the contagion matrix $C(\boldsymbol{\beta})_t$. Figure 8 therefore shows the time-series of the contagion matrix for banks, insurances and mutual funds. Returns on securities issued by the corporate sector and the public sector are not impacted by balance-sheet contagion, since balance-sheet contagion coefficients are insignificant. We make the following observations: *First*, shocks to the banking sector and mutual funds on the return of own securities are amplified through balance-sheet contagion with a stable factor of approximately 1.2 to 1.3, while the impact of shocks to the insurance sector on own securities is roughly unity. The reason for this is

the very low exposure of sectoral portfolios to the insurance sector and the fact that insurances are financed to a very small extent by security issuance. *Second*, in line with the re-balancing of sectoral portfolios towards public sector securities (Figure 4), transmission of public sector shocks to other sectors increases over the sample period: Insurance sector returns (2008Q1: 0.15; 2014Q1: 0.76) and banking sector returns (2008Q1: 0.09; 2014Q1: 0.14) become more sensitive to public sector shocks. Mutual funds securities remain relatively resilient to public sector shocks, given the small exposure of mutual funds to public sector securities (on average 4.26%).

Turning to shocks on the return of foreign securities held by domestic sectors, we generally find a large effect on financial sector returns, because all financial sectors have large foreign asset positions (banking: 46.4%, insurance: 38.7%, and mutual funds: 50.4%). Therefore, a one ppt shock to only the return of foreign securities held by the banking sector, for example, has a large *initial* impact on the value of total banking assets. The *full* contagion effect of this shock through the network will be such that the banking sector is the most resilient to shocks on the return of its foreign security position with a contagion factor of 0.49 in 2008Q1 and further reduced to 0.44 in 2014Q1 (in line with the retrenchment of the banking sector's foreign asset portfolio discussed in Section 3). Mutual funds achieve a reduction in the effect of a foreign portfolio shock to the return of its securities from 1.37 in 2008Q1 to 1.11 in 2014Q1.

The most dramatic change over the period regards the exposure of the insurance sector to foreign portfolio risk. A one ppt shock to the return of the foreign portfolio of insurances implies a change of 0.69 ppt of the return on insurance securities in 2008Q1, but a 2.26 ppt change in 2014Q1. This result comes from two sources: First, the insurance sector expands sharply its external asset portfolio in the post-crisis phase from 26.8 percent of GDP in 2008Q1 to 33.1 percent of GDP in 2014Q1. Second, the share of securities in the financing mix of the insurance sector decreased drastically from 4.5 percent of GDP in 2008Q1 to 1.3 percent of GDP in 2014Q1. Consequently, with a lower volume of securities on the liability side, a given shock to the value of assets requires, ceteris paribus, a larger change in the return on the issued securities to restore the balance-sheet identity.[5]

Shocks to the corporate sector and mutual funds transmit mostly to the insurance and the mutual fund sector, while the banking sector appears relatively resilient. Insurance sector shocks are confined to the insurance sector itself and do not transmit through the network. This again is due to the small share of securities in the liabilities of the insurances as well as therefore also the small share in other sectors' asset portfolios. Figure 8 offers

[5]Recall that because the residency principle applies to our data, the rest of the world shock also includes shocks to foreign affiliates.

an alternative representation of the same results comparing how sectoral shocks affect the returns on financial sectors' securities in 2008Q1 and 2014Q1.

5 Conclusion

In this paper, we traced the evolution of domestic and external sectoral portfolios using a unique security-level database on positions, valuation changes and flows of all domestic and foreign portfolios of French sectors between 2008Q1 and 2014Q1. We generate stylized facts on their contributions to the dynamics of the French net external portfolio position and on bilateral linkages between sectors through security portfolios. The model developed in Section 4 shows how balance-sheet contagion can be structurally derived from a balance-sheet equilibrium where sectoral asset demand and supply for securities are functions of endogenously determined returns on domestic securities. The model is estimated and used to measure the degree and evolution of balance-sheet contagion between French institutional sectors. With a similar access to detailed whom-to-whom databases on holdings and issuance of securities, the methodology put forward in this paper could be easily applied to measure contagion through security inter-linkages across countries.

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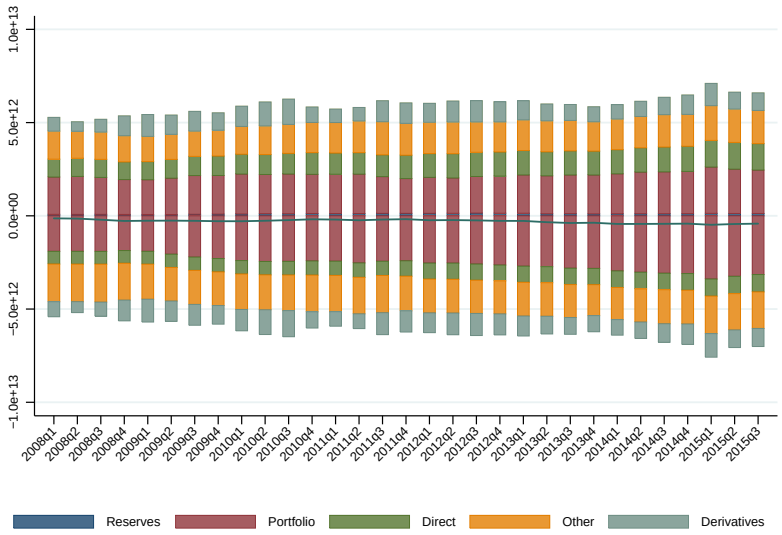
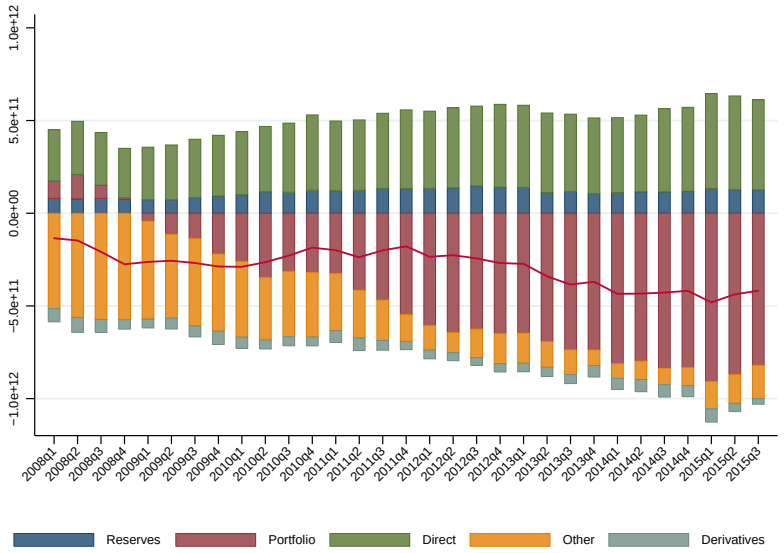
Figure 2: ***International Investment Position of France from 2008Q1 to 2015Q3.*** This figure shows the evolution of the breakdown of gross (Panel (a)) and net (Panel (b)) external assets and liabilities of French residents into the five categories: reserves, portfolio investments, direct investments, other investments, and derivatives. Amounts are in euros.

(a) Gross External Asset and Liability Positions

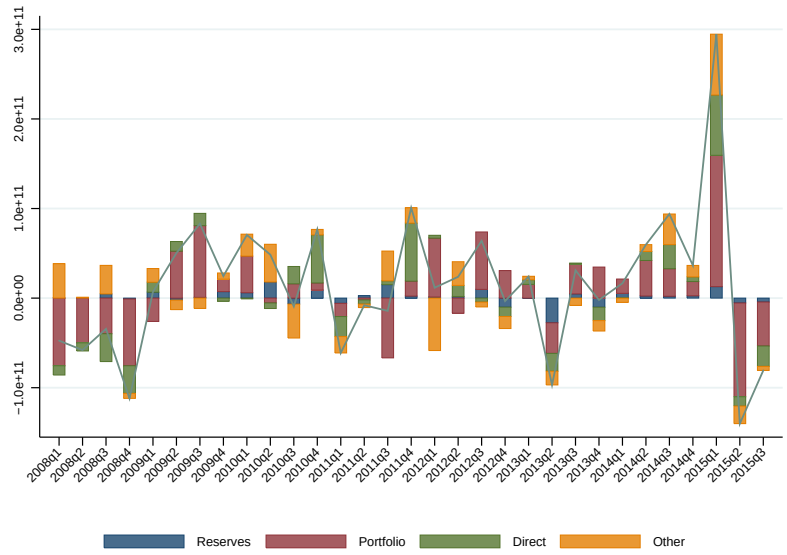


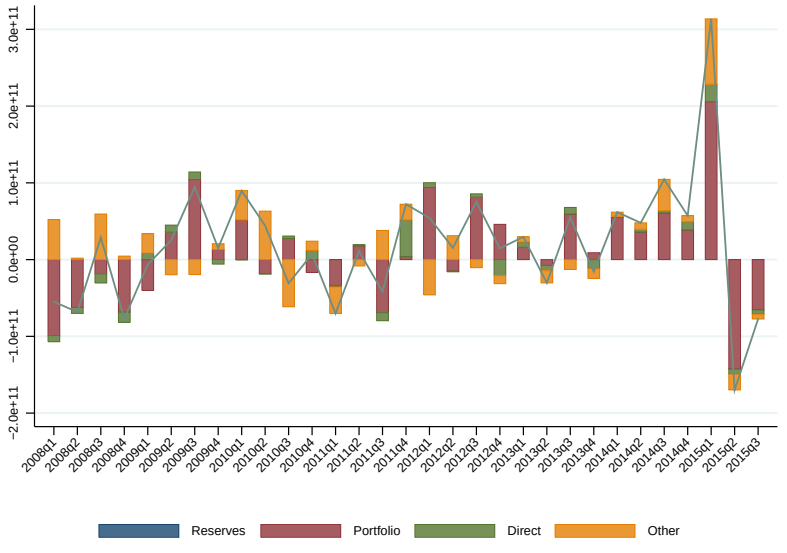


(b) Net (Asset minus Liability) External Position

Figure 3: ***Change of the International Investment Position of France due to Valuations from 2008Q1 to 2015Q3***. This figure shows the evolution of the change of the external asset (Panel (a)) and liability (Panel (b)) positions of French residents due to valuation effects for reserves, portfolio investments, direct investments and other investments. Amounts are in euros.

(a) Valuation of External Assets

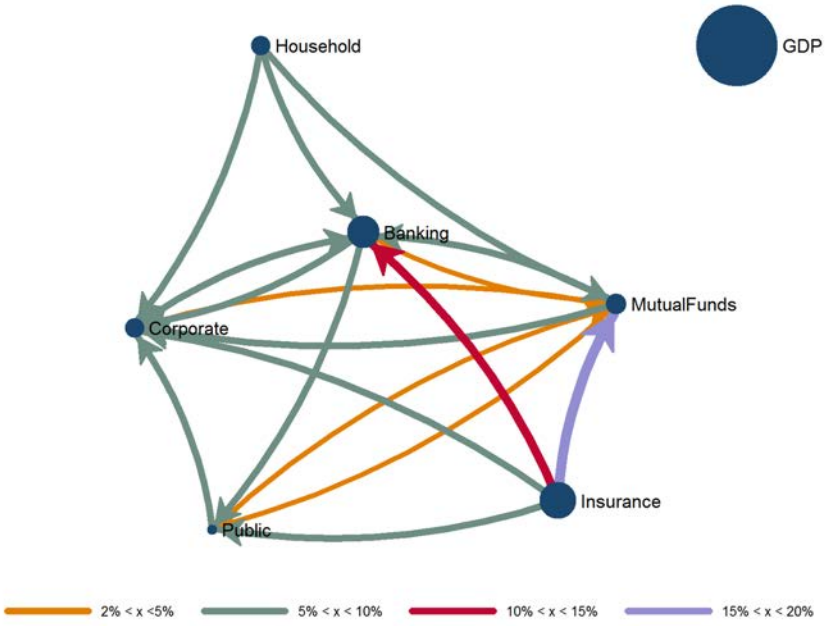


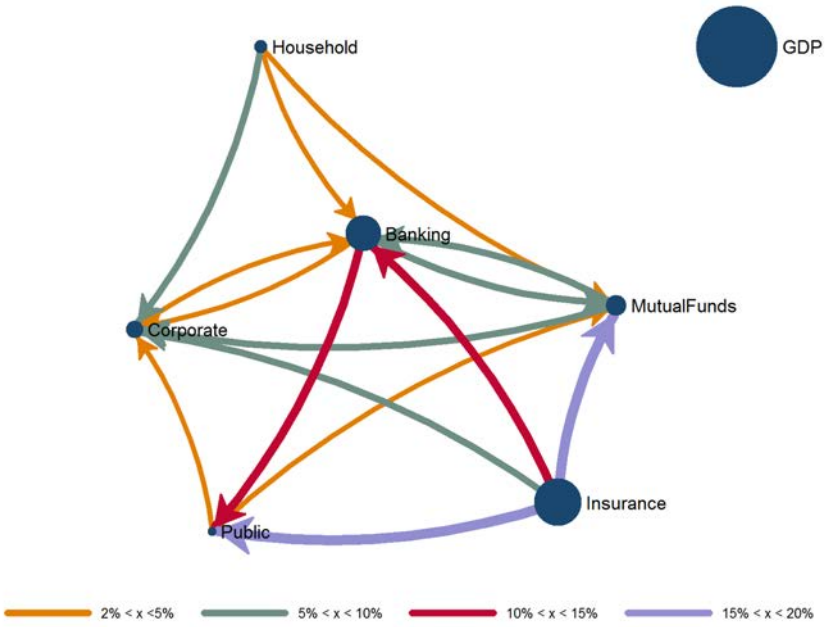


(b) Valuation of External Liabilities

Figure 4: ***Network of Domestic Sectors in 2008Q1 and 2014Q1.*** This figure shows bilateral exposures between the domestic institutional sectors of France in percent of annual French GDP. Each node represents an institutional sector. The size of the node is proportional to the sector's total assets. A parting arrow illustrates a sector's exposure to liabilities of the arriving sector. The size of the arrow is proportional to the bilateral exposure. A node of the size of French GDP is plotted at the top-right of the Figure to provide a reference for the scale of the nodes.

(a) 2008Q1

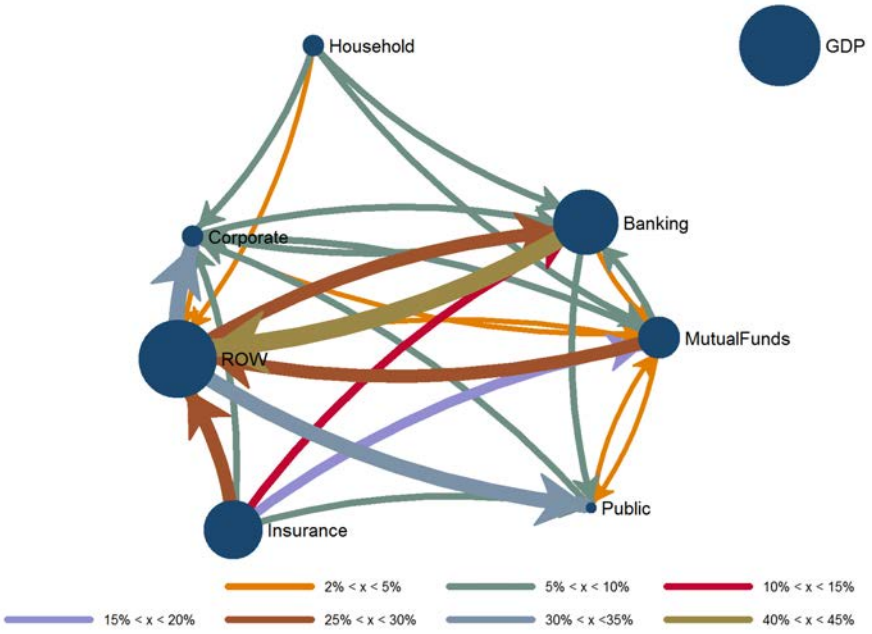


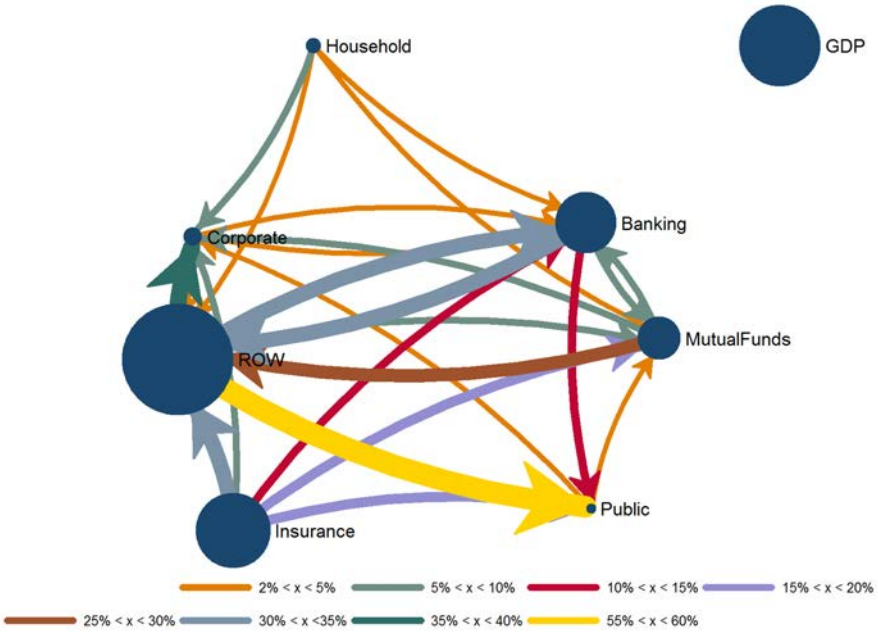


(b) 2014Q1

Figure 5: ***Network of Domestic Sectors and the Rest of the World in 2008Q1 and 2014Q1.*** This figure shows bilateral exposures between the domestic institutional sectors of France and the rest of the world in percent of annual French GDP. Each node represents an institutional sector. The size of the node is proportional to the sector's total assets. A parting arrow illustrates a sector's exposure to liabilities of the arriving sector. The size of the arrow is proportional to the bilateral exposure.

(a) 2008Q1

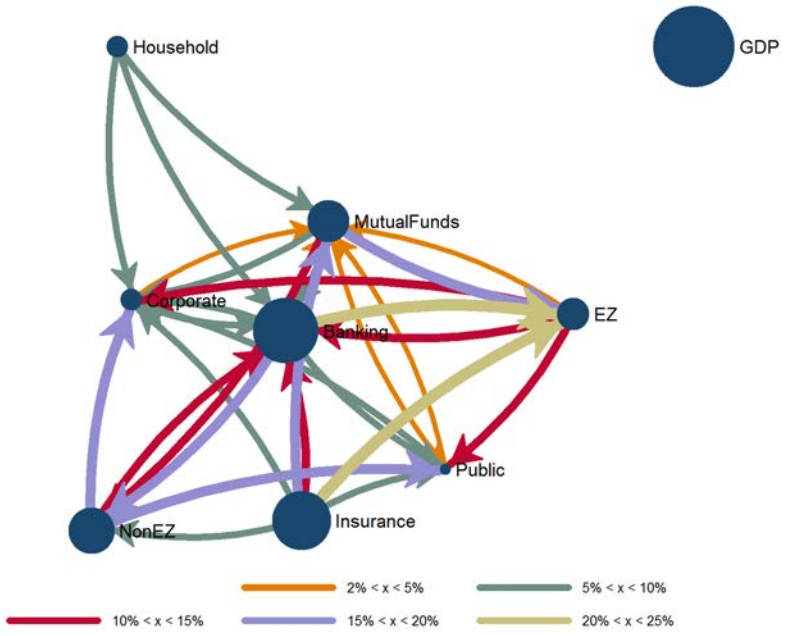


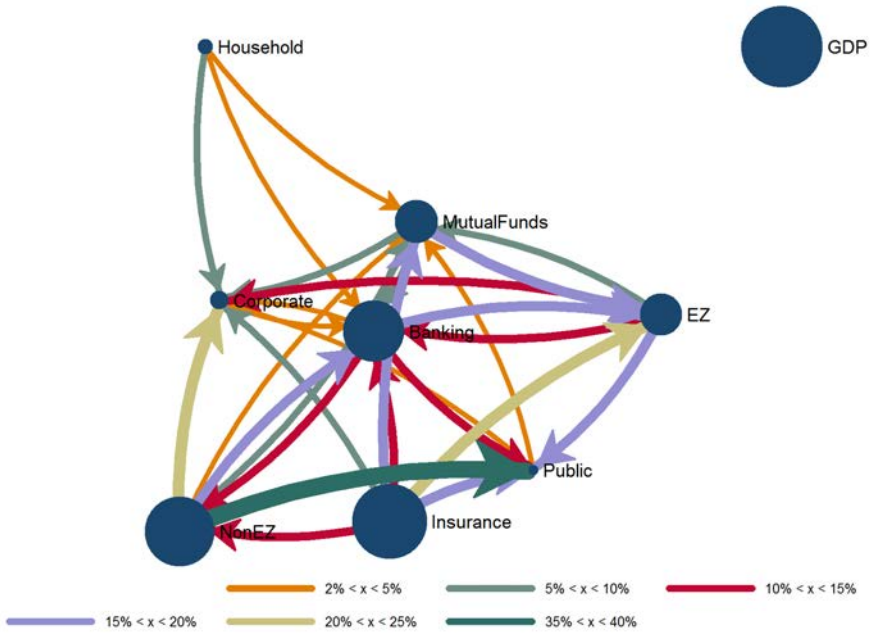


(b) 2014Q1

Figure 6: ***Network of Domestic Sectors, the rest of the Eurozone, and the Non-Eurozone in 2008Q1 and 2014Q1.*** This figure shows bilateral exposures between the domestic institutional sectors of France, the rest of the Eurozone (excluding France), and the Non-Eurozone in percent of annual French GDP. Each node represents an institutional sector. The size of the node is proportional to the sector's total assets. A parting arrow illustrates a sector's exposure to liabilities of the arriving sector. The size of the arrow is proportional to the bilateral exposure.

(a) 2008Q1





(b) 2014Q1

Figure 7: ***Evolution of Balance-Sheet Contagion Effects from 2008Q1 to 2014Q1.*** This figure shows the effect of a sector-specific shock on returns after full propagation. In particular, Panel (a) shows how the return on securities issued by the banking sector depend on a 1 ppt shock originating in different sectors of the economy. It is given by the rows of the contagion matrix $C(\boldsymbol{\beta})_t$, which varies strongly over time due to changes in the network of bilateral sectoral exposures.

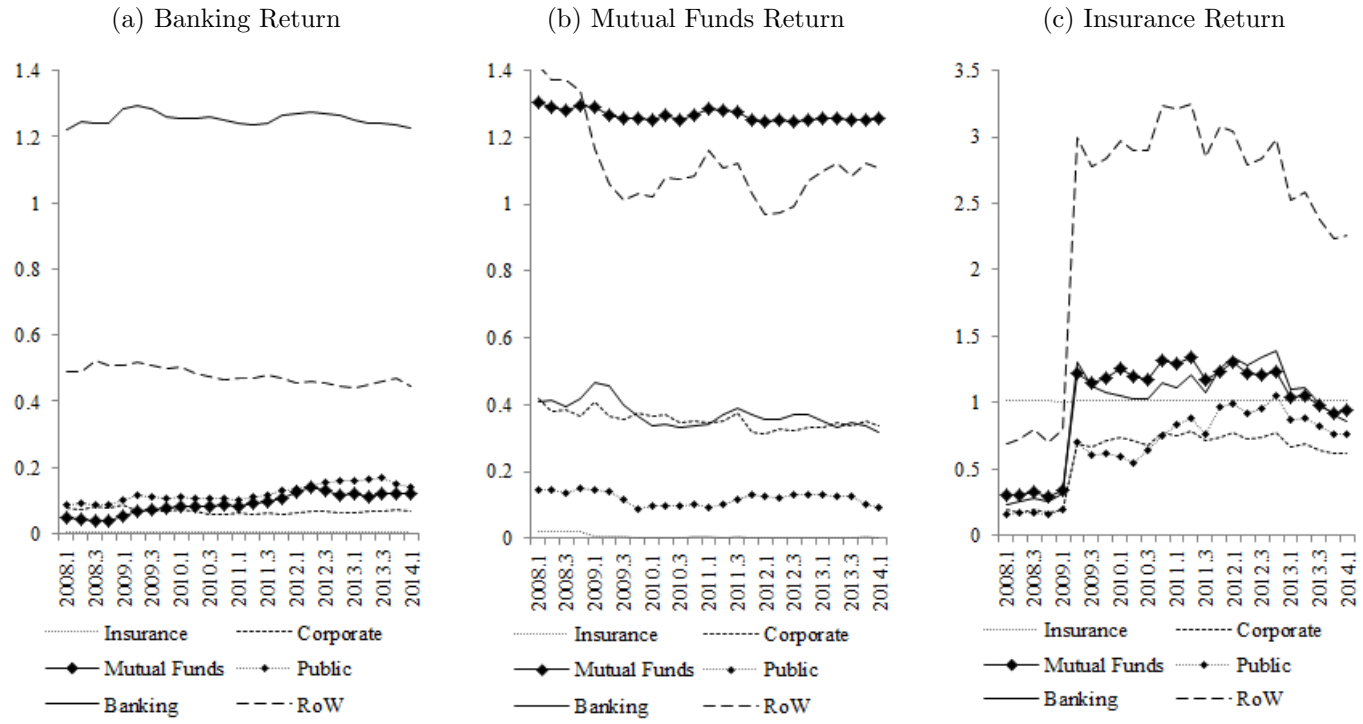
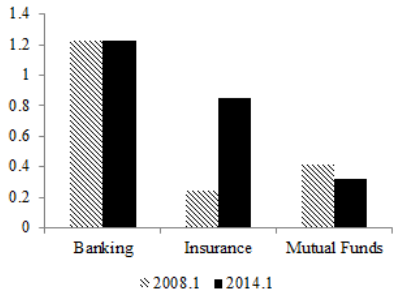
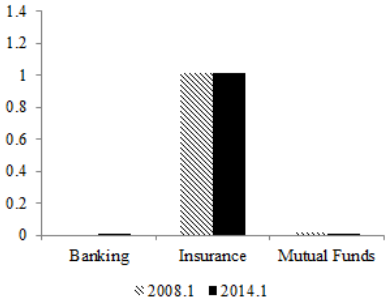


Figure 8: ***Balance-Sheet Contagion Effects in 2008Q1 and 2014Q1.*** Each panel compares the effect on returns on different securities of a shock on a specific sector. For example, Panel (a) shows the effect on the return of securities issued by the banking sector, the insurance sector and mutual fund sector of a 1ppt shock on the Banking sector in 2008Q1 and 2014Q1.

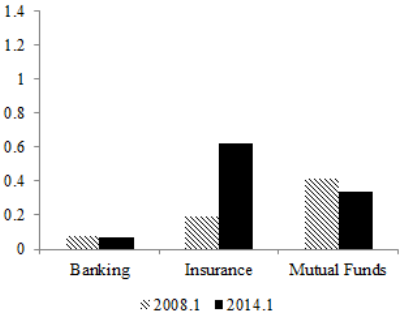
(a) Banking



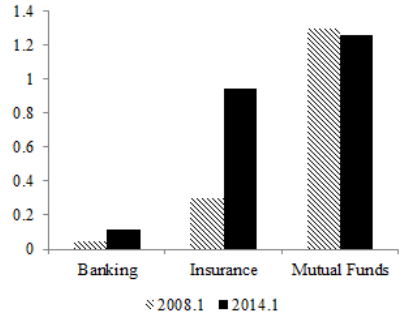
(b) Insurance



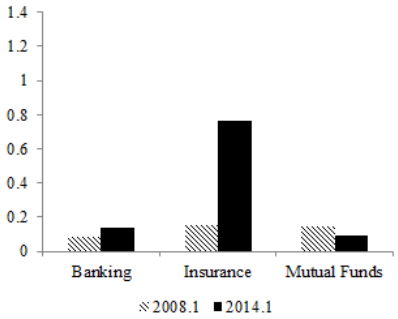
(c) Corporate



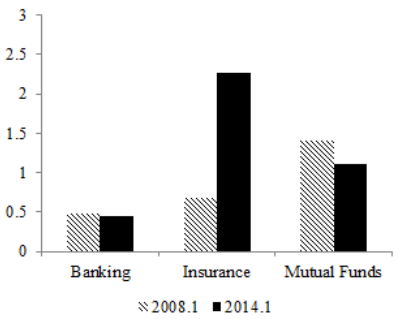
(d) Mutual Funds



(e) Public



(f) Rest of the World



	2008Q1			2014Q1		
	A	L	Δ	A	L	Δ
			Panel A: Total			
Banking	41.14	25.50	15.64	31.88	31.35	0.52
Mutual Funds	26.85	4.96	21.89	28.37	9.61	18.76
Insurance	26.83	1.91	24.92	33.11	0.57	32.54
Corporate	2.40	30.80	-28.40	2.57	38.87	-36.30
Household	2.61	0.00	2.61	2.99	0.00	2.99
Public	1.40	32.40	-31.00	1.50	56.57	-55.07
Total	100.26	95.57	4.70	101.31	136.97	-35.66
			Panel B: Equity			
Banking	4.49	4.14	0.35	5.04	3.50	1.55
Mutual Funds	14.80	3.93	10.87	15.27	6.33	8.94
Insurance	2.41	1.35	1.06	3.81	0.17	3.64
Corporate	1.08	22.92	-21.84	1.34	24.54	-23.19
Household	1.34	0.00	1.34	1.37	0.00	1.37
Public	0.71	0.00	0.71	0.74	0.00	0.74
Total	24.22	32.34	-8.12	27.95	34.54	-6.59
			Panel C: Debt			
Banking	36.65	21.36	15.29	26.83	27.86	-1.02
Mutual Funds	12.05	1.03	11.02	13.10	3.28	9.82
Insurance	24.42	0.56	23.86	29.30	0.40	28.91
Corporate	1.32	7.88	-6.56	1.22	14.33	-13.11
Household	1.27	0.00	1.27	1.62	0.00	1.62
Public	0.69	32.40	-31.71	0.75	56.57	-55.82
Total	76.04	63.23	12.81	73.37	102.43	-29.06

Table 1: ***External Portfolios of French Sectors in 2008Q1 and 2014Q1: Total, Equity, and Debt.*** This table decomposes the external asset (A), liability (L) and net (Δ, Asset-Liability) portfolio positions of French sectors (Panel A) into equity (Panel B) and debt (Panel C) portfolios. Numbers are in percent of French GDP.

	Debt			Equity			Total
	A	L	Δ	A	L	Δ	Δ
Banking	−9.8	+6.5	−16.3	0.0	0.0	+1.2	−15.1
Mutual Funds	+1.1	+2.3	−1.2	0.0	+2.4	−1.9	−3.1
Insurance	+4.9	0.0	+5.1	+1.4	−1.2	+2.6	+7.6
Corporate	0.0	+6.5	−6.6	0.0	+1.6	−1.4	−7.9
Household	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Public	0.0	+24.2	−24.1	0.0	0.0	0.0	−24.1
Total	−2.7	+39.2	−41.9	+3.7	+2.2	+1.5	−40.3

Table 2: ***External Portfolios of French Sectors in 2008Q1 and 2014Q1: Change Over Time.*** This table summarizes the change between 2008Q1 and 2014Q1 in external asset (A), liability (L) and net (Δ, Asset-Liability) portfolio positions of French sectors as exhibited in Table 2. Numbers are in percentage points of French GDP. Changes smaller than 1 ppts are set to zero.

	2008Q1			2014Q1		
	A	L	Δ	A	L	Δ
	Panel A: Eurozone					
Banking	22.90	11.56	11.34	18.49	13.64	4.85
Mutual Funds	15.54	3.23	12.31	18.94	6.30	12.64
Insurance	20.42	0.48	19.94	22.56	0.25	22.31
Corporate	1.69	11.23	-9.54	1.98	14.25	-12.27
Household	1.32	0.00	1.32	1.50	0.00	1.50
Public	0.88	12.64	-11.76	0.97	17.02	-16.05
Total	62.41	39.13	23.28	65.09	51.46	13.62
	Panel B: Non-Eurozone					
Banking	18.24	13.94	4.30	13.39	17.71	-4.32
Mutual Funds	11.31	1.73	9.58	9.43	3.31	6.12
Insurance	6.41	1.43	4.98	10.55	0.32	10.24
Corporate	0.71	19.57	-18.86	0.59	24.62	-24.03
Household	1.28	0.00	1.28	1.49	0.00	1.49
Public	0.53	19.76	-19.24	0.52	39.55	-39.02
Total	37.85	56.44	-18.58	36.23	85.51	-49.28

Table 3: ***External Portfolios of French Sectors in 2008Q1 and 2014Q1: Eurozone and Non-Eurozone.*** This table decomposes the external asset (A), liability (L) and net (Δ, Asset-Liability) portfolio positions of French sectors into Eurozone (Panel A) and Non-Eurozone (Panel B) portfolios. Numbers are in percent of French GDP.

	GIPS			Non-GIPS		
	2008Q1	2014Q1	Change	2008Q1	2014Q1	Change
Banking	10.54	4.67	-5.87	12.34	10.99	-1.35
Mutual Funds	3.88	2.20	-1.68	11.65	13.61	1.96
Insurance	8.36	4.56	-3.80	12.05	15.24	3.19
Corporate	0.38	0.44	0.06	1.31	1.37	0.06
Household	0.11	0.30	0.19	1.23	1.41	0.18
Public	0.26	0.07	-0.19	0.59	0.79	0.20
Total	23.53	12.24	-11.29	39.17	43.41	4.24

Table 4: ***External Portfolios of French Sectors in 2008Q1 and 2014Q1: GIPS and Non-GIPS.*** This table decomposes the external asset portfolio positions of French sectors into GIPS and Non-GIPS portfolios. Numbers are in percent of French GDP. GIPS comprises Greece, Italy, Portugal and Spain.

	Assets			Liabilities			Net		
	FX	Price	Flow	FX	Price	Flow	FX	Price	Flow
				Panel A: Total					
Banking	0.87	0.44	-9.00	0.58	1.62	4.82	0.29	-1.18	-13.82
Mutual Funds	0.61	-0.63	2.65	0.06	0.95	2.45	0.54	-1.58	0.20
Insurance	0.07	3.03	4.85	0.01	-0.38	0.38	0.06	3.41	4.47
Corporate	0.02	0.03	0.29	0.28	2.14	7.67	-0.26	-2.11	-7.37
Household	0.07	0.04	0.47	0.00	0.00	0.00	0.07	0.04	0.47
Public	0.06	0.06	0.07	0.16	3.89	21.96	-0.10	-3.84	-21.89
Total	1.64	3.10	1.06	1.09	8.22	37.27	0.55	-5.12	-36.21
				Panel B: Equity					
Banking	0.06	-0.75	1.08	0.01	-0.49	0.17	0.06	-0.26	0.91
Mutual Funds	0.46	-1.25	2.01	0.01	0.67	0.90	0.45	-1.92	1.11
Insurance	0.05	0.00	1.60	0.00	-0.32	0.02	0.05	0.32	1.58
Corporate	0.01	-0.04	0.38	0.00	0.87	2.40	0.01	-0.92	-2.02
Household	0.07	0.00	0.08	0.00	0.00	0.00	0.07	0.00	0.08
Public	0.04	-0.04	0.08	0.00	0.00	0.00	0.04	-0.04	0.08
Total	0.67	-1.96	6.08	0.01	0.73	3.50	0.66	-2.70	2.58
				Panel C: Debt					
Banking	0.81	1.18	-10.08	0.57	2.10	4.64	0.23	-0.92	-14.72
Mutual Funds	0.15	0.62	0.64	0.06	0.28	1.55	0.09	0.34	-0.91
Insurance	0.01	3.03	3.25	0.01	-0.06	0.36	0.01	3.09	2.89
Corporate	0.00	0.07	-0.09	0.28	1.27	5.26	-0.27	-1.19	-5.35
Household	0.00	0.05	0.39	0.00	0.00	0.00	0.00	0.05	0.39
Public sector	0.02	0.10	-0.01	0.16	3.89	21.96	-0.15	-3.79	-21.97
Total	0.96	5.06	-5.01	1.07	7.48	33.78	-0.11	-2.42	-38.79

Table 5: ***External Portfolios of French Sectors in 2008Q1 and 2014Q1: Change Over Time Due To Valuation (Exchange Rate and Price), and Flows.*** This table decomposes the change between 2008Q1 and 2014Q1 of external asset (A), liability (L) and net (Δ, Asset-Liability) portfolio positions (total, equity, and debt) of French sectors into valuation due to exchange rate movements (FX), due to price movements, and flows. Numbers are in percent of French GDP.

	Assets					Liabilities				
	Banking	Corp. & Household	Mutual F. & Insur.	Public	Total	Banking	Corp. & Household	Mutual F. & Insur.	Public	Total
					Panel A: 2008Q1					
Banking	7.73	7.88	0.75	6.52	22.88	11.03	0.37	0.17	0.00	11.57
Mutual Funds	2.60	6.02	4.07	2.84	15.53	2.60	0.22	0.40	0.01	3.23
Insurance	5.50	4.88	0.86	9.17	20.41	0.46	0.01	0.01	0.00	0.48
Corporate	0.26	0.71	0.47	0.25	1.69	9.63	1.13	0.46	0.00	11.22
Household	0.30	0.52	0.47	0.05	1.34	0.00	0.00	0.00	0.00	0.00
Public	0.18	0.32	0.06	0.29	0.85	12.43	0.00	0.20	0.00	12.63
Total	16.57	20.33	6.68	19.12	62.7	36.15	1.73	1.24	0.01	39.13
					Panel B: 2014Q1					
Banking	4.67	1.26	4.94	7.62	18.49	12.53	0.49	0.63	0.00	13.65
Mutual Funds	2.20	5.30	7.90	3.55	18.95	5.35	0.16	0.79	0.00	6.30
Insurance	4.56	3.29	7.51	7.20	22.56	0.23	0.00	0.01	0.00	0.24
Corporate	0.44	0.34	1.02	0.18	1.98	12.2	1.38	0.67	0.00	14.25
Household	0.30	0.40	0.78	0.03	1.51	0.00	0.00	0.00	0.00	0.00
Public	0.07	0.15	0.53	0.23	0.98	15.55	0.03	1.45	0.00	17.03
Total	12.24	10.74	22.68	18.81	64.47	45.86	2.06	3.55	0.00	51.47

Table 6: ***External Portfolios of French Sectors in 2008Q1 and 2014Q1: Eurozone Sectors.*** This table decomposes the external asset and liability portfolio positions of French sectors into portfolios with four institutional sectors of the rest of the eurozone, i.e. banking, corporate and household, mutual funds and insurance, as well as the public sector. Numbers are in percent of French GDP.

	2008Q1			2014Q1		
	A	L	Δ	A	L	Δ
	Panel A: Domestic					
Banking	38.82	56.11	-17.28	43.22	49.13	-5.91
Mutual Funds	24.30	39.42	-15.12	24.40	42.21	-17.81
Insurance	44.94	2.59	42.34	58.10	0.73	57.37
Corporate	23.48	47.59	-24.12	20.32	46.89	-26.57
Household	23.47	0.00	23.47	15.26	0.00	15.26
Public	11.78	21.42	-9.63	9.87	31.82	-21.95
Total	167.13	167.13	0.00	170.77	170.77	0.00
	Panel B: Foreign					
Banking	41.14	25.50	15.64	31.88	31.35	0.52
Mutual Funds	26.85	4.96	21.89	28.37	9.61	18.76
Insurance	26.83	1.91	24.92	33.11	0.57	32.54
Corporate	2.40	30.80	-28.40	2.57	38.87	-36.30
Household	2.61	0.00	2.61	2.99	0.00	2.99
Public	1.40	32.40	-31.00	1.50	56.57	-55.07
Total	100.26	95.57	4.70	101.31	136.97	-35.66
	Panel C: Consolidated					
Banking	79.96	81.61	-1.64	75.09	80.48	-5.39
Mutual Funds	51.15	44.38	6.77	52.77	51.82	0.95
Insurance	71.77	4.50	67.27	91.21	1.30	89.91
Corporate	25.87	78.39	-52.52	22.88	85.76	-62.87
Household	26.07	0.00	26.07	18.25	0.00	18.25
Public	13.18	53.82	-40.64	11.37	88.39	-77.02
Total	267.4	262.70	4.70	272.09	307.75	-35.66

Table 7: ***Portfolios of French Sectors in 2008Q1 and 2014Q1: Domestic, Foreign, and Consolidated.*** This table presents asset (A), liability (L) and net (Δ, Asset-Liability) positions in domestic (Panel A), foreign (Panel B), and consolidated (Panel C) portfolios of French sectors. Numbers are in percent of French GDP.

	Assets			Liabilities		
	2008Q1	2014Q1	Change	2008Q1	2014Q1	Change
Banking	51.45	42.45	-9.00	31.25	38.96	7.71
Mutual Funds	52.49	53.76	1.27	11.18	18.54	7.37
Insurance	37.39	36.30	-1.08	42.39	43.85	1.46
Corporate	9.27	11.21	1.95	39.29	45.33	6.04
Household	9.99	16.40	6.41	0.00	0.00	0.00
Public	10.63	13.17	2.54	60.21	64.00	3.79
Total	37.50	37.24	-0.26	36.38	44.51	8.13

Table 8: ***Portfolios of French Sectors in 2008Q1 and 2014Q1: Share of External Positions.*** This table shows the share of external positions in asset and liability portfolios of French sectors in 2008Q1, 2014Q1, and the change over time. Numbers are in percent of the total sectoral portfolio.

	(1)		(2)		(3)		(4)	
	β	σ^2	β	σ^2	β	σ^2	β	σ^2
Banking	0.71***	9.2e-5***	0.55**	7.1e-5*	0.73***	1.0e-4**	0.58***	2.9e-5***
	(0.247)	(3.0e-5)	(0.283)	(5.0e-5)	(0.297)	(6.0e-5)	(0.233)	(3.0e-5)
Insurance	0.06***	3.1e-3***	0.05***	3.1e-3**	0.06***	3.7e-3***	0.06*	3.9e-3
	(0.016)	(9.6e-4)	(0.017)	(1.51e-3)	(0.017)	(1.17e-3)	(0.036)	(1.45e-3)
Mutual Funds	1.56***	1.7e-4	1.49***	1.1e-4	1.52***	1.3e-4	1.48***	1.0e-4
	(0.269)	(1.7e-4)	(0.243)	(1.3e-4)	(0.22)	(1.3e-4)	(0.167)	(1.2e-4)
Corporate	0.86	8.5e-3	-0.46	1.2e-2	0.11	1.3e-2	0.20	1.8e-2
	(33.884)	(0.158)	(57.645)	(0.339)	(56.720)	(0.324)	(77.776)	(0.414)
Public	-0.41	2.6e-4***	-0.33	2.5e-4***	-0.35	2.6e-4***	-0.02	6.1e-4
	(0.911)	(5.0e-5)	(0.877)	(5.0e-5)	(0.957)	(5.0e-5)	(1.277)	(0.004)
Common Shock Variance								
Global	No		4.1e-6		No		No	
			(1.0e-5)					
Financial	No		No		2.6e-6		No	
					(1.7e-5)			
Real	No		No		No		3.5e-4	
							(0.004)	

Table 9: ***Balance-Sheet Contagion Model: Estimation Results.*** This table presents the GMM estimates of the structural parameters of the balance-sheet contagion model, i.e. the balance-sheet contagion parameters $\boldsymbol{\beta}$ and the variance of sectoral shocks $\sigma_1^2, ..., \sigma_5^2$ for different common shock structures: Column (1) shows the estimation results assuming no common shock; results for a shock common to all sectors (global), common to financial sectors only (financial), and common to real sectors (real) are shown in columns (2), (3), and (4), respectively. Significance is noted "***" at 1%, "**" at 5%, and "*" at 10%. Standard errors are reported in brackets.

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Jonas Heipertz
Paris School of Economics, Paris, France; email: jonas.heipertz@psemail.eu

Romain Rancière
University of Southern California, Los Angeles, United States; email: ranciere@usc.edu

Natacha Valla
European Central Bank, Frankfurt am Main, Germany; email: natacha.valla@ecb.europa.eu

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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