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Building a multilayer macro-network for the Netherlands: A new way of looking at financial accounts and international investment position data[1]

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[1] This paper was prepared for the meeting. The views expressed are those of the authors and do not necessarily reflect the views of the BIS, the IFC or the central banks and other institutions represented at the meeting.

Building a Multilayer Macro-Network for the Netherlands: A New Way of Looking at Financial Accounts and International Investment Position Data

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Abstract

We argue that who-to-whom data from financial accounts can be fruitfully combined with information on the international investment position to study interconnectedness within the financial system. We illustrate this point using detailed information for the Netherlands over the year 2016. In doing so, we contribute to recent work that uses network analysis to study financial interconnectedness at the macro level. We also discuss potential further applications, such as using these network representations for financial stability analyses.

Keywords: Network analysis, financial accounts, international investment position, interconnectedness.

JEL codes: C82, G20, L14

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1. Introduction

The financial crisis of 2007-2009 made clear that interconnectedness within the financial system can be a key driver of financial instability. Issues concerning liquidity or solvability could quickly spread across the financial system through the linkages between financial institutions. More broadly, it became apparent how instability in the financial sector could quickly affect the real economy. Since the crisis, a lot of effort has been put into better understanding interconnectedness, both within and outside the financial system. To a large extent, especially for international linkages, even the basic steps of collecting and organizing the appropriate data have shown important challenges.

This paper contributes to further understanding interconnectedness by using so-called from-whom-to-whom accounts. Exploiting the granular information about the linkages between individual sectors allows us to construct, for the first time, a detailed network representation for the Netherlands. Importantly, in addition to charting domestic linkages using financial accounts, we also take into account data from the international investment position (IIP) to enhance the available information on the 'rest of the world' sector. This allows us to study linkages with the most important counterparts in terms of geographical regions and foreign sectors. Additionally, we investigate the connections of the Dutch financial sectors with sectors from abroad. In doing so, we contribute to the debate on analysing interconnectedness at the international level. We discuss the benefits of our approach and outline a number of challenges. Having done so, we turn to a description of the network, mainly by giving various visualisations of the underlying data.

Our main conclusion is that the nature of interlinkages can differ considerably across the financial system, and are to a large extent dependent on the sectors involved. These different types of interlinkages can react differently to shocks and periods of stress. This underlines the benefits of looking at interlinkages and capital flows on a sectoral basis rather than in aggregate for the full economy.

In terms of methodology, this paper builds on recent work applying network analysis to data sets that measure financial linkages across various sectors of the economy. A closely-related paper is by Castrén and Rancan (2014), who construct a so-called macro-network for the euro area by combining flow-of-funds statistics for 11 countries with data on balance-sheet items of the MFI sector. One drawback is that they do not directly observe the bilateral links between economic sectors, which is why they have to estimate these links using entropy methods. In contrast, given the availability of from-whom-to-whom accounts for the Netherlands, we are able to construct a direct network representation.

The remainder of this paper is structured as follows. Section 2 discusses related papers that use network analysis as tools for financial stability analyses. Section 3 presents details on how we use from-whom-to-whom accounts to construct a macro-network for the Netherlands. Section 4 present various visualisations of the network that we construct. Section 5 concludes and charts paths for future analyses.

2. Related literature on network analysis

Network analysis is an intuitive tool to analyse financial interconnectedness, and the existing literature on the subject already provides a range of useful insights. An important question is at what level the network should be defined. One option is to construct a network using data on linkages between individual financial institutions. A comprehensive analysis along these lines is given in Anand et al. (2017), who focus on networks in 13 jurisdictions across 25 financial markets, with the aim of analysing the performance of different network reconstruction methods. In an analysis using data for Mexico between 2007 and 2013, Poledna et al. (2015) quantify the contributions to systemic risk from four layers of the banking system. They then assign these systemic risk levels to individual banks. They conclude that market-based systemic risk indicators underestimate expected systemic losses. Cerutti and Zhou (2017) apply network analysis to BIS data on cross-border bank lending. They find that some

parts of the network are currently more interlinked regionally than before the crisis, while being less dependent on major global lenders.

Increasingly, network analysis is also applied to macro-level data. Chinazzi et al. (2013) use the IMF Coordinated Portfolio Investment Survey (CPIS) to investigate debtor/creditor relations between countries. They find that the 2008 financial crisis led to a significant change in the network properties. They also conclude that being central in the network may make countries more vulnerable in times of crisis when they are not member of a financial hub of rich countries. Castrèn and Rancan (2014) combine data from euro area flow-of-funds statistics with data from balances sheets of MFIs. This approach allows them to construct a euro area macro-network to analyse contagion and shock propagation. They conclude, inter alia, that network properties and propagation losses are highly time-dependent. They also find that network statistics (such as degree, betweenness, or closeness) can be useful to predict how shock propagate in the financial system. Building on this study, Peltonen et al. (2015) show that a more central position of the banking sector in a macro-network increases the likelihood of a banking crisis. They also find that interconnected measures can be useful additions to early-warning models for banking crises.

To our knowledge, there is little empirical work on network linkages using macroeconomic data where the different sectors of the economy, including the sector rest of the world, are integrated. From-whom-to-whom matrices based on national financial accounts data form a solid basis for such research. These matrices are a relatively recent addition to the macroeconomic datasets available to users, and are made available by more and more national statistical agencies worldwide.[†] In this paper we contribute to the literature by augmenting data from these matrices with IIP data, to provide a more granular view of international exposures. By detailing the Dutch economic network and providing a first set of analytical results, we highlight the importance of network analysis to evaluate the degree of interconnectedness among different economies and the contagion effects between them.

3. Constructing a macro-network for the Netherlands

Our empirical analysis is based on annual data for 2016[‡] for the Netherlands at market prices. As the first step in our data preparation, we obtain the financial accounts matrix of from-whom-to-whom data from Statistics Netherlands (CBS)[§]. These data are derived from the national accounts and comprise the details of exposures between sectors within the Dutch economy, and between these sectors and the rest of the world. Financial accounts data is the most comprehensive dataset about financial relationships between the sectors of an economy and has the advantage of being internally consistent, in the sense that the assets in a particular instrument of one sector vis-à-vis another sector equal the liabilities of the latter sector vis-à-vis the former. A limitation is that non-financial assets, such as housing wealth, are not included even though they form a large part of the net worth of certain sectors.

From-whom-to-whom data is available at the level of ESA2010 (sub-)sectors and details several financial instruments. For the purposes of our analysis, we define the following sectoral combinations in our dataset: non-financial corporations (abbreviated as NFC, corresponding to sector S.11 in ESA terms), monetary financial institutions or banks (MFI = S.122), investment funds (IF = S.124), other financial corporations (OFC = S.125 + S.126), special purpose entities (SPE = S.127), insurance companies (IC = S.128), pension funds (PF = S.129), government (GOV = S.13), households (HH = S.14 + S.15) and the 'rest of the world' (S.2). For each link between these sectors, the dataset discerns various types of instruments: namely exposures in savings and deposits (AF.2), bonds (AF.3), loans (AF.4), equity (AF.5) and technical reserves (AF.6).

[†] Publishing such matrices is a recommendation of the G-20 Data Gaps Initiative, which seeks to address data gaps in the measurement macrofinancial risks and vulnerabilities. For more information, see Heath and Bese Goksu (2016).

[‡] Our dataset in fact contains annual data between 2010 and 2016. Exploiting this time series dimension is left for future work.

[§] Fassler *et al* (2012) and Tissot (2016) provide background information on the compilation of the sectoral financial positions on a from-whom-to-whom basis.

Note that this from-whom-to-whom dataset does not provide any additional geographical breakdown of exposures vis-à-vis economic actors in foreign countries; all international exposures are simply assigned to the rest of the world account (S.2). As the second step of our data preparation, we therefore include a geographical breakdown of international exposures to our dataset. We do this by obtaining the IIP data compiled by De Nederlandsche Bank, which provide exposure positions of sectors of the Dutch economy vis-à-vis foreign sectors at the country and instrument level. Note that historically these statistics are not fully consistent with the figures on the rest of the world sector in the from-whom-to-whom matrix, as a result of differences in observation and compilation strategy between the National Accounts and the External Statistics frameworks.[**] We therefore scale the exposure levels in the IIP dataset to make their total consistent with the rest of the world account. For exposures of Dutch sector X on sector Y in foreign country C, for instrument i:

$$Exposure_i(X, C_y) = RoW_X \left(\frac{IIP_{i,C_y}}{\sum_c IIP_i} \right)$$

Per year the original from-whom-to-whom data has about 325 observations, including the 10 sectors mentioned above. Once the data is enriched with the countries and the foreign sectors under S.2 using the IIP data, the dataset jumps to 6,700 observations per year divided over 250 countries and the same 5 instruments. Figure 3.1 shows schematically how we have augmented the data of the national accounts. The original who-to-whom matrix is shown in the top left corner. The blue arrows indicate the steps that use IIP data to expand the international exposures.

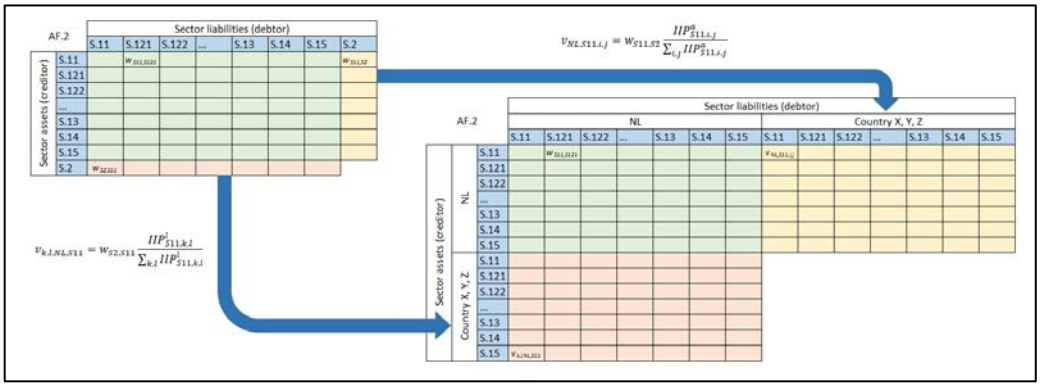

Figure 3.1: Example of constructing exposures related to the foreign counterparts using IIP data.

In the following table we show the summary statistics comparing the from-whom-to-whom data before and after including the IIP information for the year 2016. We specifically show the information for the Dutch sectors with the foreign counterparts. The observations 'original' refer to the summary statistics as in the from-whom-to-whom data when foreign counterparties were integrated into the rest of the world sector. The observations 'Inc. IIP' reflect the results after the calculations as described in Figure 3.1 aggregated over all instruments. We can see that the mean decreases as to reflect the great increase of new information to further detail the sector S.2.

Table 3.1: Descriptive statistics of counterparts in 'rest of the world' sector(s) before and after the addition of IIP data (in billions of Euro's)

Variable	Obs	Mean	Std. Dev.	Min	Max
Original	9	1043.4	1079.1	21.4	3156.4
Inc. IIP	3,242	2.8	13.6	0.0	280.9

[**] Note that for the Netherlands, due to the recent integration of the observation and compilation practices, these figures are now fully consistent from 2015 onwards.

The resulting matrix details the relationship of all Dutch sectors with each other but also with all counterpart sectors from other countries around the world. This particular combination is relatively complete – both domestic and foreign exposures are well-observed – and thus powerful for analysing interconnectedness. For the assets-side of the Dutch balance sheet the matrix is quite accurate. However, for the liabilities side the accuracy of the holder's information is lower specifically for the instruments AF.3 and AF.5. This is the case as these instrument categories can contain large volumes of tradeable securities from whom the ultimate holder is unknown; the statistical framework typically attributes these liabilities to the resident country of the security custodian.[††]

Another important issue is that at the current state of the network, the counterparts of the foreign countries are not linked to each other. Even though this paper combines statistical frameworks to provide more completeness, our resulting analysis is in this sense still partial. In an ideal world, one would run this exercise for countries worldwide and combine them to better understand global interconnectedness.

4. Visualising the macro-network

Next we visualize the networks we have created in our data compilation process.[‡‡] As an agnostic first step, we simply visualize the full exposure network including country level information for equity exposures (AF.5). Figure 4.1 shows the result. We can see that visualizing the full network is not very helpful, the output is too granular to be useful. As we focus on visualizations in this paper, we proceed to improve readability through aggregation and selection of specific sectors. It goes without saying, though, that the dataset could still be analysed to great effect at the detailed level through econometric and data-science techniques – this is an obvious avenue for follow-up work.

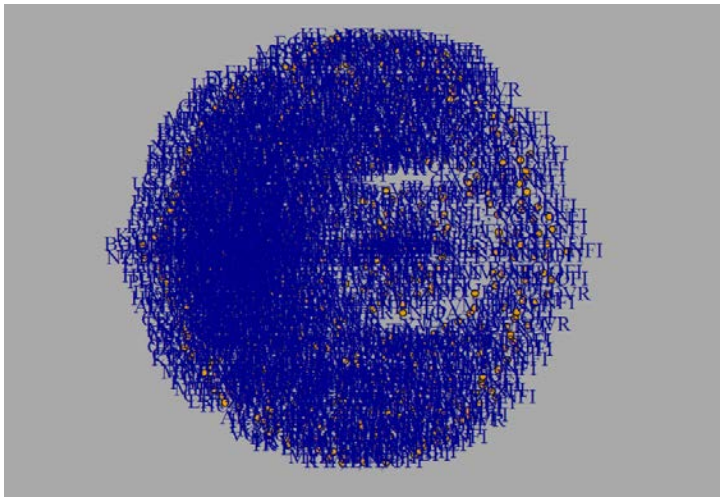

Figure 4.1: Visualisation of all equity exposures grouped by country for 2016

We aggregate data by constructing country groups instead of mapping exposures to individual countries. The country groups that comprise the rest of the world sector are Europe (=EU), North America (=US), Asia (=AZ) and other countries (OC). Each country group is further categorised into the sectors equal to the sectors for the Netherlands. Additionally, we look at all instruments aggregated. For our selection of financial sectors to analyse, we proceed to focus on the largest sectors in terms of

[††] A potential avenue for quality improvement could be to utilize mirror data from e.g. the CPIS database maintained by the IMF. Implementing such an improvement is beyond the scope of this paper.
[‡‡] We use the R-package *igraph* for this purpose.

balance sheet size; as visualized in Figure 4.2. It shows that special purpose vehicles are the largest sector in the Dutch financial system, with a balance sheet amounting to 552% gdp.[§§] The next largest sector is the MFI sector, totalling 305% gdp. The third largest sector is the pension fund sector with a combined balance sheet of 171% gdp.

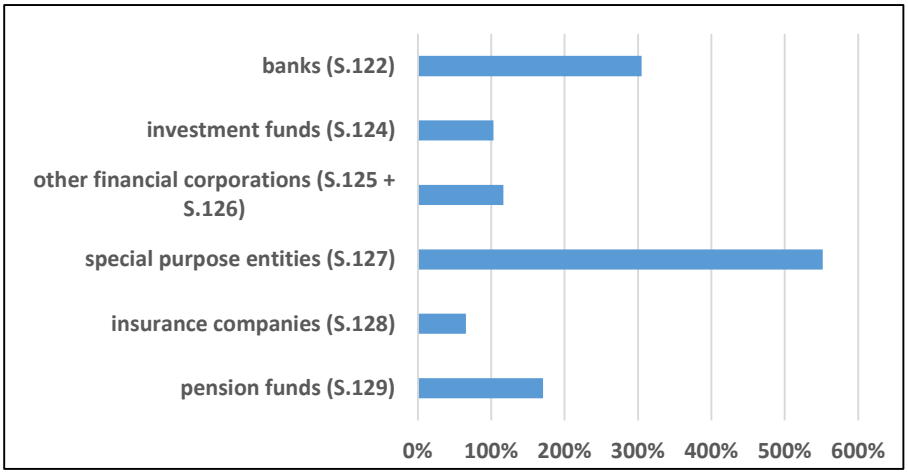

Figure 4.2: Size of the Dutch financial (sub)sectors, 2016, in % of nominal GDP

Focusing on the SPE sector, we visualize both its total assets and liabilities. Figures 4.3 and 4.4 show the results of this exercise. The figures clearly show that for this sector, international exposures dominate national exposures for both assets and liabilities. Furthermore, exposures are concentrated vis-à-vis specific sectors. Dutch SPEs main asset side exposures are to non-financial institutions and other financial institutions in the EU, Rest of the World, and to a lesser extent North America and Asia. The picture is similar on the liability side, with exposures to US non-financial and other financial institutions being more pronounced. In terms of instruments, equities (AF.5) are the dominant exposure class. Note that the in the IIP data the sector SPE is unavailable as counterpart sector. Instead, this sector is grouped with the other financial corporations (OFC) sector. Interlinkages with counterpart OFC could therefore also represent SPEs in countries other than the Netherlands. Exposures to other Dutch domestic sectors are negligible except for asset side exposures to Dutch non-financial institutions, which represents the SPE institutions with economically active sister companies in the Netherlands.

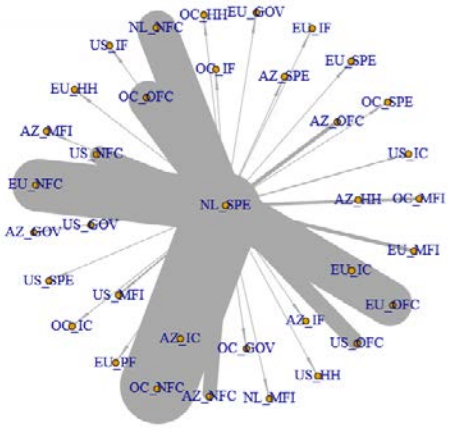

Figure 4.3: assets for the sector S.127

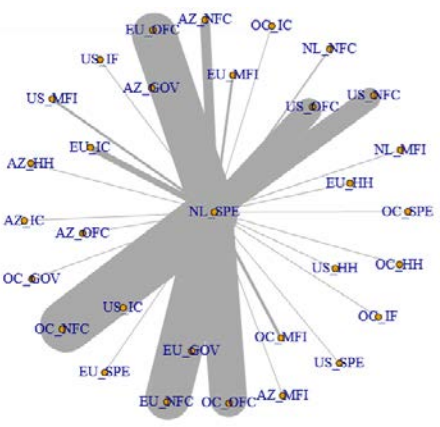

Figure 4.4: liabilities for the sector S.127

[§§] Eggelte, Bijlsma & Carlier (2016) provides a more detailed description of the Dutch SPE sector and the associated statistical issues.

In contrast to the networks of the SPE, domestic exposures dominate both the assets and liabilities of Dutch banks.*** Figure 4.5 shows the sector's assets and illustrates that exposures consist largely of loans (AF.4) to Dutch households (mortgages) and non-financial corporations. The same holds for the liability side (Figure 4.6), where banks mostly hold deposits (AF.2) from the same sectors. Thus, the network of Dutch banks show the classical intermediation role in the real economy, providing the link between investors and investees. However, on both the asset and liability side some additional exposures are visible such as interbank loans to banks and exposures to other financial corporations – both in the Netherlands and abroad.

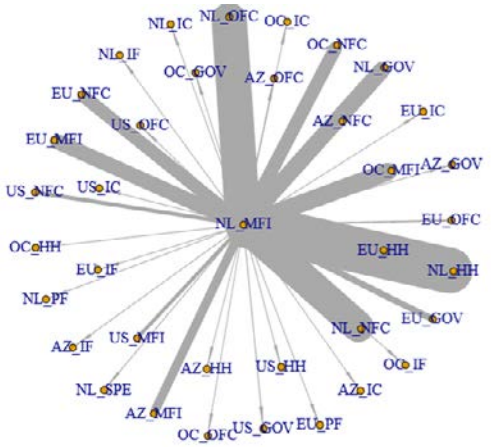

Figure 4.5: assets for the sector S.122

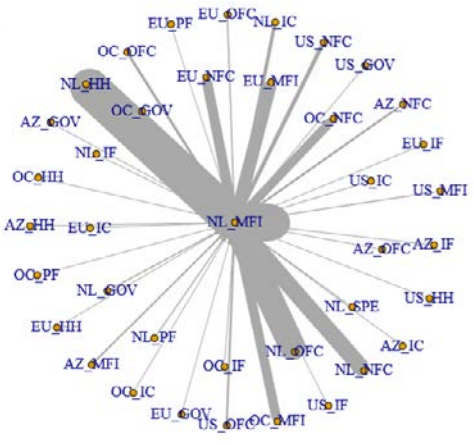

Figure 4.6: liabilities for the sector S.122

Finally, we visualize the exposures of the pension funds sector. Figure 4.7 and 4.8 show their asset and liabilities respectively. On the asset side, pension funds have concentrated exposures to Dutch investment funds (AF.5), while also maintaining a smaller diversified international exposure position mainly through bonds (AF.3). On the liability side, the sector's exposure is almost exclusively domestic: namely pension claims from Dutch households (AF.6).

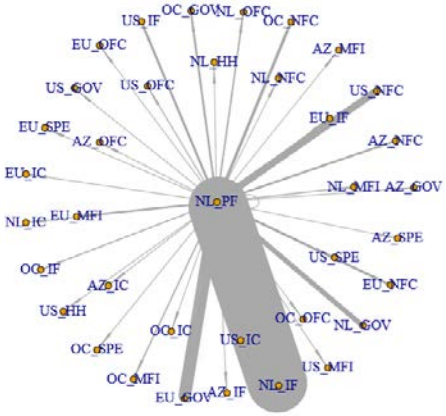

Figure 4.7: assets for the sector S.129

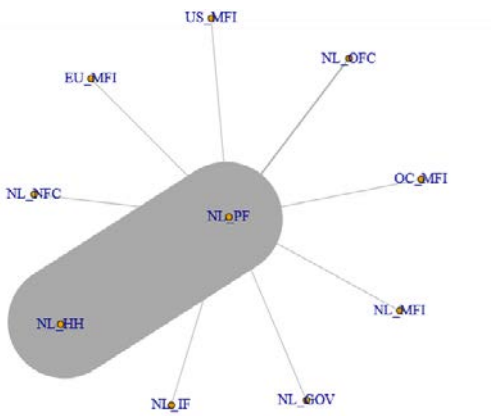

Figure 4.8: liabilities for the sector S.129

*** Note that we analyse MFI data according to statistical definitions, which encompass resident entities rather than full consolidated banking groups (such as in e.g. the BIS international banking statistics)

The concentrated exposures to Dutch investment funds is interesting to investigate further. Thus, we follow the financial intermediation chain and visualize assets and liabilities for the investment funds sector. Figure 4.9 shows that asset side exposures and illustrates that investment funds manage a geographically diversified, mostly international set of assets. Stocks of North American non-financial corporations and European government bonds form substantial investment categories. Figure 4.10 shows the sector's liabilities and confirms that these are mostly related to Dutch pension funds, and to a lesser extent other Dutch institutional investors. From these figures we see clearly that investment funds are investment vehicles of Dutch institutional investors to manage their pool of assets. There is little direct participation of the Dutch real economy in this link of the intermediation chain, except for small direct holdings by Dutch households. The network analysis helps us to pinpoint this mechanism in a relatively simple way. Note that this example also illustrates how an increase in the length of the financial intermediation chain increases financial sector asset as measured in statistical frameworks. *In extremis*, if Dutch pension funds would completely invest directly instead of through investment funds, the Dutch financial sector would be 100% of GDP smaller than it is today.

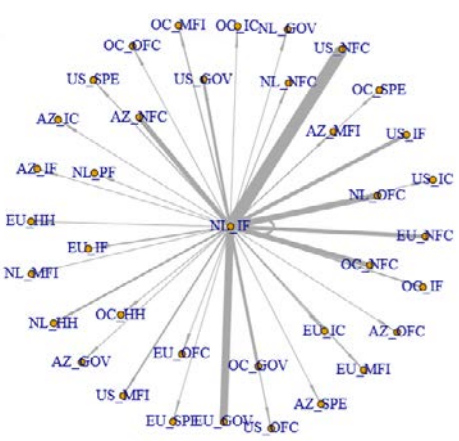

Figure 4.9: assets for the sector S.124

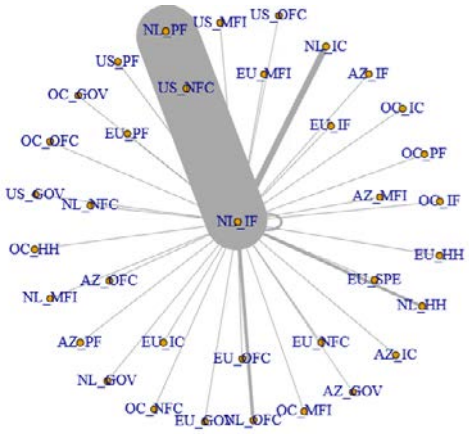

Figure 4.10: liabilities for the sector S.124

Based on the evaluation of the dynamics per financial sector in the Netherlands it is possible to conclude that the capital flows through Dutch financial sectors can have greatly varying characteristics, in terms of counterpart sectors and countries, and in terms of instruments. Several segments of interconnected sectors can be identified. SPEs generally have very little domestic exposures and are mostly exposed – through equity – to non-financial corporations, other financial institutions and SPEs abroad. MFIs generally have domestic exposures to real sectors – households and corporates – in loans and deposits. Finally, the liabilities of Dutch pension funds are (ultimately) to domestic households, and they invest in a diverse set of international assets – mostly equities and bonds – through an intermediation chain involving investment funds. The network analyses of these sectors provide a simple visualisation of these linkages and can also be used to test dynamic shocks in the economy, taking into account possible financial intermediation chains between the different sectors across multiple economies.

5. Conclusion

This paper has argued that from-whom-to-whom data from financial accounts can be fruitfully combined with information on the international investment position to study connections within the financial system. Based on annual data for the Netherlands for 2016, we provide first examples of how

this approach might yield useful insights by depicting the structural differences in the networks of the Dutch financial sectors.

Our analysis suggests two points. First, the nature of intra-country exposures can vary considerably depending on the financial sectors involved. An exposure originating from SPEs, for instance, will likely have little or no connection to the immediate counterpart country. For exposures originating from banks or pension funds, this is likely to be very different. The reaction of exposure holders in times of stress –in the receiving country, originating country, or both – can as a result be potentially different. This finding would be something for policymakers to take into account, while also underlining why analyses using sectoral breakdowns are important. Second, our paper shows the added value of looking at intermediation chains rather than stand-alone sectors. Based on the analysis of a single sector, one might think that its exposures are largely domestic even though the direct recipient of its funds in fact channels it abroad. In the process, we also show that longer intermediation chains tend to inflate financial sectors' balance sheets. This may decrease the value of balance sheet figures as an accurate measure of risk in the financial sector.

The analysis in this paper is not without limitations. Most importantly, our measurement of interlinkages is limited to exposures involving the Dutch economy. A more complete analysis of interlinkages would require similar data from multiple countries to be combined, thus creating a (near) global network. Performing such an analysis does seem to be an advanced ambition at this stage, however. Even insofar as similar data for this analysis exists in other countries, data sources such as the IMF Coordinated Portfolio Investment Survey show that there are numerous bilateral discrepancies between countries' mirror data. It will likely require time and effort to create more consistent and complete global network data in the future.

Building on the dataset and analyses presented in this paper, several potential avenues for further research suggest themselves. First, the properties of the constructed network could be examined and serve as an important complement to the growing body of literature studying the interactions between financial institutions (e.g. Billio et al., 2012, Demirer et al., 2018, or Geraci and Gnabo, 2018). In this regard, more formal methods could also be used to assess the extent to which sectoral, interconnected clusters exist as observed in the data. Second, the available time dimension, i.e. annual data from 2010 to 2015, can be used to assess the response of different exposures during periods of financial stress – e.g. during the European sovereign debt crisis or the US taper tantrum. Third, a more long-term research agenda would be to consider how these macro networks could be integrated in stress-test analyses, for instance in the context of examining second-round effects via contagion channels.

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DeNederlandscheBank

EUROSYSTEEM

Literature and paper's contribution

- Great Financial Crisis highlights the importance of mapping interconnectedness and contagion channels; network analysis has become an increasingly popular tool.
- Chinazzi et al. (2013) and Castrèn and Rancan (2014) are examples of papers using network analysis.

Our contribution is twofold:

1. Provide a look on how financial network analysis can be further explored by extending the level of detail from the rest of the world sector (S.2).
2. Show that different economic sectors have different properties that lead to possible contagion paths across multiple economic instruments and countries.

Data

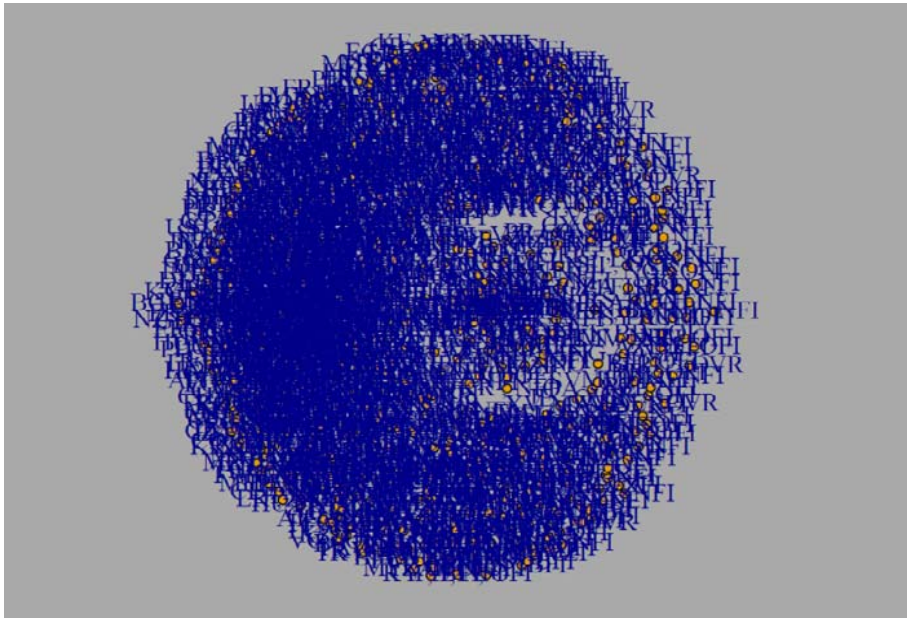
- Data from national accounts (from-whom-to-whom matrix) combined with data from the international investment position (IIP)
- IIP data is made consistent (scaled) with national accounts 'rest of the world' account positions
- Time series 2010-2016, exposures between sectors at instrument level (e.g. bonds, equity, loans)
- Data regarding counterpart rest of the world (in billion of euros):

Variable	Obs	Mean	Std. Dev.	Min	Max
Original	9	1043.4	1079.1	21.4	3156.4
Augmented data	3,242	2.8	13.6	0.0	280.9

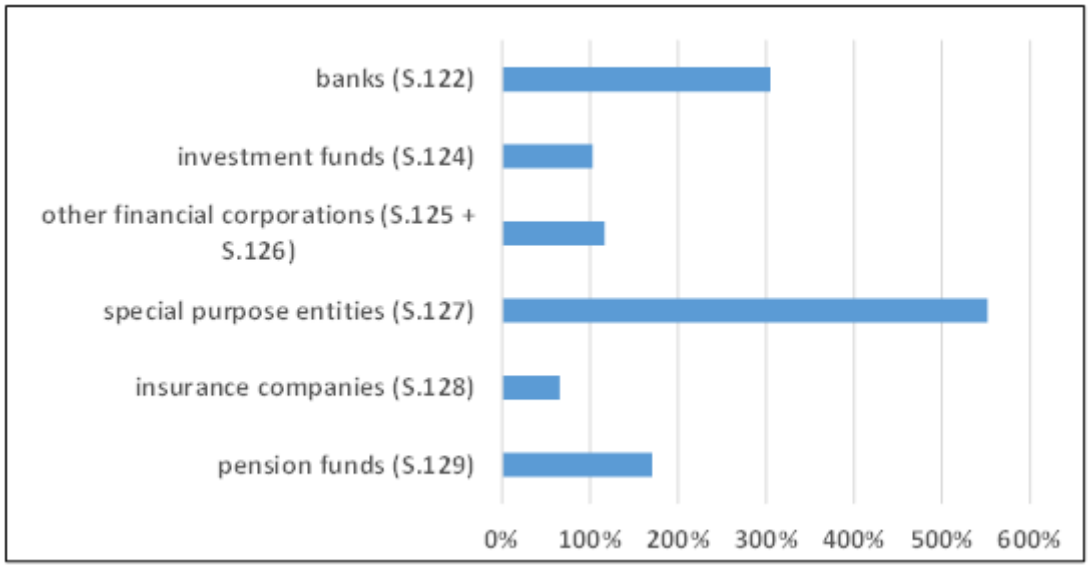
Data

- When visualizing, we take away some levels of granularity

- Country groups (Europe, United States, Asia, Other countries)
- Combine all instruments
- Use data for 2016



Size Dutch financial sectors (2016, % gdp)



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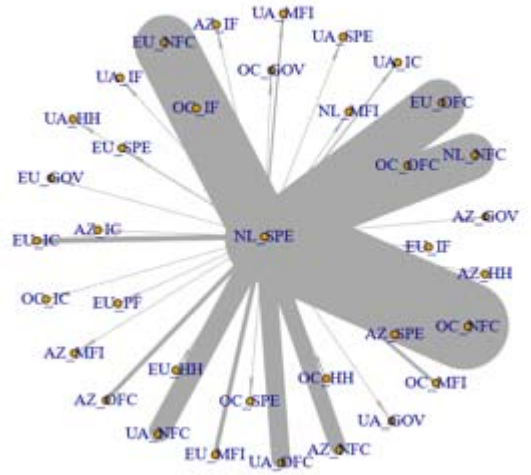
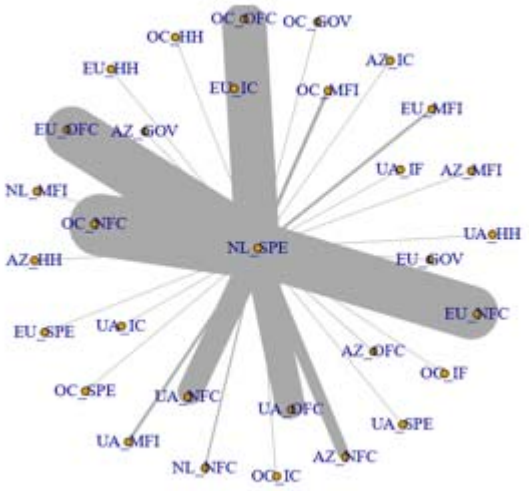
SPE (S.127)

Assets

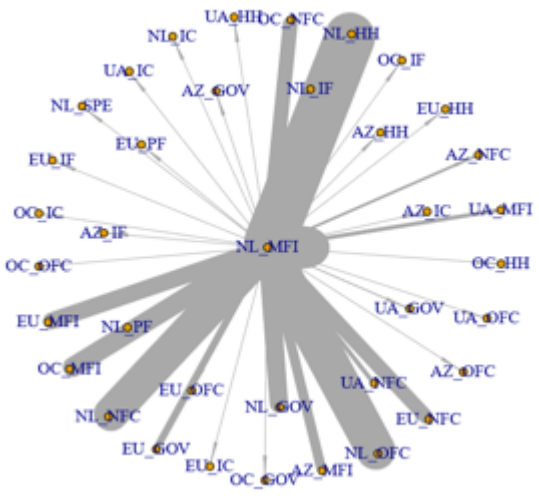


Liabilities



MFI (S.122)

Assets



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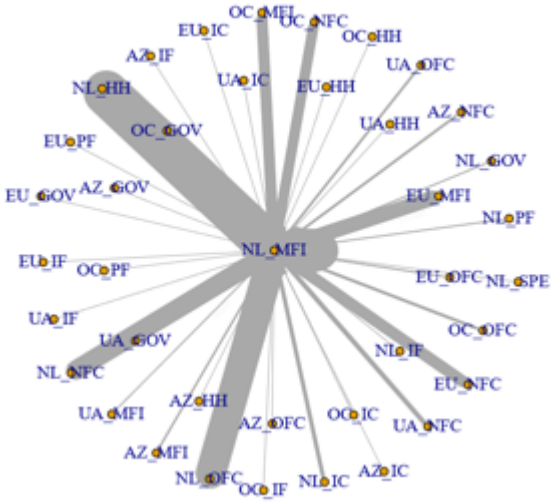

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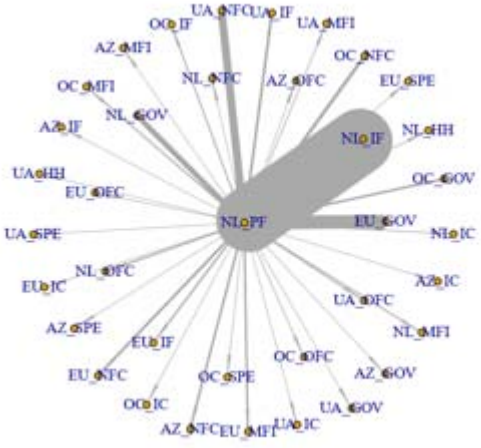
PF (S.129)

Assets



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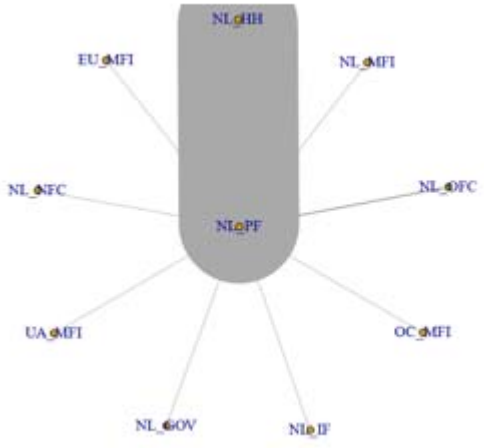

IF (S.124)

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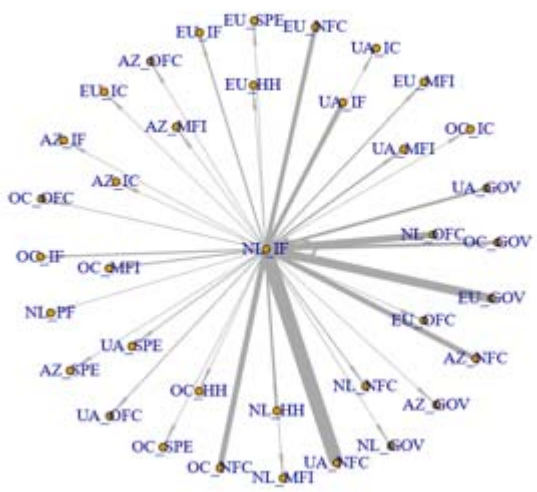

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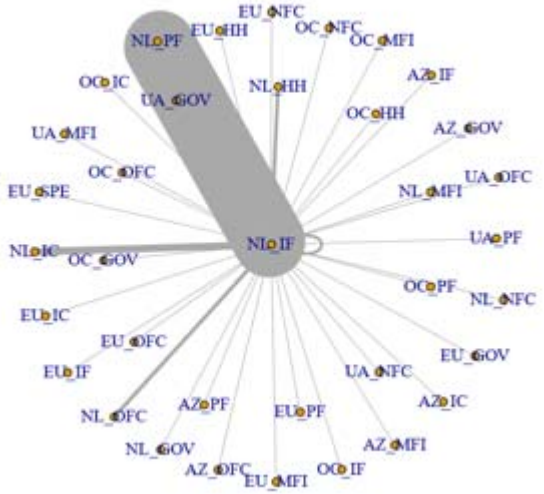

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Conclusion

- Network data analysis is a powerful tool to depict structural differences between economic sectors across the world.
- It shows that the nature of intra-country exposures can vary by financial sector.
- It also improves the analysis of intermediation chains and helps identify different contagion layers.
- Data are limited to Dutch exposures.
- Many paths for future research: evaluate de properties of the network, evaluate time series effect, include stress-test analyses.