Mapping the interconnectedness between EU banks and shadow banking entities

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Abstract

This paper provides a unique snapshot of the exposures of EU banks to shadow banking entities within the global financial system. Drawing on a rich and novel dataset, we show that 60 per cent of the EU banks' exposures are towards non-EU entities, particularly US-domiciled shadow banking entities. We also find that the exposures are concentrated by type of shadow banking counterparty with two-thirds of the volume of exposures towards non-MMF investment funds, finance companies and securitisation vehicles. At the individual level, banks' exposures are diversified although this diversification leads to high overlap across different types of shadow banking entities. We also examine the bank-level and country-level determinants of EU banks' exposures towards shadow banking entities. Our results suggest that larger and more profitable banks are more likely to have higher exposures to shadow banking entities. In addition, we find that country-pair gravity controls are also important factors in determining the volume of EU banks' exposures to shadow banking entities.

JEL classification: F65, G21, G23.
Keywords: shadow banking, interconnectedness, financial stability, macroprudential policy

"Policymakers and researchers need better models and data to understand the interconnections between the banking system and nonbank financial institutions."
- Stanley Fischer, December 2015

1 Introduction

The substantial size and growth of the shadow banking system in recent years has led to increased monitoring of this part of the financial sector.[1] Given that 'shadow banking entities' [2] can form part of complex financial intermediation chains which can also include banks and insurance corporations (Pozsar et al. 2013, Cetorelli 2014), understanding the nature of their linkages is important. The global financial crisis exposed shortcomings in the assessment of cross-sector and cross-border linkages in the financial system. The interaction of banks and insurance corporations with shadow banking entities led to the amplification of risks and spillovers which were transmitted across sectors and national borders. As shadow banking entities are subject to varying degrees of supervision, there is a lack of transparency and comprehensive macroprudential risk monitoring of their linkages and activities.

Owing to their heterogeneous activities, shadow banking entities can be direct counterparties to banks in a number of markets including derivative and funding markets. They may also have links in collateral chains that can also include banks. In addition, banks may be exposed to shadow banking entities through their common membership of a corporate group, through the provision of explicit or implicit backstops or indirectly through their common exposures to assets. In particular, liquidity support provided by banks to off-balance sheet entities can reinforce the link and potential contagion paths between the regular banking system and the shadow banking

[1] For example, according to ESRB (2019), a broad measure of the non-bank financial sector in the EU, comprising total assets of investment funds and other financial institutions (OFIs) represented approximately 40 per cent of total EU financial sector assets at the end of 2018. The FSB and ESRB recently decided to replace the term "shadow banking" with the term "non-bank financial intermediation".

[2] For the purposes of this paper 'shadow banking entities' refer to undertakings that met two conditions: (1) they carry out one or more credit intermediation activities. Here 'credit intermediation activities' means bank-like activities involving maturity transformation, liquidity transformation, leverage, credit risk transfer or similar activities. (2) they are not excluded undertakings (i.e. mainly undertakings that are subject to the CRD / CRR or are considered to be regulated in a similar way).

system (BCBS, 2015).[3] As a result of these linkages, significant shocks in the shadow banking system can have potential spillover effects on other parts of the financial system.[4]

While the interconnectedness between banks and shadow banking entities is often cited as a key financial stability concern, we are not aware of other studies which document and describe the nature of these linkages using granular EU bank and exposure-level information. Fischer (2015) points to the importance of mapping the linkages of shadow banking entities. He notes *"an important area in need of development is economic modelling on interconnectedness, particularly on the interaction of shadow banking, banks and the broader financial system… such research could guide regulatory efforts to collect data and set policies to limit possible instabilities associated with interconnectedness."* Furthermore, as described in ESRB (2016b), macroprudential policies beyond the banking sector should focus on the components of the financial system where systemic risks are higher. In order to assess the potential impact of spillovers, detailed analyses on the interconnections of different components of the financial system are required. Understanding the cross-sector and cross-border linkages will therefore equip policymakers and regulators with the necessary surveillance tools and can form a key input in the design of macroprudential policies.

This paper contributes to the growing literature on the monitoring of shadow bank-

[3]See Claessens and Ratnovski (2014) and BCBS (2015) for a discussion on explicit and implicit backstops. The results of Gornicka (2016) lend support to the view that guarantees provided by sponsoring institutions are an important element of shadow banking. Furthermore, Clerc et al. (2016) examine the channels through which indirect contagion can spread across the financial system, including funding and asset markets, and highlight the role of the market price channel and information spillovers in propagating shocks. Segura (2018) examines the interaction between sponsor banks and their SIVs and presents a signaling model of rescues.

[4]Since the global financial crisis, policymakers and regulators have sought to improve the monitoring framework for assessing the interconnectedness of the shadow banking system with the aim of mitigating systemic risks. The increasing size and complexity of the shadow banking system, coupled with its interconnectedness with the banking sector underlines the need for effective financial stability monitoring. At the global level, the Financial Stability Board (FSB) has coordinated efforts in improving data coverage for monitoring developments within the shadow banking system (see, for example, FSB (2011) and FSB (2015). At the European level, the European Systemic Risk Board (ESRB) has focused on monitoring potential financial stability risks, including those risks and negative externalities posed by entities and activities within the shadow banking system (See ESRB (2016a; 2017, 2018, 2019) and Grillet-Aubert et al. (2016) for a description of the monitoring framework developed by the ESRB for assessing developments and risks within the EU shadow banking system. The granular derivatives transaction database created by EMIR reporting requirements and the alternative investment fund database created by the AIFMD reporting requirements will be rich sources for monitoring and analysis going forward).

ing activities by providing a unique insight into the exposures of EU banks to shadow banking entities. The paper thereby fills an important data gap and sheds new light by mapping for the first time these linkages using granular bank and exposure-level information. In addition, the paper empirically examines the bank-level and country-level factors which determine the exposures between EU banks and shadow banking entities. We find that larger banks, as measured by the size of their total assets, are positively associated with the exposures between EU banks and shadow banking entities, while higher cost-to-income ratios have a negative effect on the volume of banks' exposures. Moreover, in line with the international banking literature (see, for example, Buch, 2005, Buch et al., 2013, Houston et al., 2012 and Claessens and van Horen, 2014), we employ a number of country-level gravity controls in our empirical methodology. We find that controls such as the host country of the EU bank and the host country of the shadow banking entity sharing common geographical and economic characteristics are important in determining the exposures. In particular, a common currency for a country pair has a positive effect on the size of the exposures while geographic distance exerts a negative effect.

The rest of the paper is structured as follows. Section 2 describes the data used in our analysis and provides a brief overview of our data cleaning procedure. We then take two empirical approaches to the data. Section 3 examines first the cross-sector and cross-border linkages of banks' exposures to shadow banking entities. We then exhibit characteristics of the network of exposures including the levels of concentration and overlap. The results allow us to assess the vulnerability of the banking system to shocks from the non-bank financial sector. Section 4 presents our econometric analysis of the determinants of the exposures. Section 5 concludes.

2 Data

This section describes the data used in our analysis. In December 2015, the European Banking Authority (EBA) issued guidelines on the approach that institutions (banks

and investment firms) should adopt for the purposes of setting appropriate individual and aggregate limits on exposures to shadow banking entities which carry out banking activities outside a regulated framework.[5] In parallel to the development of the guidelines, the EBA conducted a data collection to understand better the volume and distributions of institutions' exposures to certain types of unregulated and 'lightly' regulated entities, and the potential impact of imposing limits to these exposures.[6]

A sample of institutions were asked to provide information regarding their exposures to counterparties considered as 'shadow banking entities'. 'Exposures' mean any asset or off-balance sheet item used in the calculation of capital requirements for credit risk under the standardised approach, without applying risk weights or degrees of risk. These data were collected at the highest level of consolidation in a Member State, or individual level if the consolidated level did not apply. Institutions were asked to calculate their exposures in the same way as any other exposure reported under the large exposures' regime set out in Part 4 of the Capital Requirements Regulation (CRR) and to report original exposures to individual counterparties, as well as the exposure before and after taking into account the effect of Credit Risk Mitigation (CRM) and large exposures' exemptions, and also the percentage of the eligible capital.[7] The exposures used in the analysis were after CRM and large exposures' exemptions. We do not in this paper consider institutions' liabilities to shadow banking entities. For the purposes of the data collection 'shadow banking entities' were defined as undertakings that met two conditions:

1. They carry out one or more credit intermediation activities. Here 'credit intermediation activities' means bank-like activities involving maturity transformation, liquidity transformation, leverage, credit risk transfer or similar activities.

2. They are not excluded undertakings (i.e. mainly undertakings that are subject to

[5]https://www.eba.europa.eu/regulation-and-policy/large-exposures/guidelines-on-limits-on-exposures-to-shadow-banking

[6]The definition of 'shadow banking entity' used for the purposes of the data collection was broader than the definition used in the final EBA guidelines, so as to capture as much information as possible and not to pre-empt future work by the EBA and/ or the European Commission on this topic.

[7]Article 4(1), point 71 of regulation (EU) No.575/2013 defines 'eligible capital' as the sum of Tier 1 capital as referred to in Article 25 (of the same Regulation) and Tier 2 capital as referred to in Article 71 (of the same Regulation) that is equal to or less than one third of Tier 1 capital.

the CRD / CRR or are considered to be regulated in a similar way).

Institutions were asked to identify their counterparties by indicating their identifier code[8], name, and country of residence and to classify them in accordance with their underlying economic functions (i.e. activities rather than legal form). Information was collected on Undertakings for the Collective Investment in Transferable Securities (UCITS) MMFs, non-UCITS MMFs, non-MMF investment funds, finance companies, broker-dealers, credit insurers / financial guarantors, securitisations, non-equivalent banks / insurers and a residual category labelled as 'other' for institutions that can not be classified according to the types presented above. In addition, institutions were asked to indicate, to the best of their knowledge, whether a shadow banking entity was: (A) not supervised on a solo level, but supervised on a consolidated level in the Union; (B) not supervised on a solo level, but supervised on a consolidated level in a third country that has a regime at least equivalent to the one applied in the European Union, or (C) neither of the two.

The sample included 184 reporting institutions (169 banks and 15 investment firms) from 22 Member States, and the reference date for the reported data was 31 March 2015.[9] In total, there were 107,621 individual exposures reported, which amounted to a total exposure of €1,082 billion. As reporting institutions could choose to report only the exposures to individual shadow banking entities with an exposure value after exemptions and CRM equal to or in excess of 0.25 per cent of eligible capital, we must therefore use the subset of exposures equal to or above this threshold in order to undertake our analysis using the individual exposure level data. We do this in order to maintain a sample with information on the individual shadow banking counterparty which is necessary in order to undertake our analysis of the cross-sector and cross border linkages. For confidentiality reasons, the analysis did not identify individual

[8]In some cases, the identifier code provided were legal entity identifiers (LEIs) while others were internal codes.

[9]The participating Member States include Austria, Belgium, Cyprus, Czech Republic, Denmark, France, Germany, United Kingdom, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Spain and Sweden.

countries that had a sample composed of three or fewer reporting institutions.[10] EBA (2015) provides further details on the coverage of the sample in each Member State and further background information on the data collection process.

We applied a significant cleaning procedure to the data used in our analysis. As a first step, the national competent authorities (NCAs) made an initial assessment of the quality of the reported data prior to sending them to the EBA. Subsequently, the EBA performed several data quality checks in order to assess the completeness and consistency of the data and liaised with the NCAs where necessary. Some essential data cleaning was performed prior to conducting the analysis presented in this paper. For example, we exclude investment firms from our sample of reporting institutions and analyse only individual exposures of EU banks equal to or above 0.25 per cent of banks' eligible capital. The subset of exposures that are equal to or above 0.25 per cent of institutions' eligible capital represent 3,272 exposures (3 per cent of the total number of exposures) with a total exposure amount of €568 billion (52 per cent of the total exposure amount for the full sample of reported exposures) and were reported by 139 EU banks. In addition, repeated shadow banking counterparties were identified based on duplicated counterparty IDs, duplicated counterparty names or on similar names (e.g. ABC Ltd as opposed to ABC Limited). Similarly, as shown in EBA (2015), 19 per cent of the shadow banking counterparties by value of exposures were not identified by country of residence. Therefore, we manually clean and match these data to reduce this data limitation to 1 per cent of exposures. This allows us to map the geography of the exposures using network analysis techniques.

In order to explore the characteristics of EU banks (e.g. total assets, number of subsidiaries) in our sample, we also merge the EBA's data with bank-level information taken from Bureau van Dijk's Orbis database. Next, we exclude individual exposures greater than 25 per cent of banks' eligible capital, which corresponds to the large ex-

[10] In the network graphs presented in Section 3, banks from countries which have less than 3 reporting institutions are labelled 'XZ'.

TABLE 1. **Distribution of EU banks' exposures to shadow banking entities by country of reporting institution and domicile of shadow banking entity (in € billion)**

B/SB	DE	FR	GB	IE	JE	KR	KY	LU	NL	RU	TR	US	O-EU	RW	Total
AT	0.2	0.0	0.3	0.2	0.0	0.1	0.2	0.2	0.3	0.8	0.1	0.6	3.1	0.7	6.8
DE	28.1	0.8	5.1	9.4	1.3	0.4	2.9	6.9	1.7	2.3	3.9	33.5	2.2	7.6	106.0
FR	0.5	16.2	3.7	1.9	0.2	2.9	4.9	1.4	2.0	0.5	0.5	30.1	2.7	10.9	78.3
GB	5.2	4.8	44.7	19.8	14.7	7.8	24.9	12.0	3.5	1.5	3.0	84.0	4.0	54.5	284.4
IT	0.0	1.3	2.8	2.6	0.4	1.3	0.0	2.5	0.1	2.1	7.5	0.5	2.9	2.9	26.8
LU	1.1	0.7	0.8	0.4	0.0	0.0	0.3	2.5	3.0	0.2	0.0	0.1	1.0	0.4	10.4
O-EU	0.5	1.4	1.5	1.1	0.5	2.3	3.2	3.3	3.2	2.9	4.5	2.8	12.8	6.7	46.8
Total	35.5	25.1	59.0	35.4	17.0	14.8	36.4	28.8	13.8	10.4	19.5	151.5	28.7	83.5	559.4

Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to 'shadow banking entities', December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of eligible capital. Country labels on the left hand side of the chart refer to the country of domicile of the reporting institution. Country labels along the top of the chart refer to country of domicile of shadow banking entity. *O-EU* refers to other EU countries while *RW* refers to the rest of the world. The chart excludes investment firms and exposures greater than 25 per cent of the institution's eligible capital (the large exposure limit).

TABLE 2. **Distribution of EU banks' exposures to shadow banking entities by country of reporting institution and domicile of shadow banking entity (as a % of GDP of country of reporting bank)**

B / SB	DE	FR	GB	IE	JE	KR	KY	LU	NL	RU	TR	US	O-EU	RW	Total
AT	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.0	0.2	1.0	0.2	2.2
DE	1.0	0.0	0.2	0.3	0.0	0.0	0.1	0.3	0.1	0.1	0.1	1.2	0.1	0.3	3.9
FR	0.0	0.8	0.2	0.1	0.0	0.1	0.2	0.1	0.1	0.0	0.0	1.5	0.1	0.5	3.8
GB	0.3	0.3	2.4	1.0	0.8	0.4	1.3	0.6	0.2	0.1	0.2	4.4	0.2	2.9	15.0
IT	0.0	0.1	0.2	0.2	0.0	0.1	0.0	0.2	0.0	0.1	0.5	0.0	0.2	0.2	1.7
LU	2.4	1.5	1.8	1.0	0.0	0.0	0.6	5.5	6.5	0.5	0.0	0.1	2.1	0.8	22.9
O-EU	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.1	1.1
Total	0.3	0.2	0.5	0.3	0.1	0.1	0.3	0.2	0.1	0.1	0.1	1.2	0.2	0.6	4.3

Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to "shadow banking entities", December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of eligible capital. Country labels on the left hand side of the chart refer to the country of domicile of the reporting institution. Country labels along the top of the chart refer to country of domicile of shadow banking entity. *O-EU* refers to other EU countries while *RW* refers to the rest of the world. The chart excludes investment firms and exposures greater than 25 per cent of the institution's eligible capital (the large exposure limit).

posure limit in Article 395 of the CRR.[11] This leaves a final sample of 131 banks and 3,182 individual exposures. To gain an overview of the data, Table 1 shows that the total exposures amount to approximately €560 billion, representing 4.3 per cent of EU GDP (Table 2), with significant heterogeneity across countries.

2.1 Other control data used in empirical analysis

For the regression analysis presented in Section 4, we use a sub-sample of exposures data when examining the bank and country-level factors which determine the volume of the exposures between EU banks and shadow banking entities. In particular, we merge the exposures data which represent our dependent variable with a host of bank-level characteristics such as bank size, liquidity (proxied by the interbank ratio which measures if banks are net providers of liquidity in the interbank market), capitalization, return on average equity (ROAE) and profitability of banks, which are taken from the Bureau van Dijk Orbis database. Owing to missing data for some bank-level characteristics, we match 78 banks from our initial sample of 131 banks based on the bank's LEI code. The number of exposures used in our empirical analysis comprises 1,503 amounting to €387 billion. Overall, the broad patterns of the exposures data described above are consistent with the subset of matched data used in our empirical analysis.

While our final dataset is a cross-section of exposures as at March 2015, our merged sample allows us to exploit a rich geographical structure of the exposures across countries. This allows us to also examine empirically country-level factors which can explain the variation of EU banks' exposures to shadow banking entities. In this way, we merge country-level data regarding the host country of the bank such as GDP to proxy for the size of the country. Likewise, we control for the size of the host country of the shadow banking entity by also including its GDP. These GDP data are taken from the World Bank's World Development Indicators (WDI) database.

[11] We do this to exclude outliers in the data. Moreover, in line with the large exposure limit, the sum of all the exposure values of a bank to a single counterparty or to a group of connected counterparties must not be higher than 25 per cent of banks' eligible capital.

Moreover, we use a host of gravity-related controls which proxy for financial frictions and information asymmetries which are also found to be important factors in determining bilateral relationships in international banking and finance. For instance, we control for whether the host country of the bank and host country of the shadow banking entity share a common border, currency, legal system, language or past colonial links. Moreover, we include the log of geographic distance between these countries as a proxy for information costs which has been used in a number of studies in the international banking and finance literatures (e.g. Buch, 2005, Portes and Rey, 2005, Lane and Milesi-Ferretti, 2008, Houston *et al.*, 2012, Claessens and van Horen, 2014 and Brei and von Peter, 2018). These data are taken from Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). We also include a dummy variable equal to one if the country of the domicile of the shadow banking entity is classified as an offshore financial centre. Shadow banking entities such as securitisation vehicles are often found to be located in offshore financial centres. We employ the classifications used in Davies and Killeen (2018) who in turn combine the respective categorisations of Lane and Milesi-Ferretti (2011) for small international financial centres and Claessens and van Horen (2015).[12] In our extended specifications, we also include proxies for the stringency of the financial regulatory regime in place in the country of domicile of the shadow banking entity. The source and definition of each of these variables are presented in Table 10 in the Appendix.

3 Mapping EU banks' exposures to shadow banking entities

This section provides a unique analysis of EU banks' exposures to shadow banking entities. First, it examines the characteristics of the EU banks which have exposures to shadow banking entities. It then analyses the types of shadow banking entities

[12]We therefore consider the following locations as offshore financial centres: Andorra, Antigua and Barbuda, Bahamas, Bahrain, Barbados, Bermuda, British Virgin Islands, Cayman Islands, Cyprus, Guernsey, Isle of Man, Jersey, Liechtenstein, Mauritius, Netherlands Antilles, Panama, Seychelles, and Singapore.

to which EU banks are exposed before proceeding to an analysis of the cross-border nature of these linkages. This section concludes with an analysis of the concentration and overlap of EU banks' exposures to shadow banking entities.

3.1 EU banks' exposures to shadow banking entities

Our analysis of EU banks' exposures to shadow banking entities first examines the characteristics of the banks involved. As described in Section 2, we complement the EBA data using information taken from Bureau van Dijk's Orbis database.[13] Total assets of banks in our sample amount to €27 trillion. The data show that 23 per cent of the banks in the EBA sample are from Germany, 13 per cent are from the UK and 3 per cent are banks from France. Weighting by their balance sheet size, however, shows that UK banks account for 39 per cent of the total assets of the banks in our sample, while German and French banks account for 11 per cent and 21 per cent, respectively. As noted in EBA (2015), the banks in our sample cover 56 per cent of total assets of the EU financial sector, although the coverage is heterogeneous across countries. For example, French and UK banks account for 75 per cent and 85 per cent of their respective financial sectors (see EBA, 2015), while Irish banks in our sample account for only 6 per cent of the Irish financial sector. However, as described in FSB (2015), approximately 80 per cent of the Irish financial sector consists of entities outside of the regular banking system.

In terms of exposures to shadow banking entities, UK banks have a total of 779 exposures (24 per cent of the total in our sample), accounting for €284 billion (slightly more than half of the total amount and 15 per cent of UK's GDP). German and French banks have a total of 939 and 194 exposures (29 per cent and 6 per cent of the total), accounting for €106 billion and €78 billion (roughly 4 per cent of their countries' GDP), respectively. The exposures of UK banks represent 76 per cent of their aggregate eligible capital, 108 per cent for German banks and 62 per cent for French banks (Table 3). A comprehensive breakdown of the exposures by sector and country of the shadow

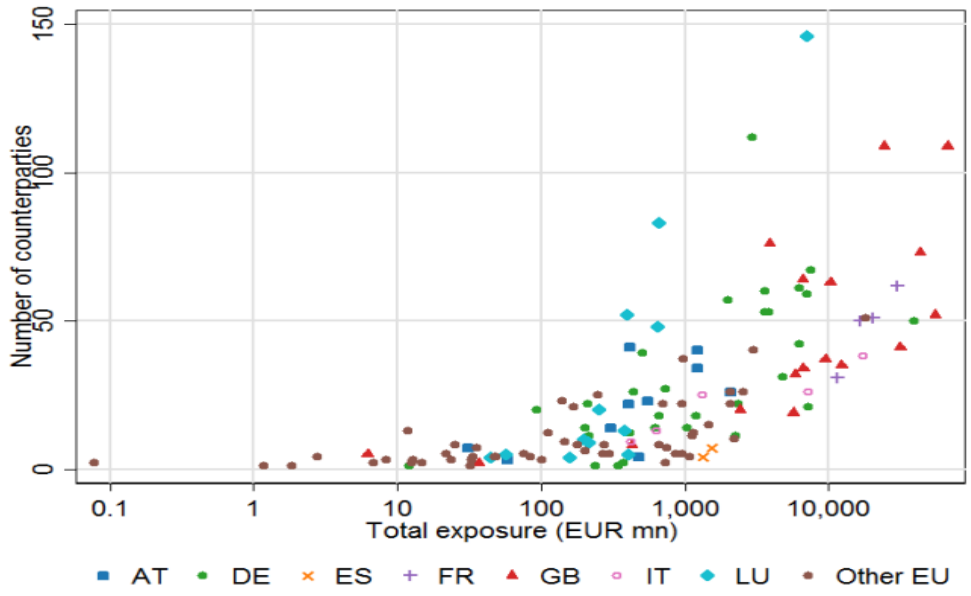
[13] This allows us to match balance sheet data on total assets for 123 out of the 131 banks in our sample.

TABLE 3. **EU banks' exposures to shadow banking entities as a % of banks' (by country) eligible capital**

B / SB	DE	FR	GB	IE	JE	KR	KY	LU	NL	RU	TR	US	O-EU	RW	Total
AT	2.2	0.0	4.4	2.0	0.0	1.2	2.4	2.8	3.5	10.3	1.5	7.0	39.1	8.9	85.1
DE	28.6	0.8	5.2	9.5	1.3	0.4	3.0	7.0	1.7	2.3	4.0	34.1	2.3	7.7	107.7
FR	0.4	12.7	2.9	1.5	0.1	2.3	3.9	1.1	1.6	0.4	0.4	23.7	2.1	8.6	61.7
GB	1.4	1.3	11.9	5.3	3.9	2.1	6.7	3.2	0.9	0.4	0.8	22.4	1.1	14.5	75.9
IT	0.0	3.4	7.5	6.9	1.0	3.5	0.0	6.6	0.4	5.6	20.1	1.3	7.7	7.7	71.6
LU	24.7	15.0	18.2	10.1	0.0	0.4	5.9	56.1	66.6	5.2	0.0	1.4	21.9	8.6	234.2
O-EU	0.9	2.7	2.9	2.1	1.0	4.4	6.1	6.3	6.1	5.5	8.4	5.3	24.2	12.6	88.5
Total	5.1	3.6	8.4	5.0	2.4	2.1	5.2	4.1	2.0	1.5	2.8	21.6	4.1	11.9	79.6

Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to 'shadow banking entities', December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of eligible capital. Country labels on the left hand side of the chart refer to the country of domicile of the reporting institution. Country labels along the top of the chart refer to country of domicile of shadow banking entity. *O-EU* refers to other EU countries while *RW* refers to the rest of the world. The chart excludes investment firms and exposures greater than 25 per cent of the institution's eligible capital (the large exposure limit).

FIGURE 1. **Number of counterparties and total exposures by bank (EUR million)**

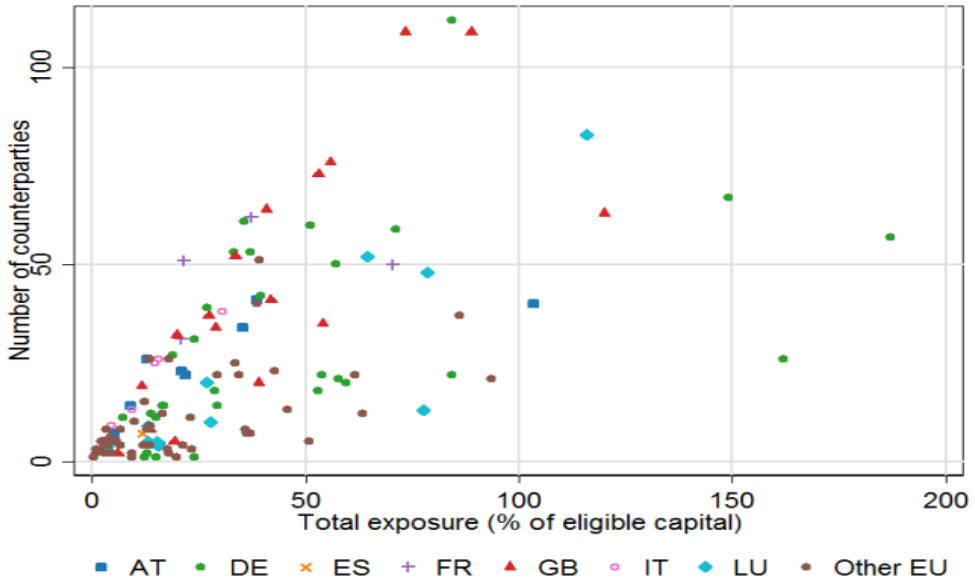


Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to "shadow banking entities", December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of eligible capital of the reporting bank. The chart excludes investment firms and exposures greater than 25% of the institution's eligible capital (the large exposure limit).

banking institutions is presented in the Sections 3.2 and 3.3.

Turning to the bank-level data, Figures 1 and 2 illustrate the positive relationship between the number of counterparties of each bank and their total exposure to shadow

FIGURE 2. **Number of counterparties and total exposures by bank (% of eligible capital)**

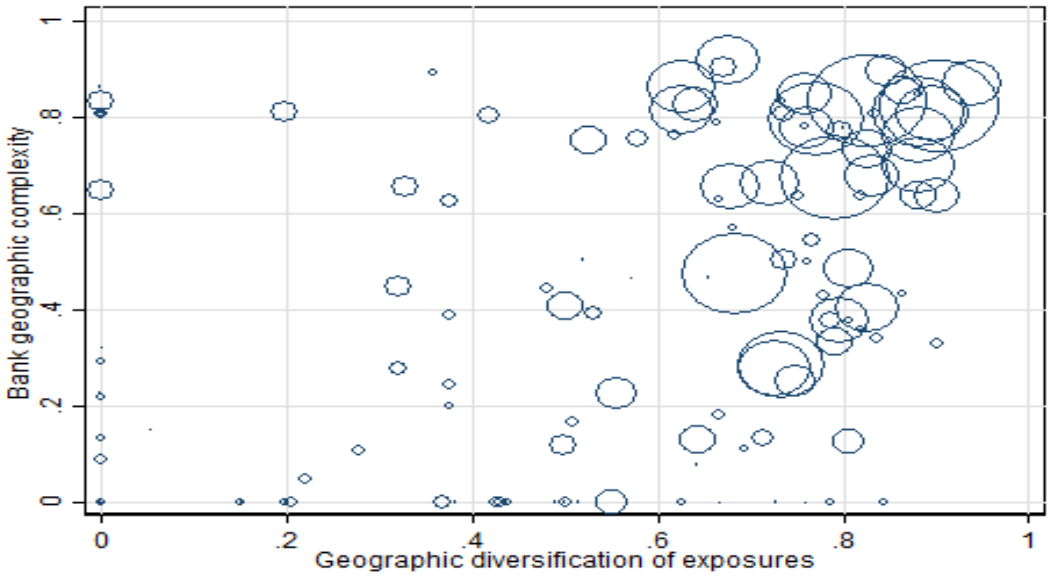


Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to 'shadow banking entities', December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of eligible capital of the reporitng bank. The chart excludes investment firms and exposures greater than 25 per cent of the institution's eligible capital (the large exposure limit).

banking entities (both measured in € millions and as a percentage of their eligible capital). Following Cetorelli and Goldberg (2014), we construct a measure of banks' geographic complexity and check whether more complex banks tend also to have a greater geographical diversification of their exposures to shadow banking entities.[14] As in their paper, this complexity measure is constructed using data on the location of the subsidiaries of the banks in our sample. Figure 3 shows that the relationship between the banks' geographic diversification of exposures to shadow banks and their geographic complexity is positive, and it is also correlated with the banks' size (depicted as the size of each of the circles). A more comprehensive analysis of the geography of the exposures is presented in Section 3.3.

[14]The geographic complexity measure is constructed as a Herfindahl concentration index. See Cetorelli and Goldberg (2014) for further details.

FIGURE 3. **Geographic diversification of EU banks' exposures to shadow banking entities and banks' geographic complexity**



Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to 'shadow banking entities', December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of eligible capital. The chart excludes investment firms and exposures greater than 25 per cent of the institution's eligible capital (the large exposure limit).

3.2 The types of shadow banking counterparties

Table 4 shows that EU banks are exposed to many different types of shadow banking entities.[15] Importantly, there are significant differences in the business models and risk profiles across entities. For example, entities such as non-equivalent banks / insurers and credit insurers / financial guarantors are less likely to be captured in shadow banking surveillance exercises depending on the definition of shadow banking employed. The final dataset we employ shows that EU banks had around 65 per cent of their exposures to securitisations (26 per cent), investment funds other than MMFs (22 per cent) and finance companies (18 per cent). Regarding the top five exposures by type and country of domicile of the shadow banking entities (in EUR billions), Table 4 highlights that EU banks are most heavily exposed to finance companies domiciled in the US, followed by US securitisation vehicles, 'other' US shadow banking entities, securitisation vehicles domiciled in Ireland and US non-MMF investment funds.

[15]Regarding non-MMF investment funds, the data are even more granular and are split into hedge funds, equity funds, real-estate funds, fixed income funds, other investment funds and 'not identified' funds.

TABLE 4. **Distribution of EU banks' exposures to shadow banking entities by country of domicile and type of shadow banking entity (weighted by size of exposure)**

Country / type	1	2	3	4	5	6	7	8	9	Total
DE	0.0	0.0	3.7	1.0	0.0	0.0	1.2	0.0	0.4	6.3
ES	0.0	0.0	0.0	0.3	0.0	0.1	0.3	0.0	0.1	0.7
FR	0.7	0.0	0.5	0.6	0.0	0.0	2.2	0.0	0.4	4.5
GB	0.0	0.4	2.5	2.0	0.4	0.5	2.2	0.0	2.4	10.5
IE	0.0	0.0	0.8	0.7	0.0	0.0	4.5	0.0	0.3	6.3
LU	0.3	0.0	2.3	0.7	0.2	0.0	1.2	0.0	0.4	5.2
NL	0.0	0.0	0.2	0.6	0.0	0.0	1.5	0.0	0.1	2.5
O-EU	0.1	0.0	2.0	1.4	0.0	0.0	0.4	0.1	0.3	4.4
HK	0.1	0.0	0.5	0.0	0.6	0.0	0.0	0.0	0.1	1.3
JE	0.0	0.0	0.2	0.1	0.0	0.0	2.7	0.0	0.0	3.0
JP	0.0	0.0	0.2	0.1	0.6	0.0	0.0	0.4	0.2	1.5
KR	0.0	0.0	0.0	0.2	0.0	0.0	0.0	1.9	0.5	2.6
KY	0.0	0.0	3.4	0.7	0.0	0.0	1.8	0.1	0.5	6.5
RU	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.7	0.1	1.9
TR	0.0	0.0	0.0	0.4	0.0	0.0	0.0	3.0	0.0	3.5
US	0.7	0.2	4.0	8.2	0.3	0.3	7.1	1.6	4.7	27.1
RW	0.0	0.1	1.9	1.2	0.6	0.6	0.8	4.4	2.5	12.1
Total	2.0	0.9	22.3	18.2	2.8	1.4	26.2	13.3	13.0	100.0

Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to 'shadow banking entities', December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of eligible capital. Country labels on the left hand side of the chart refer to the country of domicile of the shadow banking entity. *O-EU* refers to other EU countries while *RW* refers to the rest of the world. The numbers along the top of the chart refer to the type of shadow banking entity as in EBA (2015). 1 = UCITS MMF; 2 = Non-UCITS MMF; 3 = Non-MMF investment fund; 4 = finance companies; 5 = broker-dealers; 6 = credit insurers/ financial guarantors; 7 = securitisation; 8 = non-equivalent banks / insurers; 9 = other.

While some of the linkages between banks and shadow banking entities may simply capture standard financial intermediation flows, others may reflect the increased complexity of intermediation chains across the financial system. In this paper we do not explore the motives for the linkages between banks and shadow banking entities. Rather, taking a macroprudential perspective, we document the different types of linkages and consider which are the most relevant for systemic risk monitoring. For example, as the financial crisis showed, a fundamental source of shadow banking risk relates to regulatory arbitrage across borders and sectors, including from the banking system. Fragmented regulatory regimes and a lack of information and disclosure can lead to regulatory arbitrage and can impede systemic risk monitoring of shadow banking interconnectedness.

A growing number of studies including Adrian and Ashcraft (2012) and Adrian, Ashcraft and Ceterolli (2013) document some of the incentives of financial institutions to avoid taxes, accounting rules and capital requirements. Adrian (2014) highlights regulatory and tax arbitrage as a potential motivation for the increasing role of shadow banking entities within the financial system. The results of Gornicka (2016) also provide insights into the role of guarantees between banks and shadow banking entities, while Claessens and Ratnovski (2014) consider the reliance on backstops as a crucial feature of shadow banking.

Our data also show that 13 per cent of EU banks' total exposures are to entities that could not be further identified and are labelled as 'other' shadow banking entities, highlighting the information limitations for some types of entities. Moreover, the data illustrate that the reporting banks possess limited information about the supervisory treatment of their shadow banking counterparties. By value of the exposures, almost 90 per cent of the shadow banking counterparties were reported as either not supervised or not further identified by the reporting institution.

The existence and scope of regulatory regimes for shadow banking entities can vary both *across* but also *within* jurisdictions. This further reinforces the need for a detailed mapping of the cross-sector linkages. For example, consider the three types of shadow

banking entities that EU banks are most exposed to: non-MMF investment funds, finance companies, and securitisations. While investment funds and fund managers are regulated and supervised in the EU through the UCITS and Alternative Investment Fund Managers Directive (AIFMD) respectively, there is large variation with respect to the regulatory treatment of finance companies and securitisations. Similarly, the regulatory treatment of investment funds, finance companies and securitisations may vary across jurisdictions outside the EU and may not be equivalent to EU applicable regimes. In light of these differences, we proceed by examining the types of shadow banking entities that EU banks are most exposed to and discuss potential financial stability risks associated with the business models or particular features of these entities.

Securitisations: This classification includes securitisation-based credit intermediation and funding of financial entities including CLOs, ABCP and SIVs. These entities played a disruptive role during the global financial crisis and have since received increased attention from researchers, policymakers and regulators alike. Regarding empirical studies, Acharya, Schnabl and Suarez (2013) show that such shadow banking entities had insufficient risk transfer during the crisis as losses remained with the banks themselves. Similarly, Covitz, Liang and Suarez (2013) document runs in the ABCP market.[16] Their findings suggest that banks may be exposed to liquidity vulnerabilities through their implicit and explicit support of ABCP programmes or other conduits in the shadow banking system.

The interconnectedness of banks and shadow banking entities can lead to step-in risk when banks provide sponsor support to securitisation conduits and SIVs. As noted by BCBS (2015), the majority of securitisation vehicles and SIVs that encountered difficulties during the global financial crisis were supported by banks through liquidity provisions that the banks were not contractually obliged to make. In most cases, the sponsoring bank absorbed the losses of these vehicles, which resulted in bringing these

[16] From a financial stability perspective, bank step-in risks can refer to either liquidity risk (i.e. runs) or solvency issues (i.e. losses) or both. Covitz, Liang and Suarez (2013) define a run on a commercial paper program as when short-term creditors refuse to roll over their positions. Similarly, Acharya, Schnabl and Suarez (2013) examine whether an investor that was holding ABCP at the start of the financial crisis suffered losses by not rolling over maturing ABCP.

shadow banking entities back onto the bank's balance sheet. Therefore, although cross-sector interconnectedness can be unobservable or indirect in nature, step-in risk may still exist.

Our data show that, by value of exposure, approximately 27 per cent of EU banks' exposures to securitisations are to entities domiciled in the US, while they also have significant exposures to entities domiciled in Ireland, Jersey, France and the United Kingdom. Moreover, EBA (2014) points to an inconsistent regulatory treatment of securitisation vehicles across EU Member States. In some Member States, securitisation vehicles are subject to solo prudential requirements, while in others they remain outside the regulatory perimeter. Table 4 shows that 36 per cent of EU banks' exposures to securitisation vehicles are to entities which are domiciled in jurisdictions where no solo prudential requirements are in place (for example, Ireland, Luxembourg, the Netherlands and the United Kingdom). Similar to finance companies, however, securitisation vehicles may be prudentially consolidated in large banking groups or may be subject to some form of regulatory or statistical oversight. For example, euro area securitisation entities known as financial vehicle corporations (FVCs) have been subject to quarterly ECB statistical reporting obligations since the end of 2009. In addition, jurisdictions such as Ireland have recently introduced new reporting requirements on a wider sample of SPVs in order to understand better their activities and their associated cross-sector and cross-border linkages.[17] The exposures of EU banks to securitisations captured in our final dataset may also include retained transactions, namely those that are not placed in the market but held on balance sheet and used for collateral purposes in central bank refinancing operations.

Finance companies: Finance companies comprise entities that engage in loan provision that is dependent on short-term funding and include entities such as leasing companies and finance companies. Pozsar et al. (2013) document the role played by finance companies in the shadow banking system, which typically involves loan origination funded through commercial paper or medium term notes. Similarly, Grillet-

[17] See Godfrey, Killeen and Moloney (2015).

Aubert et al. (2016) note that these entities are relevant from a shadow banking perspective if they engage in credit intermediation outside of the regulatory perimeter and are interconnected with the regular banking system.

Regarding their regulatory treatment, EBA (2014) highlights the fragmentation of national regulatory regimes applicable to finance companies in the EU. For example, in some EU Member States, finance companies are subject to solo prudential requirements (for example, France, Italy, Portugal and Spain), whereas in others they are not (for example, Belgium, Bulgaria, Czech Republic, Denmark, Greece, Ireland, Lithuania, Latvia, the Netherlands, Slovakia, the United Kingdom). As shown in Table 4, 45 per cent of EU banks' exposures to finance companies (in € billions) are towards US-domiciled entities, while a significant share of exposures to finance companies within the EU relate to jurisdictions that do not report solo prudential regulatory requirements for finance companies in EBA (2014). It is important to note, however, that some of the finance companies domiciled in these jurisdictions may be consolidated in large banking groups. A lack of data on the supervisory treatment of these entities does not allow for such a detailed assessment.

Non-MMF investment funds: Our data include categories for hedge funds, equity funds, real-estate funds, fixed income funds, other investment funds and 'not identified' funds. There is a large diversity of business models within the sector which affects their susceptibility to financial stability risks, including run risk. For example, alternative investment funds like hedge funds can employ significant leverage and are therefore relevant for shadow banking monitoring, while others such as equity funds are less exposed to shadow banking risks. As noted by Grillet-Aubert et al., (2016), owing to the diversity of the investment fund sector, the underlying liability structures, investor profiles and regulatory constraints should be assessed when monitoring risks within this sector.

More recently, liquidity and leverage within the investment fund sector and business models such as open-ended real estate funds and high-yield corporate bond funds have attracted increasing attention owing to their potential for amplifying financial sta-

bility risks. Therefore, understanding the exposures of EU banks to these types of investment funds is important. Overall, our data show that 22 per cent of total exposures of EU banks are to non-MMF investment funds with many of these entities domiciled in the US, Cayman Islands, Germany, Luxembourg and the United Kingdom.

3.3 The cross-border exposures of EU banks to shadow banking entities

Next, we explore the cross-border nature of the exposures of EU banks to shadow banking entities to understand better the internationalisation of the shadow banking system and the cross-border complexity of the linkages. Our data highlight the global and cross-border nature of the interconnectedness of shadow banking entities, as approximately 60 per cent of EU banks' total exposures to shadow banking entities are towards non-EU domiciled entities. In particular, these data show the strong links between EU banks and US-domiciled shadow banking entities, which account for approximately 27 per cent of the total exposures in our final dataset. A number of studies including, for example, IMF (2014) and Maes (2014) highlight the interaction of EU banks and US-domiciled shadow banking entities during the financial crisis.

Figures 4 and 5 map the international exposures of EU banks to shadow banking entities using granular bank-level and individual exposure level information. The green nodes represent the reporting banks, while their size is determined by the number of individual counterparties or shadow banking entities to which they are exposed to (degree centrality). Orange nodes represent non-EU-domiciled shadow banking entities while the purple nodes represent EU domiciled shadow banking entities. Moreover, the orange links in the network in Figure 4 show that EU banks have a large number of exposures to non-EU domiciled shadow banking entities. The purple links show that EU banks have exposures to a number of EU domiciled shadow banking entities while the blue links represent domestic exposures (EU bank exposure to a shadow banking entity domiciled in the same country as the bank).

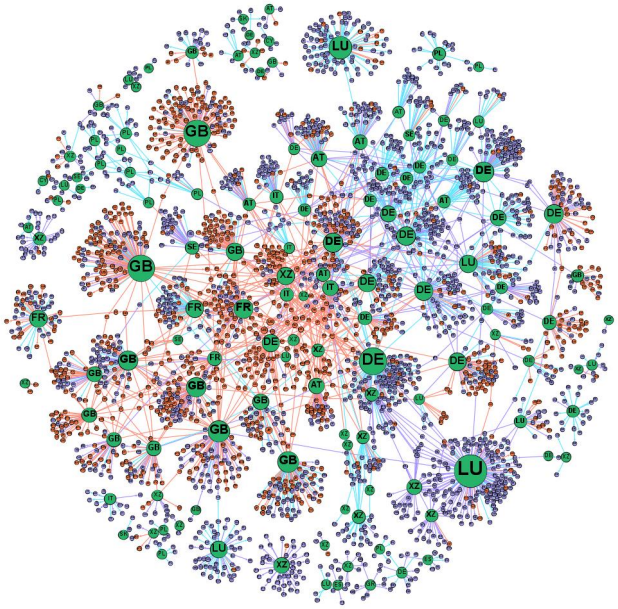
Figure 5 shows a network where the positioning is identical to the network pre-

sented in Figure 4. However, the node size in Figure 5 is proportional to total exposures (i.e. sum of all individual exposures) while the colour of links range from green (smaller exposures) to orange (larger exposures) depending on the size of the individual exposure in € billions. Taken together, these network graphs show that many of the most interconnected EU banks (those with the largest number of linkages measured by degree centrality) are typically the banks with the largest individual exposures.

In Figure 6, we examine the geography of the exposures of the top twenty-five banks by their exposures to shadow banking entities. While there is some heterogeneity across banks, it is clear the EU banks are heavily exposed to shadow banking entities located outside of the EU. The monitoring of such linkages is particularly challenging if authorities lack an holistic view of banks' and shadow banks' international activities or if they lack information on some aspects of their activities. Moreover, Figure 7 presents a global map of the exposures based on the country of domicile of the shadow banking entity. As highlighted by Lane (2016a), information sharing amongst regulators and policymakers can be an important component in the surveillance of international shadow banking activities.

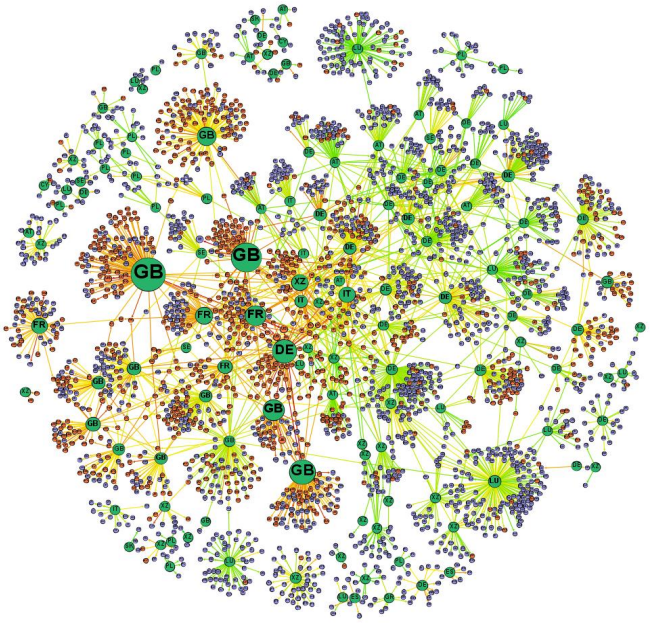
While our analysis provides a unique insight into the geography of the exposures of EU banks to shadow banking entities, it is subject to a number of limitations. The data underpinning our analysis show the domicile of the shadow banking entity. As noted by Grillet-Aubert et al., (2016), the "country of domicile is important in determining the geographic locus of potential supervisory measures". However, such geographic data are based on a first counterparty basis and may not reflect the ultimate risk bearers within the shadow banking entity. For example, while a shadow banking entity may be domiciled in country A owing to a favourable business or tax environment, the end investor may be located in country B, and therefore such flows of potential risk would not be captured in our analysis. In addition, we lack information on the regulatory treatment of the shadow banking counterparty which would be required to map the cross-border risks in more detail.

FIGURE 4. **Network of EU banks' exposures to shadow banking entities**



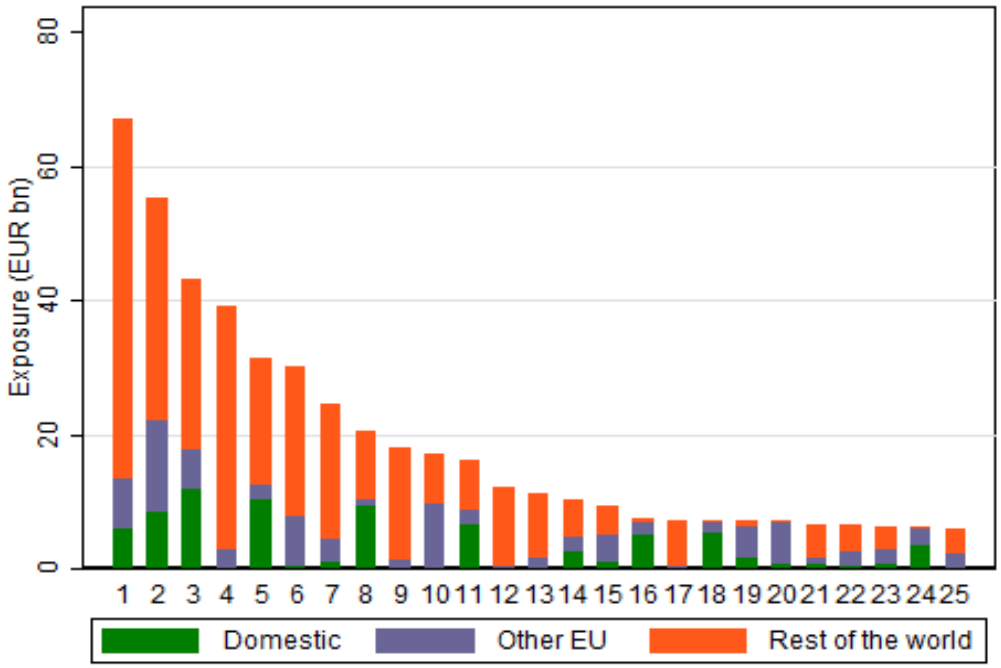
Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to "shadow banking entities", December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of institutions' eligible capital. Green nodes: reporting institutions (banks) labelled by country of residence. Purple and orange nodes: EU and non-EU domiciled shadow banking entities, respectively. The chart excludes investment firms and exposures greater than 25% of the institution's eligible capital (the large exposure limit). Node size is proportional to degree centrality (the number of counterparties). Blue links represent domestic exposures (EU institution to a domestic shadow banking entity); purple links represent EU exposures (EU institution to EU-domiciled shadow banking entity) and orange links represent non-EU exposures (EU institution to non-EU domiciled shadow banking entity).

FIGURE 5. **Network of EU banks' exposures to shadow banking entities**



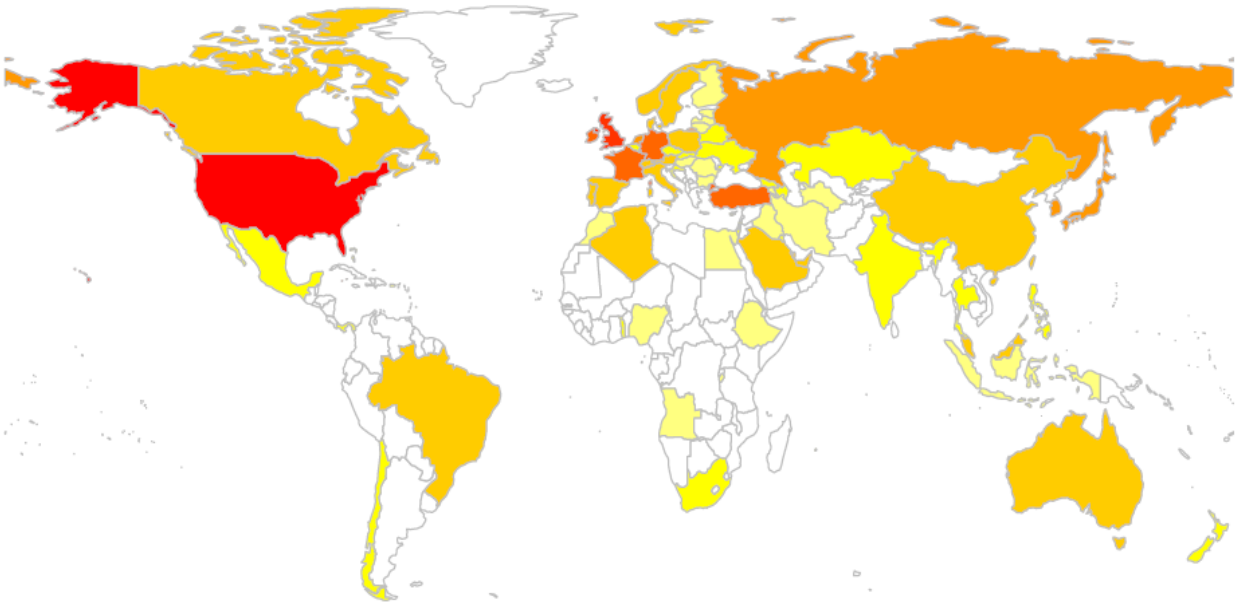
Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to "shadow banking entities", December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of institutions' eligible capital. Green nodes: reporting institutions (banks) labelled by country of residence. Purple and orange nodes: EU and non-EU domiciled shadow banking entities, respectively. The chart excludes investment firms and exposures greater than 25% of the institution's eligible capital (the large exposure limit). Node size is proportional to total exposures (sum of all individual exposures). Colour of link ranges from green to orange depending on the size of the individual exposure (green links: smaller exposures, orange links: larger individual exposures).

FIGURE 6. **Top 25 EU banks by their exposures to shadow banking entities**



Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to 'shadow banking entities', December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of eligible capital.

FIGURE 7. **Geography of risk: distribution of exposures by domicile of shadow banking entities**



Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to 'shadow banking entities', December 2015. Note: Data refer to individual exposures equal to or above 0.25 per cent of eligible capital.

3.4 Concentration / Overlap Analysis

We now move to analyse to what extent EU banks' exposures to shadow banking entities are concentrated and overlapped. By "overlap", we intend to measure the common exposures of EU banks towards shadow banking entities, and we introduce a specific measure to do so.

There is a natural relationship between concentration and overlap, which we illustrate in the following example, where we analyse three different financial systems composed of 2 banks and 3 shadow banks. For illustrative purposes, for each bank, we consider its portfolio structure as the normalised total exposures (so that they sum up to one).

Example Consider the three financial systems represented by the following portfolio matrices:

$$\pi^1 = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \pi^2 = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 1 \end{bmatrix} \qquad \pi^3 = \begin{bmatrix} 1/3 & 1/3 & 1/3 \\ 1/3 & 1/3 & 1/3 \end{bmatrix}$$

where the element π^s_{ik} refers to the exposure from bank i to shadow banking entity k in the s-th system.

The first system (matrix π^1) presents zero overlap because of the high concentration of the two banks. Each of the banks has no diversification and concentrates its exposures to one entity. A shock to any of the shadow banking entities will not impact the two banks at the same time. The second system (matrix π^2) has maximal overlap because of the concentration of its banks. Banks have a concentrated portfolio of exposures (no diversification) but they are both exposed to the same shadow banking entity. A shock to the third shadow banking entity will affect both banks at the same time. The third system, captured by the matrix π^3, presents a completely different picture: the two banks achieve maximal diversification by being exposed to all shadow banking entities in the system. The third system has therefore maximal overlap because of low concentration (maximal diversification) of its banks. Any shock will

impact equally both banks at the same time.

Overall, this example highlights that the increased diversification of exposures may increase overlap and therefore reduce the benefit of diversification owing to the commonalities of the sources of shocks. In this sense, banking systems may be potentially fragile to certain types of shocks while being robust to others: a system with a high degree of common exposures due to diversification may be resilient to small common shocks, but vulnerable to shocks beyond a specific threshold (see, for example, Acemoglu et al., 2015). This *systemic* feature of the financial system has received increased attention in recent years. As financial systems increase their levels of complexity and interconnectedness, they face a trade-off between diversification and systemic risk (Battiston et al., 2012). This stream of research shows that more connections may increase *individual* diversification while, at the same time, making the *system* more susceptible to common shocks which may lead to wide-scale systemic failures.

Some studies argue that a certain degree of individual concentration can be beneficial. Stomper (2006), for instance, links concentration to the expertise lenders have in certain sectors. On the other hand, a more locally concentrated system does not benefit from diversification and individual institutions may become riskier. Concentration risk therefore still represents one of the main possible causes of major losses in a credit institution. The global financial crisis brought to light many examples of risk concentrations within financial institutions. Since it can directly affect the survival of an institution, concentration risk requires special attention by supervisors. This has led policymakers to focus specifically on concentration.[18] Understanding whether overlap is ascribable to either concentration or diversification or both is therefore important from a financial stability perspective.

3.4.1 Setup

Hence we seek to understand the type and geography of the shadow banking entities for which overlap occurs, which we hereby analyse. To this end, consider the set of

[18]See, for example, the BIS (BCBS, 2006) and EBA study on Concentration (CEBS Guidelines on the management of concentration risk).

n banks (indexed by $i = 1, 2, \ldots, n$) and the set of the m shadow banks (indexed by $k = 1, 2, \ldots, m$). Given an exposure x_{ik} of bank i to shadow bank k, the total exposure to shadow banking entities of each bank i is therefore $\sum_k x_{ik}$. Further, define the following two ratios:

$$\pi_{ik} = \frac{\text{exposure of } i \text{ to } k}{\text{total shadow bank exposures of } i} = \frac{x_{ik}}{\sum_k x_{ik}}$$

and

$$l_{ik} = \frac{\text{exposure of } i \text{ towards } k}{\text{capital of } i} = \frac{x_{ik}}{c_i}$$

where π_{ik} can be thought of as the elements of the portfolio matrix of the system (with $\sum_k \pi_{ik} = 1, \forall i$), and l_{ik} are individual exposures as a fraction of bank i's capital. Moreover the total exposure of i as a fraction of its capital is simply given by $l_i = \sum_k l_{ik}$ and, therefore, it holds that $l_{ik} = l_i \times \pi_{ik}$. A simple, yet useful interpretation of the term l_{ik} is the percentage of equity lost by i given a shock on k. In this sense, if $l_{ik} > 1$, i may itself default from the default of k.

Concentration A well-known measure of concentration is the Herfindahl index (HHI) of concentration, computed in our case as follows:

$$H_i = \sum_k \pi_{ik}^2$$

which measures the concentration of the portfolio of exposures to shadow banking entities of bank i. The top panel of Figure 8 reports the values of H_i for each bank versus their normalised degree (i.e. the number of shadow banking entities to which bank i is exposed). It shows that concentration is inversely related to the number of shadow banking counterparties. Therefore, banks with less concentration in their exposures to shadow banking entities also have a larger set of counterparties. The bottom panel of Figure 8 reports the values of H_i versus the number of different countries to which each bank is exposed. It suggests that banks with low levels of concentration have

their exposures split across many different countries. This has an important implication for our cross-border analysis if diversification is achieved by having exposures to jurisdictions or sectors where prudential regulation may not apply.

Overlap We focus on a simple measure for portfolio overlap between two banks:

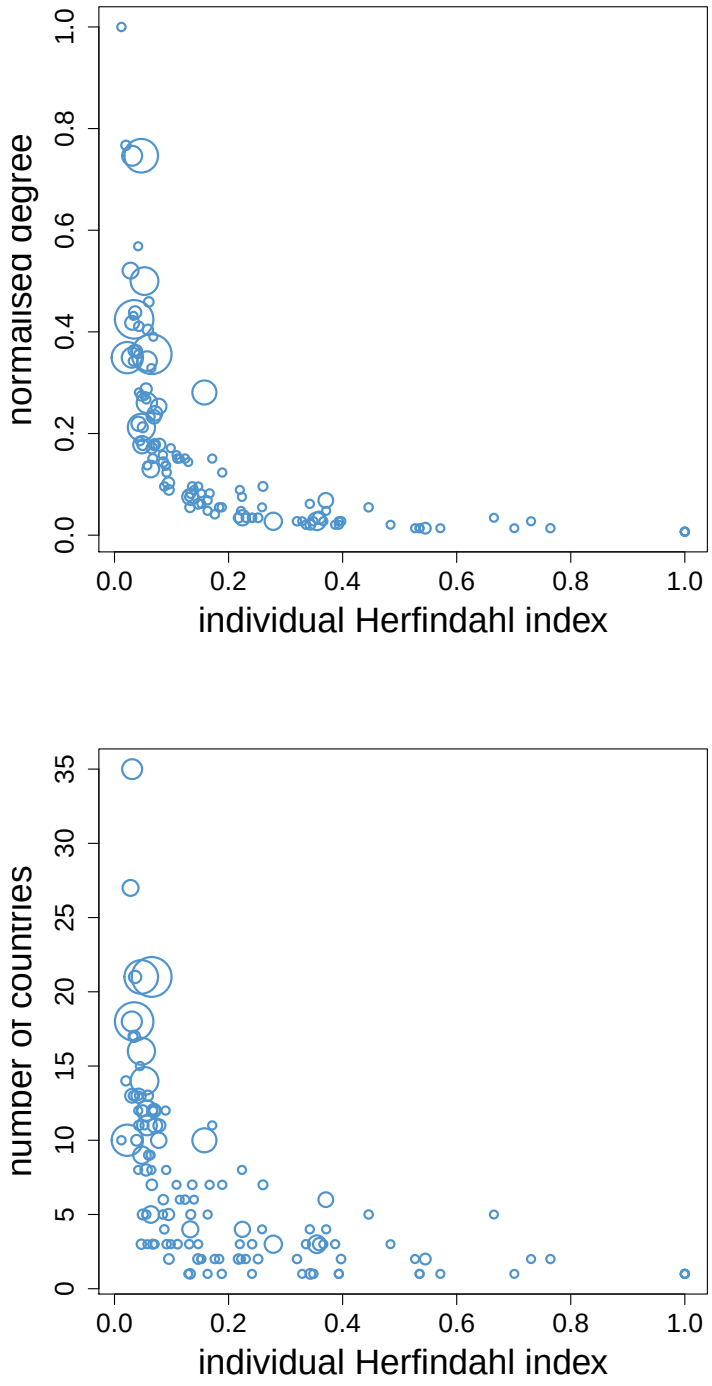
$$s_{ij}^{\pi} = \sum_{m} \min\{\pi_{im}, \pi_{jm}\} \tag{1}$$

where the index m refers to each of the nine shadow banking categories in our sample (as described in Section 3.2), aggregated by their country of domicile. The quantity s_{ij}^{π} can be interpreted as the intersection of the two portfolios. Therefore, the common amount of exposures to the same combinations country/type of shadow bank entities. We compute this *pairwise* quantity for all the banks in our sample. Naturally, given the large number of shadow banking entities in our sample, many banks will have zero overlap, in that they will have no shadow bank exposure in common. It is therefore useful to compute the overlap both conditional on the existence of common exposures and unconditionally. Also, given the granularity of our dataset, we can analyse the levels of overlap at two levels of aggregation: by country of shadow banking entity and by type of shadow banking entity. The results are reported in Figure 9, where we plot the empirical cumulative density functions (ECDF) of the overlaps for these two levels of aggregation. In both cases, the aggregation by type of shadow banking entity provides higher levels of overlap. The conditional overlap (ECDF) on the top panel shows that, once strictly positive overlaps are computed, these overlaps can be high for a relatively large amount of bank pairs. For example the overlap by country is at least 0.6 for ten percent of the bank pairs. An important fraction of banks may therefore be exposed to common shocks originating from the same set of countries.

3.5 Vulnerability

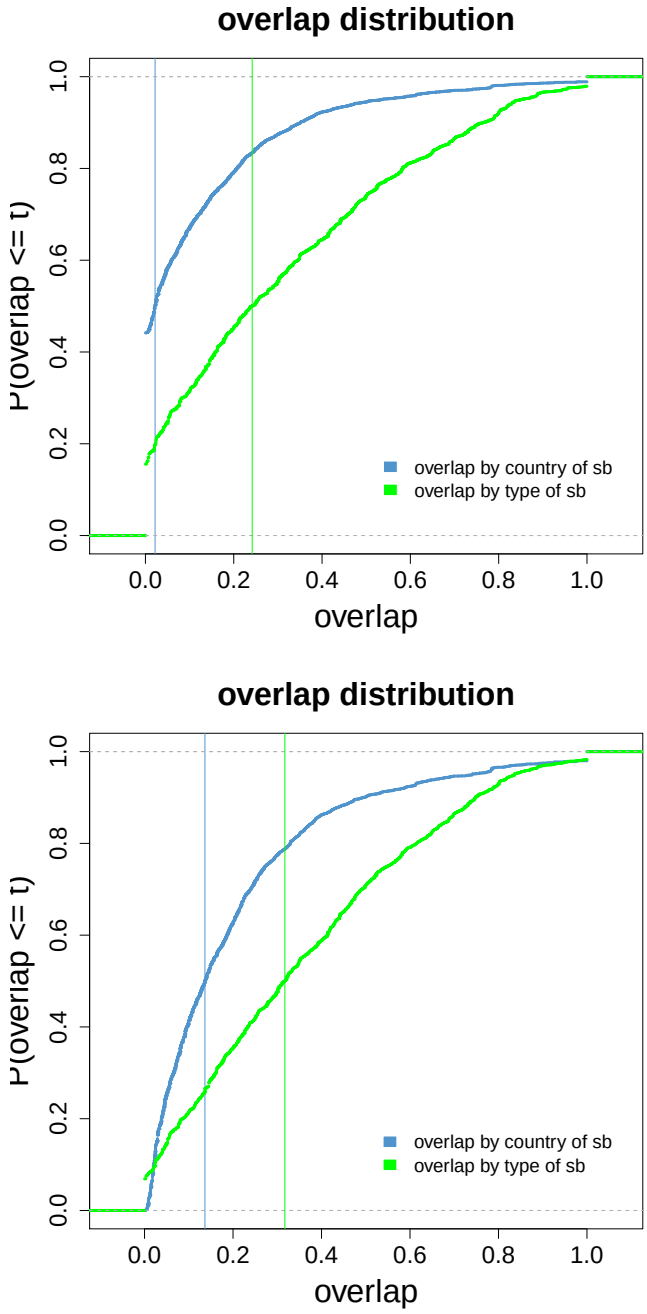
Shocks from the shadow banking system may potentially engender distress in the banking sector and can lead to significant losses. To explore this, we build on the

FIGURE 8. **Concentration.**



Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to "shadow banking entities", December 2015. Note: the horizontal axes represent concentration indices for each bank as measured by Equation (1). The vertical axes represent normalised degree (top panel) and number of countries to which each bank is exposed (bottom panel).

FIGURE 9. **Overlap.**



Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to "shadow banking entities", December 2015. Note: empirical cumulative density functions (ECDF) of the overlap measure is computed by Equation (1). Blue lines represent the overlap in terms of countries to which banks are exposed. Green lines represent the overlap in terms of the types of shadow banking entities (as defined in Section 3.2). Top panel: distribution of overlap conditional on the existence of commonalities. Bottom panel: unconditional distribution.

framework of Battiston et al. (2016) to understand potential capital losses owing to shadow banking activities. First, define the following quantity:

$$h_i = \min\left\{1, \sum_k h_{ik}\right\}, \text{ where } h_{ik} = l_{ik} r_k$$

which measures the potential relative equity loss due to a shock $r_k \in [0, 1]$ on a shadow banking entity k. The total relative equity loss for the banking system of a country C is:

$$H_C = \min\left\{1, \sum_{i \in C}\left(w_i \sum_k l_{ik} r_k\right)\right\}$$

where $w_i = \frac{c_i}{\sum_j c_j}$ is the relative capital of i with respect to the total aggregate capital in the system.

Within this framework, it is possible to understand what are the types of shadow banking entities, aggregated by their country of domicile, that could lead to the largest losses for the EU banking system, by computing the following quantity:

$$H_m = \min\left\{1, \sum_i w_i l_{im} r_m\right\}, \tag{2}$$

where m represents one of the nine shadow banking categories in our sample (as described in Section 3.2), aggregated by their country of domicile. By assuming a common shock to all sectors ($r_m = r, \forall k$), we can rank them in terms of the potential equity loss they would cause in the EU banking system. Table 5 presents the ranking for the top ten results. We observe that finance companies (Type 4) domiciled in the US represent the top source of vulnerability for the EU banking sector, followed by US-domiciled securitisation vehicles (Type 7) and US-domiciled shadow banking entities that could not be further defined or classified as 'other' (Type 9). This shows that the top three largest exposures for the EU banking system are indeed US-domiciled shadow banking entities.

Last, we analyse how these different sources of vulnerability may impact the same

TABLE 5. **Vulnerability**

Rank	Source	Rank	Source
1	US Finance companies	6	DE Non-MMF investment funds
2	US Securitisation	7	KY Non-MMF investment funds
3	US 'Other'	8	TR Non-equivalent banks/insurers
4	IE Securitisation	9	JE Securitisation
5	US Non-MMF investment funds	10	GB 'Other'

Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to "shadow banking entities", December 2015. Note: Rank of the top ten sources of vulnerability (from highest to lowest) for the EU banking system (in terms of potential equity loss). The sources of vulnerability are shadow banking categories as classified in Section 3.2, aggregated by their country of domicile.

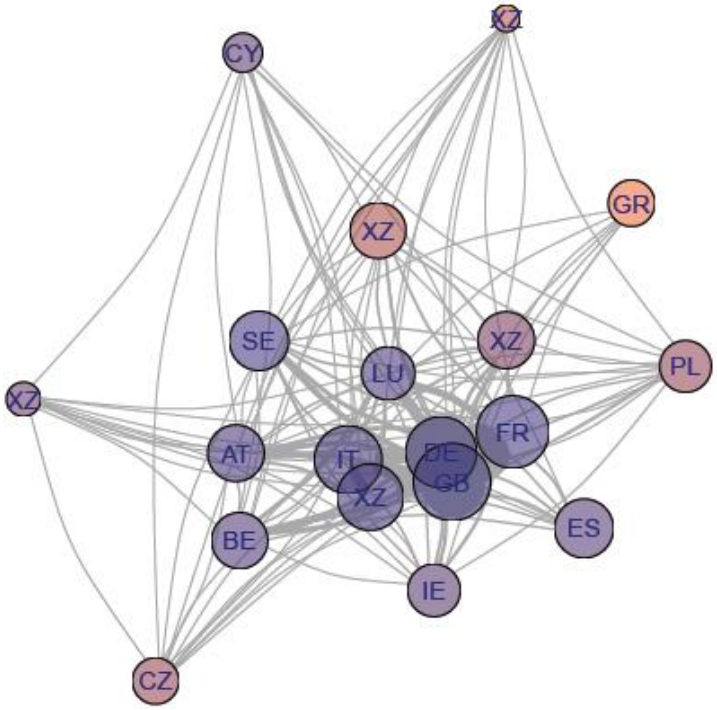
banks by computing a *leverage-based* overlap measure:

$$S_{ij}^{l} = \sum_{k} \min\{l_{ik}, l_{jk}\} \tag{3}$$

which measures the common relative equity loss to the banking systems of any pair of countries following a given shock.[19] We plot the network associated to S_{ij}^{l} in Figure 10. The colour of the nodes reflects the level of concentration computed as the Herfindahl index, ranging from blue (smaller concentration) to red (larger concentration). It shows that less concentrated banking systems tend have more overlap: more diversification leads to more overlap between banking systems of different EU countries. Given that a common source of vulnerability is represented by US-domiciled entities, this highlights the potential transmission channels stemming from the US shadow banking system which were exposed during the financial crisis (Maes, 2014).

[19] By *banking system* of a country, we refer to the aggregation of all banks in a given country, weighted by the size of their equity.

FIGURE 10. **Common vulnerability overlap: less concentrated systems tend to be more overlapped**



Source: Authors' calculations based on EBA (2015), Report on institutions' exposures to "shadow banking entities", December 2015. Note: each node in the network represents a banking system, defined as the aggregation of the banks by country. The size of the nodes is proportional to the system's total exposures to shadow banking entities. The size of the weights reflects the level of leverage-based overlap as computed in Equation 3. The colour of the nodes reflects the level of concentration computed as the Herfindahl index, ranging from blue (smaller concentration) to red (larger concentration).

4 Determinants of EU banks' exposures to shadow banking entities

Following an empirical methodology similar to Buch *et al.* (2013), we next employ an augmented gravity model to examine the determinants of EU banks' exposures to shadow banking entities. Our empirical methodology can thus be written as follows:

$$\ln(EXP_{bij}) = W_{ij}\beta_1 + X_b\beta_2 + V_i\beta_3 + Z_j\beta_4 + \lambda_b + \alpha_j + \gamma_s + \varepsilon_{ij} \quad (4)$$

In this specification $\ln(EXP_{bij})$ is the natural logarithm of bank b in country i's exposures to shadow banking entities located in country j.[20] Therefore, we exploit the cross-sectional variation of the exposures as of March 2015 across countries by estimating an augmented gravity regression for exposures against a host of bank-level and country-level controls. W_{ij} is a vector of bilateral gravity related controls such as share a common border, currency, legal system, language or past colonial links; X_b are bank-group level explanatory variables such as size, capitalization, liquidity and cost-to-income ratio; V_i represents country-level controls related to the location of the bank such as GDP; while Z_j represents country-level explanatory variables for the location of the shadow banking entity. λ_b, α_j and γ_s relate to bank-group level, shadow banking *country* and shadow banking entity *type* fixed effects while ε_{ij} is an error term. Standard errors are robust to heteroskedasticity and clustered at the bank group level. Summary statistics for the variables used in our empirical analysis are presented in Table 6.

4.1 Main regression results

The estimates from our baseline specification are reported in Table 7. In column (1), we control for bank-level characteristics such as bank size (measured by the log of total assets), bank capitalization, the interbank ratio, ROAE and bank's cost-to-income

[20] In our robustness tests shown in Table 7, we use an alternative dependent variable when proxying the internationalization of EU banks' exposures to shadow banking entities.

TABLE 6. Summary statistics

Variable	N	Mean	Std. Dev	Min.	Max.
Log(size)	1503	18.9	2.1	12.4	21.5
Equity/total assets	1503	6.9	7.3	2.3	90.6
Interbank ratio	1468	95.83	71.1	4.3	421.9
ROAE	1503	2.1	13.6	−90.4	29.6
Cost-income ratio	1467	71.9	16.3	33.9	136.5
Log(distance)	1503	6.9	1.5	4.0	9.8
Log(GDP˙bank˙host)	1503	28.1	1.1	23.9	28.9
Log (GDP˙shadow˙bank˙host)	1503	28.3	1.5	23.9	30.4

ratio. We find a significant positive impact of bank size and capitalization and ROAE on the volume of EU banks' exposures to shadow banking entities.

In columns (2) to (6), we add a host of country-level controls such as the GDP of the country of the bank and shadow banking entity, gravity related bilateral regressors and a dummy variable equal to one whether the shadow banking entity is domiciled in an offshore financial centre.[21] In line with a number of empirical papers in the international banking and finance literatures (see, for example, Buch, 2005, Portes and Rey, 2005, Lane and Milesi-Ferretti, 2008, Houston *et al.*, 2012, Claessens and van Horen, 2014, Davies and Killeen, 2018, and Brei and von Peter, 2018), we include the log of geographic distance between the country of the bank and shadow banking entity. This control variable has been widely employed in the empirical trade, FDI and finance literatures as a proxy for information costs and financial frictions. We find a significant negative effect of distance on the size of banks' exposures to shadow banking entities across all our specifications.

In column (3), we add a number of bilateral gravity related variables on whether the country of the bank and shadow banking entity share a common border, currency, language, legal system and past colonial links. The positive and significant effect (at the

[21] Comparing the specifications from column (1) to (3) with (4) to (6) highlights the changes in the sign and significance of the bank-level covariates once we control for bilateral-gravity and other country-level determinants.

1 per cent level) of sharing a common currency suggests that economic ties between the country of the bank and country of the shadow banking entity is an important determinant when examining the exposures of EU banks to shadow banking entities. In contrast, we find that a common border has a significant negative effect. In column (4), we add two additional country-level regressors - the size of the country of the bank and shadow banking entity as proxied by their GDP. Both covariates enter negatively although the size of the country of the shadow banking entity is insignificant. Moreover, it is noteworthy that the sign on some of our bank-level covariates change once we control for the size of the country of the reporting bank and the size of the country of the shadow banking entity. In columns (5) and (6), the inclusion of the offshore international financial centre dummy is positive but insignificant in both specifications. Finally, column (6) includes a set of shadow banking entity type specific dummy variables. Overall, our earlier findings remain robust to their inclusion and the specification in column (6) now represents our preferred baseline estimation.

TABLE 7. Estimates from Baseline Regressions

	(1) Full sample	(2) Full sample	(3) Full sample	(4) Full sample	(5) Full sample	(6) Full sample
Log(size)$_{t-1}$	2.938***	2.461***	2.274***	1.471***	1.471***	1.532***
	(0.127)	(0.122)	(0.128)	(0.065)	(0.065)	(0.080)
Equity/total assets$_{t-1}$ 2.885***	1.725***	1.695***	-0.317***	-0.317***	-0.424***	
	(0.129)	(0.202)	(0.236)	(0.069)	(0.069)	(0.101)
Interbank ratio$_{t-1}$	-0.286***	-0.175***	-0.174***	0.0227***	0.0227***	0.0292***
	(0.013)	(0.020)	(0.023)	(0.008)	(0.008)	(0.009)
ROAE$_{t-1}$	1.056***	0.629***	0.623***	-0.163***	-0.163***	-0.194***
	(0.052)	(0.074)	(0.089)	(0.029)	(0.029)	(0.033)
Cost-income ratio$_{t-1}$	0.001	-0.008**	-0.005	-0.0162***	-0.0162***	-0.0268***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
log(distance)		-1.120***	-0.778***	-0.778***	-0.778***	-0.765***
		(0.166)	(0.202)	(0.202)	(0.202)	(0.199)
comcur			0.952***	0.952***	0.952***	0.886***
			(0.323)	(0.323)	(0.323)	(0.303)
colony			0.571	0.571	0.571	0.466
			(0.506)	(0.506)	(0.506)	(0.487)
comleg			0.021	0.021	0.021	0.038
			(0.261)	(0.261)	(0.261)	(0.242)
comlang_off			0.290	0.290	0.290	0.305
			(0.408)	(0.408)	(0.408)	(0.380)
contig			-1.197***	-1.197***	-1.197***	-1.134***
			(0.333)	(0.333)	(0.333)	(0.320)
GDP˙bank˙host$_{t-1}$				-1.510***	-1.510***	-1.686***
				(0.189)	(0.189)	(0.214)
GDP˙shadow˙bank˙host$_{t-1}$				-5.480	-5.480	-4.660
				(3.324)	(3.324)	(3.455)
Offshore˙fin˙centre					0.684	0.911
					(1.147)	(1.203)
N	1432	1432	1432	1432	1432	1432
No. banks	78	78	78	78	78	78
Bank Group fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
SB entity fixed effects	No	No	No	No	No	Yes
R^2	0.817	0.853	0.875	0.875	0.875	0.881
adj. R^2	0.800	0.840	0.863	0.863	0.863	0.869

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents the baseline estimates for the cross-section data (2015) with bank fixed effects and shadow banking entity *host country* fixed effects. The dependent variable is the log of banks' total exposures to shadow banking entities in different host countries. Column (6) includes dummy variables for the type of shadow banking entities. Standard errors are robust to heteroskedasticity and clustered at the bank group level (shown in parentheses). Bank-level and time-variant country regressors are lagged by one period with respect to the dependent variable.

We repeat our preferred baseline specification in column (1) of Table 8. As noted by Buch et al. (2013), bank-level covariates are potentially endogenous and therefore it is worthwhile to examine the determinants of EU banks' exposures to shadow banking entities with and without these bank-level controls. To this end, in columns (2) and (3) we include the bank-level regressors and the country-level regressors separately. Looking at the bank-level regressors in column (2), we find that the sign of bank size remains positive although it is noteworthy that the sign of the coefficients on banks' capitalization, interbank ratio and ROAE now change when compared to our baseline specification.

In column (3), we find that the direction, and in almost all cases, the significance of our country-level regressors are robust to the exclusion of the bank-level covariates. Overall, these country-level results highlight the importance of gravity related economic and geographical factors in determining the volume of exposures of EU banks to shadow banking entities in different host countries. Moreover, these results suggests banks from countries that share common characteristics with host countries of shadow banking entities are likely to also share common exposures to these host countries. This may engender common cross-border exposures owing to these shared gravity related characteristics.

TABLE 8. Estimates from Additional Regressions

	(1) Baseline	(2) Bank-level covariates only	(3) Country-level covariates only
Log(size)$_{t-1}$	1.532***	3.184***	
	(0.080)	(0.165)	
Equity/total assets$_{t-1}$	-0.424***	2.987***	
	(0.101)	(0.121)	
Interbank ratio$_{t-1}$	0.029**	-0.302***	
	(0.009)	(0.012)	
ROAE$_{t-1}$	-0.194***	1.104***	
	(0.0325)	(0.051)	
Cost-income ratio$_{t-1}$	-0.0268***	-0.0124**	
	(0.004)	(0.005)	
log(distance)	-0.765***		-0.661***
	(0.199)		(0.198)
comcur	0.886***		0.840***
	(0.303)		(0.306)
colony	0.466		0.780
	(0.487)		(0.486)
comleg	0.0382		0.246
	(0.242)		(0.284)
comlang_off	0.305		-0.0814
	(0.380)		(0.443)
contig	-1.134***		-0.805**
	(0.320)		(0.364)
GDP*bank*host$_{t-1}$	-1.686***		-6.710***
	(0.214)		(0.760)
GDP*shadow*bank*host$_{t-1}$	-4.660		-4.495
	(3.455)		(3.593)
Offshore*fin*centre	0.911		0.943
	(1.203)		(1.275)
N	1432	1432	1503
No. banks	78	78	78
Bank Group fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
SB entity fixed effects	Yes	Yes	Yes
R^2	0.881	0.831	0.882
adj. R^2	0.869	0.814	0.870

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents additional estimates for the cross-section data (2015) with bank, shadow banking entity *type* and shadow banking entity *host country* fixed effects using sub-samples of data. The dependent variable is the log of banks' total exposures to shadow banking entities in different host countries. Standard errors are robust to heteroskedasticity and clustered at the bank group level (shown in parentheses). Bank-level and time-variant country regressors are lagged by one period with respect to the dependent variable.

4.2 Regressions based on sub-samples

We next run a number of additional regressions based on sub-samples of data. The results so far have not considered potential differences in the determinants of exposures across different types of shadow banking entities or categories of banks.

Given the diversity of entities and business models which comprise the shadow banking system, it may be expected that different types of shadow banking entities may have different determinants of exposures. To investigate these issues, Table 9 repeats our baseline specification across different sub-samples of data. In column (1), we use the shadow banking entity categorisations included in the EBA data collection (and described in Section 2) to examine the determinants of EU banks' exposures to non-MMF investment funds only. Similarly, in column (2) we examine the determinants to finance companies only while column (3) focuses specifically on securitisation vehicles. We do this as these three categories of shadow banking entities account for approximately two-thirds of the exposures to shadow banking entities. Consistent with our baseline estimates where we group all types of shadow banking entities together, we find that bank size is positively and statistically significantly associated with banks' exposures to the three types of shadow banking entities. Of the gravity and country-level controls, we again find that the distance between the country of domicile of the bank and shadow banking entity and whether they share a common currency or border are important determinants and are in line with the sign and significance levels of our baseline estimates.

In columns (4) to (8) we examine differences across the business models of banks by splitting our sample of exposures by type of bank. To do this, we use the categorisations of banks from the EBA data collection in columns (4) and (5) while we draw on a separate classification of banks taken from the Orbis database for columns (6) to (8). In column (4), we focus specifically on the exposures of banks labelled as Group 1 banks while the results from the sample of Group 2 banks are shown in column (5). As per EBA (2015), Group 1 banks have Tier 1 capital in excess of €3 billion and are internationally active while other banks would be considered Group 2 banks. We do

find differences in the determinants of the size of the exposures to shadow banking entities according to these classifications. While larger banks are likely to have higher exposures to shadow banking entities for both categories, we do find differences in the direction of the estimates for the other bank-level controls. Similarly, regarding the country-level control variables, our results suggest that the distance between the host country of the bank and shadow banking entity has a significant negative effect for Group 1 banks (at the 5 per cent significance level) while it is negative and insignificant for Group 2 banks. Moreover, the other gravity related controls are largely insignificant for Group 2 banks. This suggests that internationally active banks are more responsive to these cultural, economic and geographical financial frictions.

Having exploited the bank business model classifications from the EBA (2015), we proceed next by cross-checking our findings using the bank categorisations provided by the Orbis data. Column (6) of Table 9 presents the estimates for banks that are classified as commercial banks, column (7) shows the results for bank holding companies while column (8) shows the estimates for banks classified as savings banks. Of the three types of banks considered, it is noteworthy that commercial banks, those which one would expect to be active in international financial markets, appear most responsive to the importance of the distance coefficient which enters negatively for these types of banks but is positive and significant for the other two categories of banks. We also find differential responses on the bank size coefficient with larger banks that are classified as bank holding companies or savings banks are more likely to have higher exposures while the coefficient for commercial banks is negative and insignificant. We find that savings banks and bank holding companies with higher capitalization ratios are also less likely to hold significant exposures to shadow banking entities. Turning to the country level controls, we again find that the host country of the bank and shadow banking entity sharing a common currency is an important determinant for all three categories of banks while sharing a common language is important for bank holding companies but is negative and significant for savings banks.

Finally, we examine variations with respect to our dependent variable. In column

(9), we replace our dependent variable with the per cent of bank b from country i's exposures to shadow bank country j as a percentage of each banks' shadow banking exposures. This alternative specification therefore proxies for the concentration of each banks' shadow banking exposures to entities located in specific host countries. While the sign and significance for the GDP of the country of the bank and common border are consistent with our preferred baseline, we observe a loss of significance for some of the other control variables. For example, bank size is positive and significant at the 5 per cent level compared to our preferred baseline.

TABLE 9. Results from Additional Regressions based on Sub-Samples

	(1) Non-MMF inv. funds	(2) Finance companies	(3) Securit-isations	(4) Group 1 banks	(5) Group 2 banks	(6) Commercial banks	(7) Bank holding companies	(8) Savings banks	(9) Dep. var: Concentration
Log(size)_{t-1}	1.602***	1.297***	1.803***	1.468***	37.94***	-1.130	10.40***	2.195***	0.040**
	(0.122)	(0.158)	(0.162)	(0.063)	(9.800)	(0.709)	(0.790)	(0.038)	(0.017)
$\text{Equity/total assets}_{t-1}$	0.431***	0.269	0.976***	-0.272***	1.838	-0.302	-5.194***	-1.055***	0.075***
	(0.05)	(0.169)	(0.210)	(0.082)	(0.753)	(0.246)	(1.176)	(0.06)	(0.023)
$\text{Interbank ratio}_{t-1}$	-0.011	-0.006	-0.037***	0.185	0.261***	-0.006	0.093***	-0.008***	-0.006***
	(0.007)	(0.005)	(0.010)	(0.009)	(0.028)	(0.006)	(0.012)	(0.000)	(0.002)
ROAE_{t-1}	0.021	0.044	0.061	-0.158***	0.486***	-0.196***	0.0	-3.460***	0.015**
	(0.041)	(0.031)	(0.036)	(0.036)	(0.038)	(0.043)	(0.0)	(0.099)	(0.007)
$\text{Cost-income ratio}_{t-1}$	0.022***	0.005	0.021	-0.021***	1.043	0.047	0.0	-0.205***	-0.003***
	(0.007)	(0.009)	(0.016)	(0.004)	(0.601)	(0.047)	(0.0)	(0.003)	(0.001)
log(distance)	-2.034***	-1.443***	-1.030***	-0.587**	-0.745	-0.588***	0.941**	0.611***	-0.127***
	(0.317)	(0.467)	(0.362)	(0.243)	(0.739)	(0.185)	(0.257)	(0.081)	(0.047)
comcur	1.334***	0.738**	0.812	1.368***	0.630	0.941**	3.297**	0.864**	0.085
	(0.428)	(0.360)	(0.656)	(0.370)	(0.676)	(0.397)	(0.588)	(0.352)	(0.063)
colony	0.173	0.922	-0.357	1.201***	0.0	1.425***	-3.267***	0.0	0.010
	(0.422)	(0.568)	(0.907)	(0.386)	(0.0)	(0.433)	(0.068)	(0.0)	(0.119)
comleg	-1.038**	-0.167	-0.0587	-0.400	-0.843	-0.313	-1.295***	3.149***	0.071
	(0.472)	(0.550)	(0.536)	(0.266)	(1.043)	(0.394)	(0.072)	(0.237)	(0.051)
comlang_off	1.206	0.644	1.132	0.809	-2.423**	0.970	10.78***	-5.026***	0.017
	(0.721)	(0.812)	(0.887)	(0.450)	(1.157)	(0.570)	(0.448)	(0.426)	(0.098)
contig	-1.867***	-0.984**	-1.507*	-1.305***	0.339	-1.078***	-7.081**	2.522***	-0.244***
	(0.424)	(0.458)	(0.684)	(0.328)	(1.205)	(0.304)	(1.067)	(0.174)	(0.067)
$\text{GDP}^{\cdot}\text{bank}^{\cdot}\text{host}_{t-1}$	1.908	1.096	-0.385	-1.539***	-10.51	1.135	0.0	-12.74***	-0.240***
	(1.148)	(0.627)	(0.304)	(0.318)	(11.91)	(0.598)	(0.0)	(0.369)	(0.037)
$\text{GDP}^{\cdot}\text{shadow}^{\cdot}\text{bank}^{\cdot}\text{host}_{t-1}$	-4.296	0.775***	0.762***	-9.997***	0.591	-11.62**	-1.808***	-0.315***	-0.325
	(3.943)	(0.199)	(0.156)	(2.867)	(0.809)	(4.048)	(0.059)	(0.024)	(0.794)
$\text{Offshore}^{\cdot}\text{fin}^{\cdot}\text{centre}$	-12.41	0.0	1.246	-1.044	-4.917**	-35.00***	-3.413***	0.0	0.141
	(6.419)	(0.0)	(1.007)	(0.979)	(1.896)	(11.55)	(0.249)	(0.0)	(0.277)
N	440	324	253	947	485	585	133	175	1432
Bank Group fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SB entity fixed effects	No	No	No	No	No	No	No	No	Yes
R^2	0.972	0.940	0.903	0.834	0.934	0.946	0.873	0.966	0.844
adj. R^2	0.966	0.919	0.882	0.818	0.24	0.936	0.848	0.961	0.828

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table presents additional estimates for the cross-section data (2015) with bank, shadow banking entity *type* and shadow banking entity *host country* fixed effects using sub-samples of data. In columns (1) to (8) the variable is the log of banks' total exposures to shadow banking entities in different host countries. As per EBA (2015), Group 1 banks have Tier 1 capital in excess of €3 billion and are internationally active while other banks would be considered Group 2 banks. In column(9) the dependent variable is the percentage of banks' total exposures to shadow banking entities in different host countries as a percentage of each banks' total exposures to shadow banking entities. Standard errors are robust to heteroskedasticity and clustered at the bank group level (shown in parentheses). Bank-level and time-variant country regressors are lagged by one period with respect to the dependent variable.

5 Conclusions

The increasing size of the shadow banking system underlines the need for a better understanding of the linkages of shadow banking entities with different parts of the financial system, including the banking system. Despite the increased focus on assessing the interconnectedness between banks and shadow banking entities since the financial crisis, to the best of our knowledge no study documents these linkages using bank- and exposure-level information. This paper therefore examines the exposures of EU banks to shadow banking entities drawing on a unique data collection exercise by the EBA in March 2015.

Our analysis confirms that the exposures of EU banks to shadow banking entities is global and spans regional and national borders. EU banks have significant exposures to shadow banking entities globally and, in particular, to entities domiciled in the US, which represent approximately 27 per cent of the total exposures. Moreover, we find that EU banks' exposures to shadow banking entities are concentrated by type of counterparty, with approximately 65 per cent of the exposures to securitisations, non-MMF investment funds and finance companies. At the individual level, banks' exposures are diversified, although this diversification leads to high overlap across different types of shadow banking entities. The global financial crisis showed how such linkages can act as contagion paths and can lead to the amplification of shocks across borders and sectors. Therefore, for the purposes of systemic risk monitoring, our findings highlight the cross-border linkages of shadow banking entities and therefore the need for coordinated policy responses, which can be facilitated through greater cooperation and information sharing amongst regulators.

Moreover, using a unique exposure and bank-level dataset, we study for the first time the determinants of EU banks' exposures to shadow banking entities. Our results suggest that larger and more profitable banks have higher exposures to shadow banking entities. Hence, as one might expect, larger and more internationally active banks are therefore likely to be more exposed to any potential shocks or spillovers from the shadow banking system as compared to more retail and domestically oriented banks.

The results also highlight the importance of economic and geographical characteristics of the host country of the bank and shadow banking entity as key factors in determining the volume of exposures between EU banks and shadow banking entities. In line with the international finance literature, we find that the distance between countries and whether they share a common currency are important determinants for explaining the volume of exposures between EU banks and shadow banking entities. Detailed geographical data on the linkages between banks and shadow banking entities are important in understanding fully the factors driving the distribution of exposures.

Our results also suggest a number of avenues for future research. The analysis in this paper presents EU banks' exposures to shadow banking entities and is therefore based on the asset side of banks' balance sheets. Building on this, future work can seek to investigate the liability side of banks' balance sheets and specifically the role of shadow banking entities as a source of funding for banks. Moreover, understanding the linkages of shadow banking entities to other non-bank financial institutions is also an important part of the financial ecosystem which needs to be monitored. A mapping of these linkages and potential contagion paths between sectors and jurisdictions will provide a more complete picture of the interconnectedness of the banking and shadow banking systems. Other potential areas for further work include an examination of the supervision and regulation of individual shadow banking entities, including their potential prudential consolidation, in order to understand better which entities lie fully outside of the regulatory perimeter.

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Appendix: Data Definitions

TABLE 10. Variable Definitions and Data Sources

Variable	Description	Data Source
Log (Value-banks-exp)	Natural logarithm of gross exposures from bank b in country i to shadow bank country j	EBA and authors' calculations
Concentration	Per cent of banks' exposures from country i to shadow bank country j as percentage of each banks shadow banking exposures	EBA and authors' calculations
Colony	Dummy variable equal to 1 if home and host country ever shared a colonial relationship and 0 otherwise	CEPII
Comcurr	Dummy variable equal to 1 if home and host country share a common currency and 0 otherwise	CEPII
Comleg	Dummy variable equal to 1 if home and host country share a common legal system and 0 otherwise	CEPII
comlang_off	Dummy variable equal to 1 if home and host share a common language	CEPII
Contiguity	Dummy variable equal to 1 if home and host share a common border and 0 otherwise	CEPII
Cost-income ratio	Cost to income ratio of bank, per cent	Bureau van Dijk Orbis
Log(size)	Natural logarithm of banks' total assets in '000 €	Bureau van Dijk Orbis
Equity/total assets	Equity of bank / banks' total assets	Bureau van Dijk Orbis
Log(distance)	Log of distance, measured by km between host and home country capital cities, weighted by population	CEPII
Interbank ratio	Interbank Lending to Interbank Borrowing	Bureau van Dijk Orbis
GDP_bank_host	Log of GDP, constant 2005 prices US Dollars	WDI
GDP_shadow_bank_host	Log of GDP, constant 2005 prices US Dollars	WDI
Offshore_fin_centre	Dummy variable equal to 1 if shadow banking host country is offshore fin centre	Davies and Killeen (2017)
ROAE	Return on average equity of bank	Bureau van Dijk Orbis