INTERNATIONAL MONETARY FUND

IMF Country Report No. 15/256

NORWAY

FINANCIAL SECTOR ASSESSMENT PROGRAM

September 2015

TECHNICAL NOTE—LINKAGES AND INTERCONNECTEDNESS IN THE NORWEGIAN FINANCIAL SYSTEM

This Technical Note on Linkages and Interconnectedness in the Norwegian Financial System for Norway was prepared by a staff team of the International Monetary Fund. It is based on the information available at the time it was completed in August 2015.

Copies of this report are available to the public from

International Monetary Fund • Publication Services
PO Box 92780 • Washington, D.C. 20090
Telephone: (202) 623-7430 • Fax: (202) 623-7201
E-mail: publications@imf.org Web: http://www.imf.org
Price: $18.00 per printed copy

International Monetary Fund
Washington, D.C.

INTERNATIONAL MONETARY FUND

NORWAY

FINANCIAL SECTOR ASSESSMENT PROGRAM

August 17, 2015

TECHNICAL NOTE

LINKAGES AND INTERCONNECTEDNESS IN THE NORWEGIAN FINANCIAL SYSTEM

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program in Norway. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations. Further information on the FSAP can be found at http://www.imf.org/external/np/fsap/fssa.aspx

CONTENTS

EXECUTIVE SUMMARY[1]

Norway's banks have important connections with global financial centers, but regional links are also important. Norwegian banks are very dependent on global financial centers as sources of funding and to hedge currency risks. Norwegian banks arrange for a sizeable fraction of their wholesale funding in foreign markets. Foreign bank branches and subsidiaries from other Nordic countries are also active in the direct provision of credit to nonbank sectors in Norway. In addition, equity returns data show that Norwegian banks show strong links with British, Swedish, and other European banks which may extend beyond funding and include common risk exposures and ownership links.

Norwegian banks have a limited potential as a source of shocks to foreign institutions, but are vulnerable to shocks stemming from abroad. Data on the volatility of equity returns shows that Norwegian financial institutions are mostly on the receiving end, and are only able to influence the volatility of foreign banks' equities in neighboring countries. In addition, an analysis based on data on bank claims from the Bank for International Settlements (covering only a part of funding risks) suggests that Norwegian banks show a very limited ability to spread contagion to other banking systems but are, in turn, vulnerable to imported shocks. However, the level of vulnerability is similar to that of peer countries and has been declining. Similarly, simulations of funding shocks coming from global financial centers suggest that Norwegian banks are now less exposed to such risks.

Cross-sectoral exposures of Norway's banks, insurance companies, and real estate companies are significant and extend beyond the Nordic region. Evidence based on a variance decomposition of the volatility of equity returns suggests that Norwegian banks are significantly affected by the performance of banks in Sweden, the Euro Area, and the United Kingdom, as well as British real estate companies and European insurers. Norwegian insurers are significantly affected by banks from the major financial centers and by foreign insurers, while the Norwegian real estate sector is very exposed to the performance of American and British financial firms.

Foreign banks and institutional investors are important investors in Norwegian covered bonds. The importance of foreign investors is suggested by flow of funds data and supported also by anecdotal evidence. However, more detailed and complete data are needed on foreign ownership of covered and unsecured bonds issued by banks and mortgage companies. A careful analysis of these data will serve to improve the quality of funding stress tests.

Within the Norwegian economy, connections between the financial sector and oil-related industries are particularly strong. Although direct credit exposures of banks to oil-related sectors (oil and gas production, oil services and engineering, and shipping) are around three percent of total credit, total direct and indirect exposure is around 30 percent. Similar exposures hold for the insurance and real estate sectors.

[1] Prepared by Mr. Luis Brandao-Marques (MCM).

The Norwegian banking system is becoming more closely interconnected. The analysis of spillovers across institutions suggests that the potential for the transmission of financial stress among banks operating in Norway is a function of size, with DNB and Nordea exhibiting the highest transmission potential. The former, however, plays a more important role as the interface between smaller Norwegian banks and the larger foreign banks active in the local market. Confidential balance sheet data also suggests that, although bank-to-bank exposures are limited, they have been growing in recent years. Financial supervisors would benefit from collecting bilateral asset exposure data on a regular basis and complementing with higher frequency analyses based on market data.

The authorities are encouraged to expand their current monitoring efforts of crossborder and cross-sectoral exposures of the Norwegian financial sector, and to conduct regional stress tests. For this effect, the authorities can resort to market data and, if available, to balance sheet data of exposures at the individual financial institution level.

The authorities are also urged to enhance the existing surveillance of interbank lending and exposures, and to consider options to dampen the cross-ownership of covered bonds in the banking sector, subject to the restrictions imposed by European Union laws and regulations.

INTRODUCTION

1. The Norwegian financial system is well integrated into the Nordic region. To a large extent, the engine of Nordic banking integration is the direct provision of credit to nonbanks by foreign branches and subsidiaries—a business-driven model—and not a crossborder wholesale funding model. The same pattern of crossborder activities can be found in financial firms other than banks, especially among non-life insurers. Although this business-driven model of financial integration may be less sensitive to short-term financial shocks emanating elsewhere in the Nordic region, it may make local credit markets more sensitive to macroeconomic developments in other countries in the region (see IMF 2013).

2. This note aims at describing the linkages between Norway's financial system and the rest of the world, as well as the existing interconnectedness within the Norwegian financial sector, using a comprehensive and to some extent unique dataset. The note uses market and balance sheet data summarizing Norwegian banks' exposures both domestically and internationally. The balance sheet data include a unique dataset of confidential bank-level bilateral exposures for Norwegian banks and country-level data from the Bank for International Settlements (BIS) Consolidated Banking Statistics. Market data are analyzed using Diebold and Yilmaz's (2014) spillovers methodology and include daily equity returns, the monthly volatility of equity returns, and estimated default frequencies, sampled at the country level, sector level, or individual institution level.[2] The methodology and data are described in Appendix I.

3. Network analysis based on market and confidential balance-sheet data yield similar conclusions. Although bilateral balance sheet exposures data allow for a deeper investigation of the possible sources of spillovers, market data are a viable alternative when such data are not available.

4. The note is organized as follows. First it discusses the regional and global linkages affecting Norway's banks. Then it analyzes the crossborder linkages of Norway's financial industries—banks, insurance, and real estate—and the central role of oil in terms of domestic spillovers. Finally, it studies the connectedness of major banks operating in Norway and discusses policy implications.

REGIONAL AND GLOBAL INTERCONNECTEDNESS OF NORWAY'S BANKS

5. Norwegian banks are closely connected with other Nordic banking systems and economies, but also show significant global connections (Figure 1). A study of spillovers based on the volatility of bank returns—a measure loosely related to bank stress—shows a close

[2] This approach provides an estimate of how much each sector contributes to total risk in other sectors, as well as useful summary statistics of directional connectedness.

connection between Norwegian banks and other Nordic banks, in particular Swedish banks.[3] In total, the rest of the Nordic region represents 23 percent of the inward spillovers to Norway.[4] In contrast, the euro zone (excluding Finland) contributes with 48 percent and the other major financial centers (Japan, Switzerland, United Kingdom, and the United States) account for 18 percent.

6. Bank stress (equity return volatility) in Norway is explained, for the most part, by bank stress in several large European economies and seems to affect the performance of Swedish banks. The latter can be understood in light of the importance of the Norwegian market to Swedish banking groups. The estimated linkages among the banking sectors under study uncover, for the most part, causal connections in the sense that bank stress in one country leads to more stress in another country (Figure 2). A Granger causality analysis suggests that the measured spillovers reflect more than exposures to common risk factors or markets.

7. Norway shows strong credit links with the other Nordic countries and global financial centers. Cluster analysis suggests that Norway, in spite of having important credit links with Denmark, Finland, and Sweden, is part of the global bank credit cluster and not of the Nordic cluster (see Figure 3).[5] Norway's position, in part, reflects the role of oil in its economy and the effect it has on its banks' funding models.[6] Analyses using market data (which may cover other types of exposures besides credit) confirm Norway's intermediate position between the Nordic region and the rest of the world.

[3] The methodology and data are described in Appendix I. Data coverage varies by country and over time. See Appendix I for additional caveats on the data. See also Diebold and Yilmaz (2014) for a defense of the study of volatility connectedness on the grounds that volatility is particularly associated with crises.

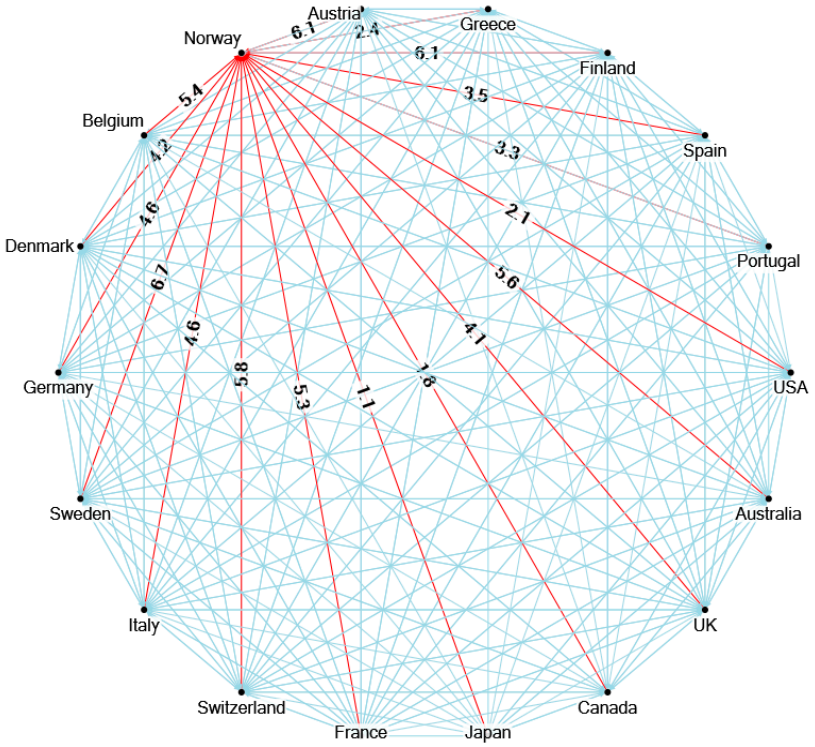
[4] The contribution of Denmark, Finland, and Sweden to Norway, measured according to the methodology described in Appendix I, sums to 17 percent. The fraction of the variance decomposition of the volatility of equity returns of Norway's banks that is explained by itself is 27 percent. Hence, the contribution of the rest of the Nordic region to Norway's inward bank spillovers is 17/(100-27)=23 percent.

[5] The clusters are formed using Clauset, Newman, and Moore's (2004) algorithm which maximizes the number of connections within a cluster and minimizes the number of connections between clusters. The results were checked for robustness using alternative network configurations (for instance, by dropping some nodes, namely Chile, Greece, Turkey, India, or Portugal) and different algorithms (namely the Girvan-Moore algorithm). Although the cluster configurations varied, Norway was never part of Nordic cluster and always belonged to the same cluster as many major global financial centers. The results were also checked for the possibility that smaller clusters could be just aggregating cluster-less nodes but this was not the case.

[6] Large Norwegian banks are active in the FX swap market both for funding and to facilitate the conversion of oil-companies' revenues from U.S. dollars into Norwegian kroner. See Akram and Christophersen (2013).

Figure 1. Norwegian Banks' Global and Regional Linkages

Norwegian banks' performance is very closely associated not only with that of other Nordic banks, but also with that of banks in most advanced economies.

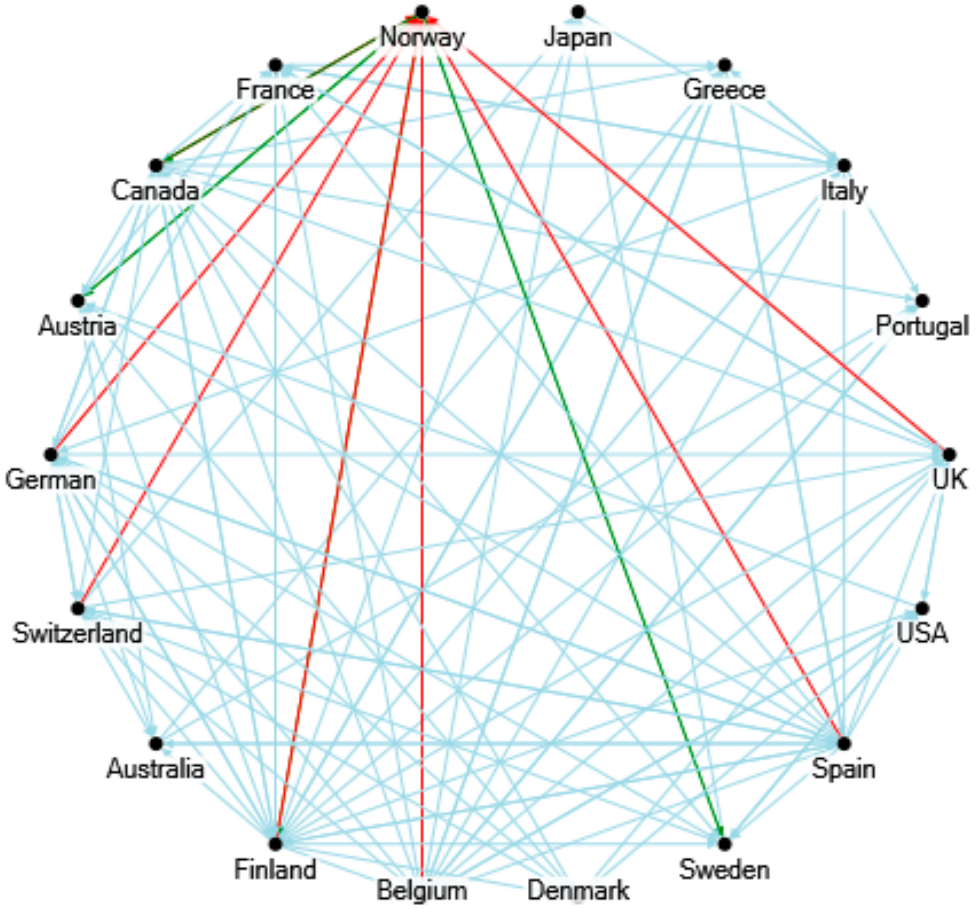


Sources: Thomson-Reuters/Datastream; and IMF staff calculations. Chart constructed with NodeXL.

Notes: Red arrows (and associated figures) denote the contribution of each country's banking sector to Norwegian banks' volatility of stock returns. For instance, the volatility of Swedish banks' stock returns explains 6.7 percent of Norwegian banks' behavior. The contribution is measured using a variance decomposition and is the percentage of each index's 3-month ahead forecast error variance explained by another index's behavior (see Appendix 1). Each country's measure of stock returns is the volatility of a country-specific stock index containing only bank stocks. All data are monthly. See Appendix I for important caveats about data coverage.

Figure 2. Causation of Norwegian Banks' Stress

Norwegian banks' performance association with foreign banks' is in part due to common exposures, but there are significant causal effects.



Sources: Thomson-Reuters/Datastream; IMF staff calculations. Chart constructed with NodeXL.

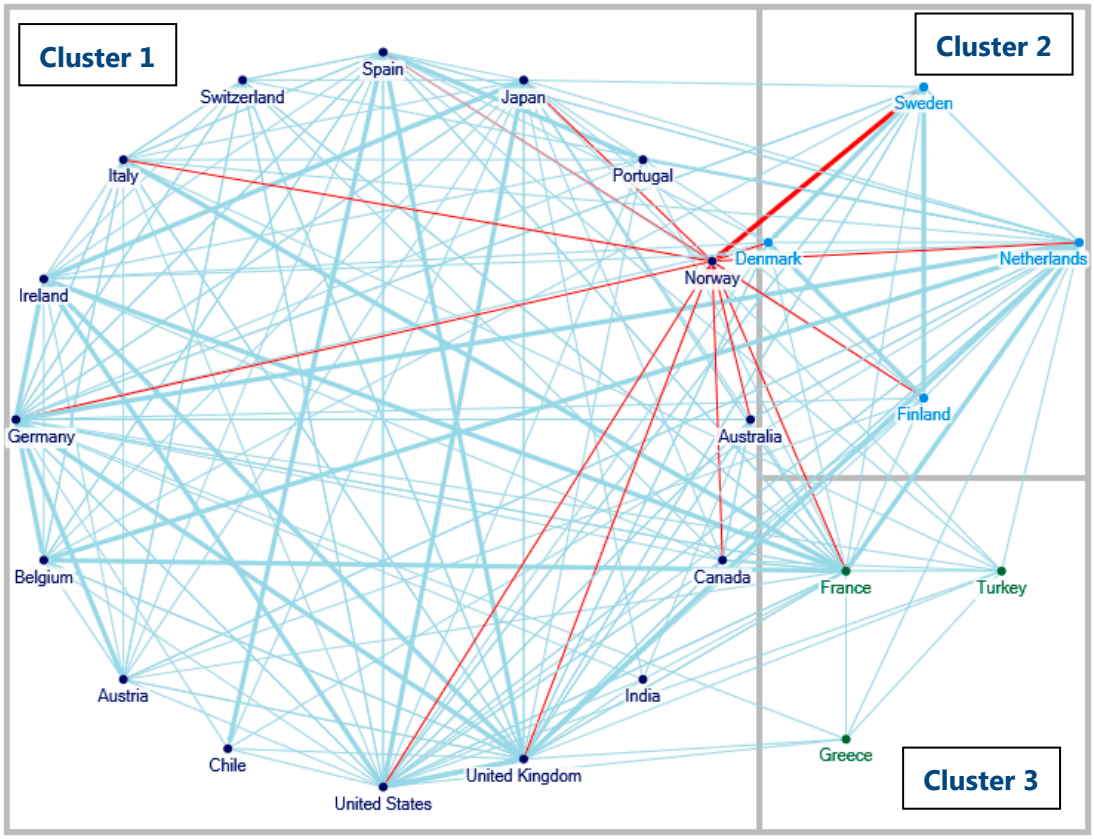
Notes: Red arrows denote that a given country's banking sector performance Granger-causes the performance of Norway banks. Green arrows denote that Norwegian banks' performance Granger-causes another country's bank performance. Performance is measured by the volatility of a country-specific stock index containing only bank stocks. All data are monthly.

8. Among Nordic banks, the direct provision of credit to nonbanks by foreign branches and subsidiaries is the main driver of regional integration. A comparison between a network constructed using BIS data on bilateral total claims and another using BIS data on bank-to-bank crossborder claims, suggests that the former has a smaller diameter (that is, it is more connected) than the latter.[7] Confidential data on crossborder bank exposures within the Nordic region confirms that wholesale interbank funding is considerably less significant than total crossborder bank claims.

[7] The diameter of a network is the maximum distance between any two nodes (Diebold and Yilmaz 2014). The smaller the diameter, the greater is the level of network connectedness.

Figure 3. Crossborder Bank Linkages

Norwegian banks' claims over other countries show strong Nordic and global connections.



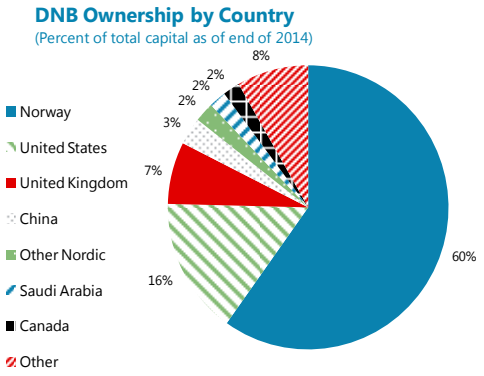
Sources: BIS Consolidated Banking Statistics; IMF staff calculations. Chart constructed using NodeXL.

Notes: The chart describes total crossborder claims by banks, grouped by clusters. Clusters are calculated using the Clauset-Newman-Moore algorithm. Countries in cluster 2 are Denmark, Finland, The Netherlands, and Sweden; countries in cluster3 are France, Greece, and Turkey; all other countries are in cluster 1. The red arrows signify lending from foreign banks to Norway. Lending by Norwegian banks is not reported due to data confidentiality. The thickness of the arrows is proportional to recipient country GDP.

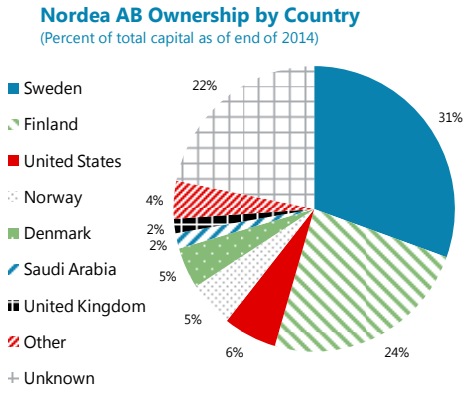
9. Crossborder ownership of banks and other financial institutions is a key common factor driving financial-sector connections among Nordic countries. Several large Nordic bank and insurance groups have important foreign shareholders, coming from a variety of countries. There is a preponderance of Nordic ownership for Denmark, Finland, and Sweden's largest financial groups (Danske Bank, Nordea, and Sampo , respectively), but Norway's largest bank (DNB) shows a more diversified foreign investor base (see Figure 4).

Figure 4. Ownership of Major Nordic Financial Groups

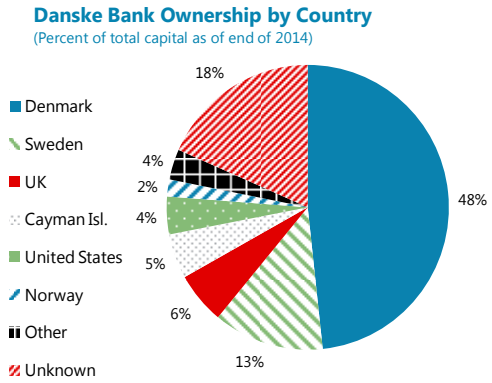
About 40 percent of DNB is foreign-owned.



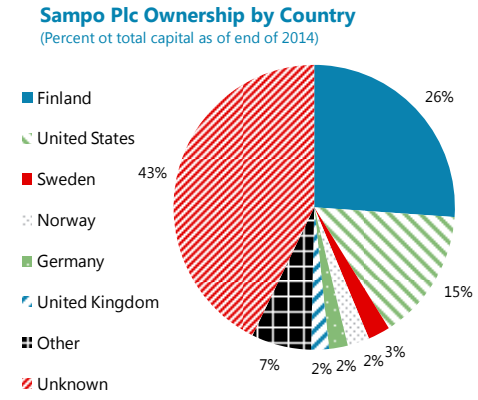
While Nordea is more than 2/3 foreign-owned.



Danske Bank also shows large foreign ownership, in particular from other Nordic countries.



And more than half of Sampo's known shareholders are not from Finland.

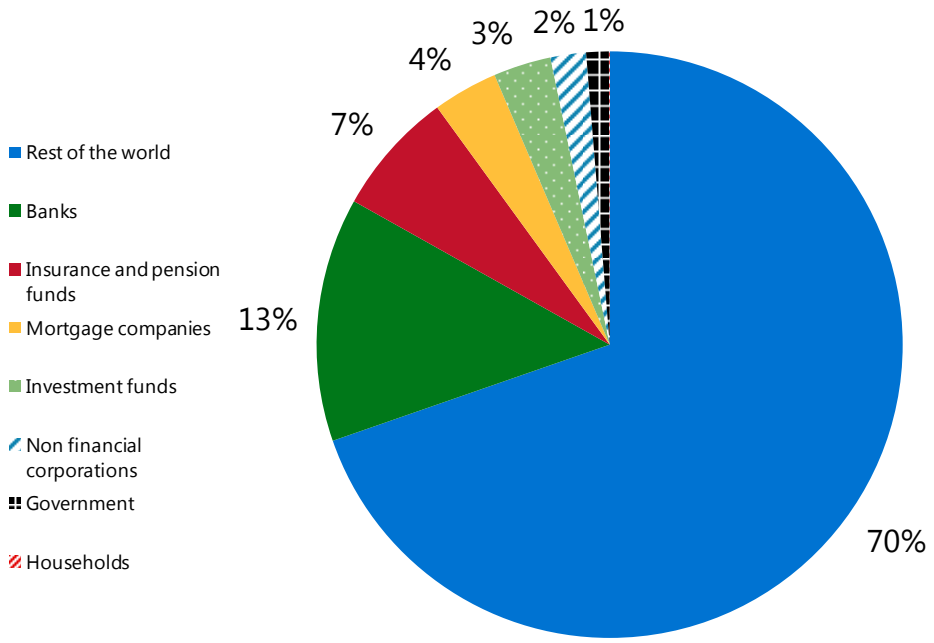


Sources: Bankscope; Isis; and IMF staff calculations.

10. The funding channel is an additional conduit for spillovers to and from Norwegian banking groups which has become increasingly important. Norwegian banking groups have increased their reliance on long-term wholesale funding through covered and unsecured bonds issued by their associated mortgage credit companies. In September 2014, Norwegian mortgage companies owed about 70 percent of long-term funding to foreign investors (Figure 5). Norwegian banks also rely on foreign markets for short-term funding and to hedge currency risk via foreign currency swaps. A disruption in these funding markets could lead to increased funding costs for Norway's banks.

Figure 5. Ownership of Bonds Issued by Norwegian Mortgage Companies

Most unsecured and covered bonds issued by Norwegian mortgage companies are foreign-owned.



Sources: Statistics Norway; IMF staff calculations.

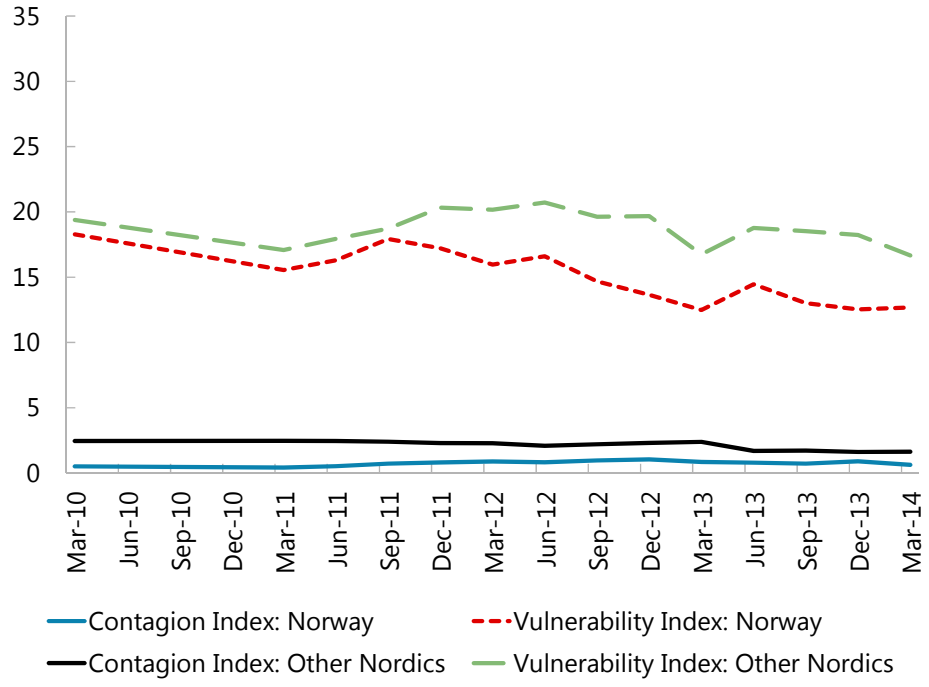
Note: Data are for 2014Q3.

11. Although mortgage companies must fully hedge their foreign currency issuance of covered bonds to match the maturity of the issue, from a systemic point of view these exposures may still be relevant. According to the Finanstilsynet (Financial Supervisory Authority of Norway), in 2013, for the first time a majority of covered bonds was issued in foreign currency (Finanstilsynet 2014).[8] In spite of mortgage companies being mandated to fully hedge the currency risk of a foreign issue for the entire life of the bond, it is possible that they do so by signing currency swap agreements with the parent company which, in turn, may not fully transfer this risk.

[8] For Norwegian banks, foreign currency funding at the end of 2014 corresponded to 60 percent of total funding, with similar figures for banks' long-term funding. See Norway FSAP 2015 Technical Note on "Stress Testing the Banking Sector."

Figure 6. Vulnerability and Contribution to Contagion of Nordic Banks

Vulnerability to external funding shocks has been declining in Norway and is below the average for other countries in the region.



Sources: BIS Consolidated Banking Statistics and IMF staff calculations.

Note: Indices of contagion and vulnerability are based on Espinosa-Vega and Solé (2014). The vulnerability index for Country A roughly measures how often Country A's banking sector becomes insolvent if other banking sectors induce a funding shock. The contagion index for Country A roughly measures the number of banking sectors that become insolvent if Country A's banking sector becomes insolvent. The indices only measure contagion and vulnerability to shocks originating from all BIS reporting countries (not just the Nordic countries), do not take into account funding from central banks, and are not a measure of overall financial strength of each country's banking sector. Other Nordics = Simple average for Denmark, Finland, and Sweden.

12. Norwegian bank's resilience against external credit and funding shocks seems to have improved. An analysis based on confidential data on bank claims from the Bank for International Settlements (covering only a part of funding risks) suggest that this vulnerability is similar to that of peer countries and has been declining (Figure 6). Similarly, simulations of funding shocks coming from global financial centers, namely the euro area, the United Kingdom, and the United States, also show that Norwegian banks are now less exposed to such risks.[9] However, the overreliance on

[9] The simulations use Espinosa-Vega and Solé's (2014) methodology. In the three cases, it was assumed that 95 percent of the funding coming from the euro area, the United Kingdom, or the United States, is withdrawn. In order to make up for the funding shortfall, banks (in this case, each country's entire banking system) must liquidate assets and incur a loss. If the losses wipe out all equity, it is assumed the banking sector defaults. The decreased vulnerability of the Norwegian banking sector to the simulated shocks is due to bigger capital buffers and reduced crossborder bank activity (see IMF, 2015, for global evidence on the phenomenon of banking fragmentation). See Appendix I for an explanation and additional details on the exercise.

external sources for bank funding still poses some risks, given the small number of active counterparties in the foreign currency swap market. A ratings downgrade or strategic business decision may reduce the number of foreign banks willing to serve as counterparties in the Norwegian krone (NOK) swap market and hurt banks' access to funding.

CROSS-SECTOR INTERCONNECTEDNESS

13. Cross-sectoral linkages of Norway's banks extend beyond the Nordic region and include foreign insurance companies and real estate companies. Evidence based on a variance decomposition of the volatility of equity returns, suggests that Norwegian banks are significantly affected by the performance of banks in Sweden, the Euro Area, and the United Kingdom. American and British real estate companies and European insurers are the most significant nonbank sectors affecting the behavior of Norwegian banks' stocks. Although available data do not allow the identification of the drivers behind the measured spillovers, several explanations arise. First, foreign institutional investors are an important source of funding for Norwegian banks—foreign liabilities (including equity) of banks and mortgage companies were, in December 2014, 46 percent of total liabilities.[10] Second, Norwegian financial firms have considerable investments abroad—by the end of 2014, 34 percent of insurance and pension fund assets and 24 percent of bank assets were abroad.[11] Third, asset prices, in particular real estate, show considerable international co-movement (Scatigna, Szemere, and Tsatsaronis 2014), which would explain the importance of foreign real estate sector returns, for instance.

14. Norwegian insurers are significantly affected by banks and insurers from major financial centers and the Norwegian real estate sector is exposed to the performance of American and British financial firms (Figure 7). The largest contributors to the volatility of equity returns of Norwegian insurance companies are German and British insurers. Although some of these connections may be driven by common exposures, statistical evidence based on Granger causality analyses suggests that most of them reflect direct causation and could be driven by funding structures. See Appendix I for a description of the methodology and data, as well as some important caveats on data coverage.

[10] Data from Statistics Norway's financial accounts. Foreign debt liabilities were approximately 60 percent of wholesale bank funding (see Norway FSAP Technical Note on "Stress Testing the Banking Sector").

[11] Ibidem. The share of foreign loans in total bank loans is 22.8 percent (see Norway FSAP Technical Note on "Stress Testing the Banking Sector").

Figure 7. Global Connectedness of the Norwegian Financial System

The Norwegian financial sector is highly connected with the Nordic and global financial systems.

Sources: Thomson Reuters Datastream; IMF staff calculations. Chart constructed with NodeXL.

Note: The chart shows a variance decomposition network for the monthly volatility equity return indexes for each financial industry, by country. The arrows signify and figures show the percentage of the variance of the 3-month ahead forecast error that is explained by the node where the arrow starts. The number of arrows originating in one node measures that industry's spillover potential. The number of arrows ending in a node measures that industry's vulnerability.

15. Cross-sectoral spillovers between the financial and non-financial corporate sectors in Norway are dominated by the importance of the oil-related industries. The same type of spillover analysis used elsewhere in this note is applied to sector-level excess returns, including financial and non-financial sectors (see Figure 8). The analysis suggests that the oil sector's contribution to the performance of Norwegian banks could be as high as 30 percent, far exceeding what can be explained by their direct credit exposure to the oil industry (around three percent of total credit).[12] The large effect of oil activity in banks' profitability is likely driven by the oil sector's large spillovers into the rest of the economy, in terms of output and employment.[13]

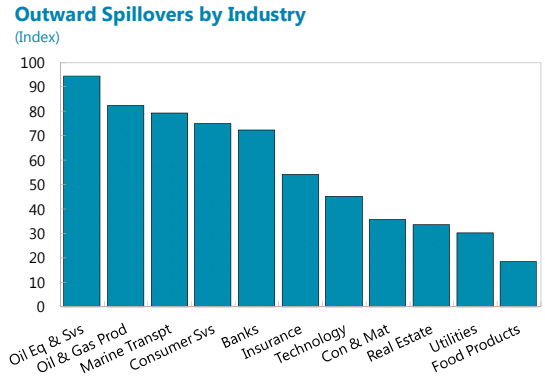
[12] This figure does not include credit exposures to foreign firms in the oil and shipping sectors.

[13] Bjørnland and Thorsrud (2014) find very similar estimates for the contribution of oil-related activity and shocks to Mainland Norway GDP.

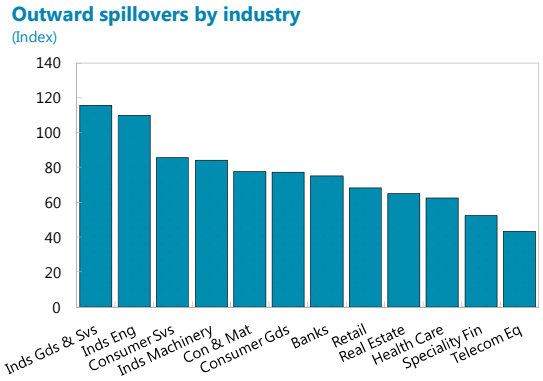
Figure 8. Spillovers Across Industries in Norway

Industries related to oil—extraction, services, and shipping—are dominant in Norway.

In contrast, Sweden has a more diversified economy.



Sources: Datastream; IMF staff calculations.



Sources: Datastream; IMF staff calculations.

The total spillover of the oil-related sectors into the Norwegian financial sector is around 30 percent.

Norway

To ↓ From →	Oil & Gas Prod	Oil Eq & Svs	Banks	Insurance	Marine Transpt	Consumer Svs	Con & Mat	Real Estate	Other	Total Oil	out ward	inward
Banks	9.0	10.6	35.3	9.0	8.5	9.2	4.0	3.7	10.8	30.2	72.4	64.7
Insurance	8.4	9.5	10.6	41.2	7.2	7.8	3.1	2.8	9.5	30.4	54.2	58.8
Real Estate	5.5	6.9	5.9	3.7	6.4	5.6	4.1	53.5	8.4	26.5	33.5	46.5

Sweden

To ↓ From →	Banks	Inds Gds & Svs	Inds Eng	Inds Machines	Consumer Svs	Speciality Fin	Consumer Gds	Con & Mat	Real Estate	Other	out ward	in ward
Banks	23.22	9.96	9.49	6.94	6.95	5.12	7.45	8.42	6.80	15.65	81.42	71.95
Speciality Fin	6.65	8.99	8.26	6.40	6.31	29.71	6.62	6.53	5.69	14.85	42.92	55.86
Real Estate	7.57	9.91	9.34	6.59	5.99	4.89	6.90	8.06	25.41	15.34	70.72	73.12

16. According to these estimates, a one percentage drop in oil production equity returns, causes bank returns to drop by 0.68 percentage points after 12 days,[14] and the impact is similar for insurance companies (see Table1)**.** The impact of oil engineering and services, and marine transportation, on financial sector returns are of similar magnitudes. The effects are large when compared to those of other sectors. See Appendix I for details in the methodology.

[14] The choice of a 12-day horizon follows Diebold and Yilmaz (2014), but results are very stable after four or five days.

Table 1. Financial Sector's Exposure to Other Sectors

A one percentage point drop in equity returns of the Norwegian oil and gas production sector has the largest impact on Norwegian banks, insurers, and real estate companies.

	Oil Equipment & Services	Oil & Gas Production	Marine Transp.	Consumer Services	Technology	Construction & Materials	Banks	Insurance	Real Estate
Banks	0.51	0.68	0.61	0.52	0.35	0.38	1.00	0.43	0.42
Insurance	0.53	0.65	0.59	0.51	0.32	0.32	0.57	1.00	0.37
Real Estate	0.28	0.38	0.38	0.28	0.20	0.24	0.29	0.20	1.00

Sources: Thomson Reuters Datastream; IMF staff calculations.

Note: Table shows the drop in bank, insurance, and real estate sector returns caused by a one percentage drop in another sector's returns, after 12 days. The calculation comes from a generalized impulse response derived from a VAR model of excess returns for Norway. See Appendix I for details.

SYSTEMIC INTERCONNECTEDNESS AMONG NORWEGIAN BANKS

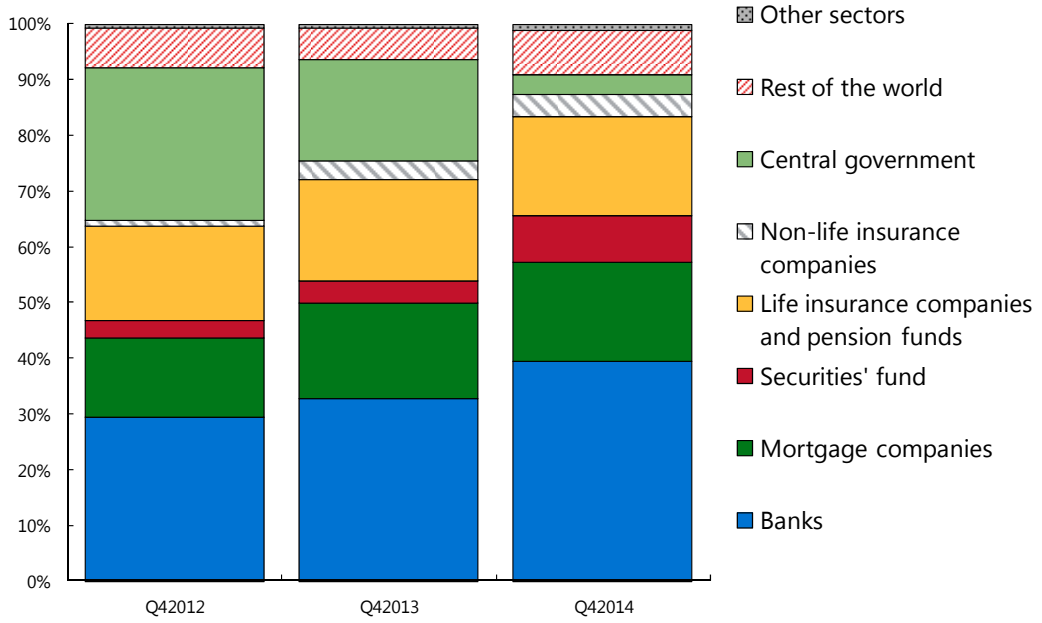
17. Systemic interconnectedness among Norwegian banks has increased since 2011. Network analysis based on confidential bank-level data suggests that Norwegian banks were significantly more connected in September 2014 than at the end of 2011. During that period, the network diameter—which is inversely related to connectedness—decreased by almost 20 percent.[15] Although the connectivity elicited by these data is only moderate (less than 10 percent of assets), its continued increase should be monitored.

18. Most of the increase in bank interconnectedness in Norway has happened through increased holdings of covered bonds issued by other banks. In recent years, Norwegian banks have increased their reliance on other banks operating in Norway as a source of long-term funding (Figure 9). This increase in the cross-ownership of covered bonds in the Norwegian banking system is, in part, a consequence of the expected implementation of the Basel Accord's liquidity coverage ratio (LCR) and of the scarcity of high-quality liquid assets (HQLA). In fact, because of Norway's strong fiscal position, bank-issued covered bonds are the most abundant HQLA. However, this increase in overlapping claims can amplify the risk of systemic illiquidity events and contribute to bank fragility.

[15] Network diameter is calculated using the Erdős–Rényi formula cited in Diebold and Yilmaz (2014): $S=ln(N)/ln(E(\delta))$ where N is the total number of nodes in the network and $E(\delta)$ is the average number of connections per node. Other measures of network connectivity confirm the trend. See Appendix Table 1.

Figure 9. Ownership of Domestic Covered Bonds[1]

Covered bonds issued by Norwegian covered bond mortgage companies are increasingly owned by other Norwegian banks.



Source: Finanstilsynet.

[1] The large share of covered bonds held by the Norwegian central government, in December 2012, was due to the government swap arrangement introduced in 2008 and terminated in 2014.

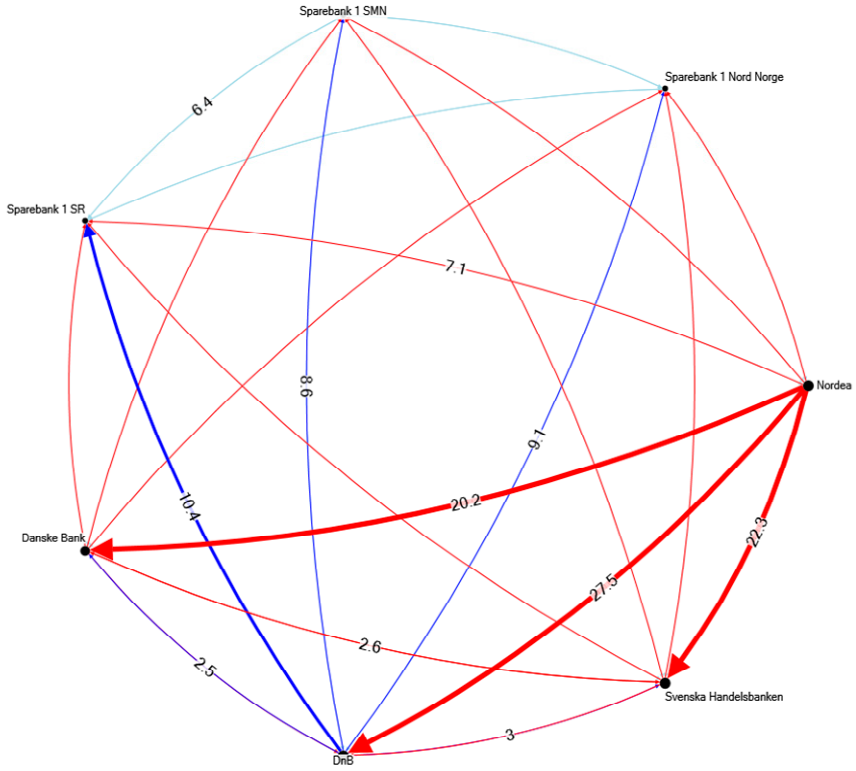
19. An analysis of bank connectedness using market data suggest that DNB and Nordea display the largest spillover potential (Figure 10) and confirms that Norway's banks are well integrated with the rest of the region but mostly at the receiving end. The same methodology employed before in this note, but now applied to 1-year ahead expected default frequencies (EDF),[16] implies that the Norwegian banking sector has a two-tier structure with the foreign banks operating in Norway, and the smaller commercial banks and largest savings banks showing only limited connections.[17] Only the DNB shows important connections with both groups, confirming its leading role in Norway. However, in the context of the Nordic region, Nordea has the highest outward spillover potential as it explains around 25 percent of the other large Nordic banks probabilities of default.

[16] Using EDF as a measure of bank stress instead of the volatility of equity returns, allows the study to cover more banks since many of the savings banks do not have listed equities but do have listed and rated debt securities.

[17] The large Nordic banks operating in Norway, and included in this analysis, are Nordea, Danske Bank, and the Svenska Handelsbanken, in addition to DNB. The largest savings banks considered here are Sparebank 1 Nord-Norge, and Sparebank 1 SMN. In addition, a smaller commercial bank, Sparebank 1 SR Bank, is considered.

Figure 10. Connectedness Among Norwegian and Nordic Banks

The Norwegian banking sector is characterized by two levels of connectedness: one between DNB and large foreign banks operating in the country and another between DNB, and the largest savings banks.



Sources: Moody's CreditEdge+; and IMF staff estimations. Chart constructed with NodeXL.

Notes: Figures show percentage of the 10-day ahead variance decomposition of bank A's 1-year EDF is explained by bank B's 1-year EDF. All estimations were done using a VAR with daily data from January 2006 to January 2015. Red arrows signify contributions from Nordea to other banks, and dark blue arrows signify contributions from DNB to other banks.

21. A comparison between the network analysis based on market data and that based on confidential balance sheet shows that they yield similar conclusions. Therefore, analyses based on market data are a viable alternative when such data are not available. However, bilateral balance sheet exposures data allow for a deeper investigation of the possible sources of spillovers and connections. Financial supervisors would benefit from collecting bilateral asset exposure data on a regular basis and complementing with higher frequency analyses based on market data.

POLICY RECOMMENDATIONS

22. Norway should continue to maintain significant buffers. Norway shows strong financial and trade links with the rest of the world, but is mostly on the receiving end of shocks originating elsewhere. Therefore, there is a strong justification for maintaining significant buffers both economy-wide and at the bank level.

23. The Norwegian authorities should consider conducting regional stress tests. Norway has important credit and economic links with other Nordic countries. Although there is a considerable amount of regional cooperation, authorities should consider complementing their own stress testing efforts with regional stress test exercises.

24. The Norges Bank and the Finanstilsynet already monitor the crossborder exposures of the financial sector, but should consider enhancing its scope. The authorities should expand their regular monitoring of crossborder bank-to-bank direct and indirect exposures beyond the large-exposures framework. Specifically, the collection and analysis of data should go beyond credit exposures and emphasize the role of non banks. To this end, it is important that Norwegian regulators and supervisors have available the sufficient resources to collect the necessary data, including from commercial sources.

25. The authorities are encouraged to enhance the surveillance of interbank lending and exposures and to consider options to dampen the cross-ownership of covered bonds in the banking sector, subject to the restrictions imposed by European Union laws and regulations. Network analysis based on confidential bank-level data, as well as public price data, suggests that connectedness among domestic banks is on the rise. Hence, authorities should resume regular monitoring of bank-to-bank direct and indirect exposures, including interbank lending and in addition to the ongoing monitoring of large credit exposures. Since the increase in connectedness in the banking sector is also related to the emergence of overlapping ownerships of covered bonds brought about, in part by LCR, authorities should contemplate measures to mitigate the associated risks within the legal and regulatory boundaries imposed by the European Union. However, authorities should be aware that remedial measures may carry side-effects.

26. The authorities are actively monitoring risks posed by Norwegian banks' funding structures but would benefit from having more detailed ownership data of unsecured and covered bonds issued by Norwegian financial institutions. Foreign banks and institutional investors are important investors in Norwegian covered bonds, as suggested by flow of funds data and anecdotal evidence (see Figure 5 and Figure 9). In particular, more detailed and complete data are needed on foreign ownership of covered and unsecured bonds issued by banks and mortgage companies. A careful analysis of these data will serve to improve the quality of funding stress tests.

References

Akram, Q. Farooq, and Casper Christophersen, 2013, "Norwegian Overnight Interbank Interest Rates." *Computational Economics* 41, no. 1: 11–29.

Bjørnland, Hilde C. and Thorsrud , Leif Anders, 2014, "Boom or Gloom? Examining the Dutch Disease in a Two-Speed Economy." *Norges Bank Working Paper* No. 12/14.

Clauset, Aaron, Mark EJ Newman, and Cristopher Moore, 2004. "Finding Community Structure in Very Large Networks." *Physical Review* E. 70, no. 6: 066111.

Chordia, Tarun, Asani Sarkar, and Avanidhar Subrahmanyam, 2005, "An empirical analysis of stock and bond market liquidity." *Review of Financial Studies* 18, no. 1: 85–129.

Diebold, Francis X., and Kamil Yılmaz, 2014, "On the network topology of variance decompositions: Measuring the connectedness of financial firms." *Journal of Econometrics* 182, no. 1: 119–134.

Espinosa-Vega, Marco A., and Juan Solé, 2014, "Crossborder financial surveillance: a network perspective." Chapter 14 in Ong, Li L. (editor), *A Guide to IMF Stress Testing: Methods and Models*. (Washington: International Monetary Fund).

Finanstilsynet (2014), *Risk Outlook 2014*. (Oslo: Finanstilsynet).

International Monetary Fund–IMF, 2013, "Sweden—Staff Report for the 2013 Article IV Consultation," IMF Country Report no. 13/176. (Washington: International Monetary Fund).

_____, 2015, "International Banking After The Crisis: Increasingly Local And Safer?" Chapter 2 in *Global Financial Stability Report April 2015–Navigating Monetary Policy Challenges and Managing Risks*. (Washington: International Monetary Fund).

Pesaran, H. Hashem, and Yongcheol Shin, 1998, "Generalized impulse response analysis in linear multivariate models." *Economics letters* 58, no. 1 (1998): 17–29.

Scatigna, Michela, Robert Szemere, and Kostas Tsatsaronis, 2014, "Residential Property Price Statistics Across the Globe." *BIS Quarterly Review September*.

Wells, Simon, 2002, "U.K. Interbank Exposures: Systemic Risk Implications," *Financial Stability Review*, December, pp. 175–82.

Appendix I. Empirical Approaches

Methodology

1. The methodology employed to measure spillovers draws from two sources: Diebold and Yilmaz (2014) for market data analyses and Espinosa-Vega and Solé (2014) for those using balance sheet data.

A. Spillover Analysis Using Market Data

2. The measurement of spillovers using market data starts by estimating a vector autoregression (VAR) using a specification as follows.

$$A(L)Y_t + B(L)X_t = \varepsilon_t.$$
$$D^H \equiv \left[d_{i,j}^H \right] \text{ is the H-step variance decomposition matrix.}$$
$$\mathrm{X}_t = VIX_t.$$

Depending on the study, *Y* can be a vector of equity excess returns, or of the logarithm of the volatility of equity returns, or of expected default frequencies, depending on the study (see data description in Annex II). X is a vector of control variables, usually the *VIX* or, in some instances, oil prices as well. *A(L)* is a lag polynomial with order chose by the Bayesian Information Criterion (BIC), *B(L)* a vector of constants, and *e* is an error term.

3. The VAR model above is used to build a generalized forecast-error variance decomposition, using Pesaran and Shin's (1998) methodology, to identify uncorrelated structural shocks to returns or probabilities of default. The spillover measures consist of the percent contribution of entity A to the H-step-ahead forecast error variance of entity B, where the entities can be banks, sectors, or countries. The advantage of this approach relative to the more standard Cholesky ordering or a more structural approach is that it does not require any assumption on the order of the variables.[18]

4. Since variance decompositions do not fully control for common exposures, this approach was complemented with a test of Granger causality using the same VAR model. To test Granger causality, a Wald test is performed on each entity, where the null is that lagged returns

[18] Although, in some cases market size may be a natural order, experiments based on trying different ordering showed that results were moderately sensitive to the choice of ordering.

(or volatility of returns or probabilities of default) of entity A do not help explain the returns of entity B, in a statistical sense. If the null hypothesis is rejected at the five percent significance level, a direct connection exists from A to B, beyond what can be explained by the exposure to common factors (see Chordia, and Subrahmanyam 2005 for an explanation in the context of liquidity spillovers).

5. The contribution of different corporate sectors to bank and overall financial sector performance is also analyzed using the baseline model and Diebold and Yilmaz's (2014) methodology. In this case, instead of monthly volatilities of returns, daily excess returns of sectoral stock indices are used. The sectoral indexes used are: Oil and Gas Production, Oil Equipment and Services, Marine Transportation, Banks, Insurance, Real Estate, Food Products, Consumer Services, Technology, Construction and Materials, and Utilities. The contribution of oil to financial sector returns is the sum of Oil and Gas Production and Oil Equipment and Services' contribution to the 12-day ahead forecast error variance of bank, insurance, or real estate excess returns, divided by the fraction of said returns not explained by their own past values. The VIX is included as a control.

6. The exercise was repeated for Sweden, but using this country's most relevant sector by market value—Banks, Industrial Goods and Services, Industrial Engineering, Industrial Machines, Consumer Services, Specialty Finance, Consumer Goods, Construction and Materials, Real Estate, Health Care, and Retail. In addition to the VIX, the model includes oil prices as an additional control so that the comparison with Norway is fair.

B. Spillover Analysis Using Balance Sheet Data

7. The measurement of exposures of individual financial institutions relative to their peers or of aggregate exposures of each country's banking sector uses Espinosa-Vega and Solé's (2014) methodology. This method was applied to crossborder bank claims using BIS data and to confidential bank-level exposures within Norway. The method requires two data inputs—bilateral asset exposures and a measure of capital—and three parameters summarizing the following: losses given default, percent of funding withdrawn, and losses in asset fire sales as a percentage of the initial value of assets.

Simulation of a Funding Shock

8. The analysis using BIS crossborder bank claims also contains a simulation of a funding shock using the same method, considering three possible sources for the shock: the euro area, the United Kingdom, and the United States. In all three cases, it was assumed that 95 percent of the funding coming from either country or region is withdrawn. In order to make up for the funding shortfall, banks (in this case, each country's entire banking system) must liquidate assets and incur a

loss of 50 percent (haircut). If the loss is sufficiently large that it exhausts the banks (or banking system's) capital base, it is assumed that the bank (or banks) fails.

9. The chosen scenarios are extremely pessimistic and admittedly simplistic as they do not allow for a differentiation of haircuts across countries or institutions.[19] The simulation is conducted at each quarter between 2010Q1 and 2014Q1 and assumes that no policy action is taken. Hence, it only compares the resilience of a bank or banking system and cannot be used to assess the likelihood of a crisis.

10. The analysis (details omitted to preserve data confidentiality) shows that, under this dramatic scenario, the Norwegian banking system would not fail now—that is, using the most recent data available, 2014Q1—while it would have failed in 2010Q1. A more detailed investigation showed that bigger capital buffers and reduced crossborder bank activity (see GFSR 2015 for global evidence on the phenomenon of banking fragmentation) explain the increased resilience to external funding shocks.

Interbank Connectedness

11. The study of the connectedness of the Norwegian financial system was complemented with confidential interbank exposure data covering all significant banks operating in Norway for December 2011 and September 2014. The goal of the analysis was to show whether the Norwegian banking system is now more connected than in 2011. For this effect, several measures of network connectivity were calculated (see Appendix Table 1). All metrics confirmed the assertion that the Norwegian banking sector is now more connected than before.

[19] The assumption of large losses in this study is in line Wells's (2002) remark that network studies should do so to take into account the large uncertainty about recovery values in periods of financial stress.

Appendix Table 1. Connectivity of the Norwegian Banking Sector

All measures of connectivity of the Norwegian interbank lending market have increased from 2011 to 2014.

Year	Diameter[1]	Average Geodesic Distance[1]	Reciprocated Vertex Pair Ratio[2]	Reciprocated Edge Ratio[2]	Graph Density[2]
2011	1.6531	1.0370	0.4000	0.5714	0.5833
2014	1.3468	0.9877	0.4375	0.6087	0.6389

[1] A lower value signifies higher connectivity.

[2] A higher value signifies higher connectivity. All metrics except diameter calculated using NodeXL.

Data

12. Data for equity returns comes from Thomson Reuters Datastream and is sampled at the daily frequency starting in 1993 and ending on 1/30/2015. Volatilities are calculated as the standard deviation of daily returns over the month. Excess returns are calculated as deviations from average total market returns.

13. Analyses which are conducted at the sector level—banking, insurance, and real estate—use Datastream's sectoral indices, when available. Countries covered are: Denmark, Finland, France, Germany, Norway, Sweden, United Kingdom, and United States. The number of constituents varies from country to country and over the years covered in the sample. As of January 2015, the number of constituents in each index ranged from 74 for the United States real estate index, to one for Finnish bank and insurance indices, and the Danish real estate index.

14. Data for estimated default frequencies come from Moody's CreditEdge+ and reflect 1-year ahead EDFs. Data are sampled at the daily frequency between January 2006 and January 2015.Data for crossborder bank claims are from the Bank for International Settlements' Consolidated Bank Statistics, normalized by recipient country GDP (from the IMF's International Financial Statistics) when used in network charts. The sample covers all BIS reporting countries for which data on total crossborder claims is publicly available, plus Norway. The analysis was complemented with public and confidential data from BIS on claims over banks. Capital buffers for network analyses are calculated using Bankscope data for banks which are likely to be BIS reporting banks. For Australia, Canada, European Union, Japan, Switzerland, and the United States, information on the possible sample of BIS reporting banks is drawn from BIS's Regulatory Consistency Assessment Program (RCAP). For all other countries, commercial banks with at least 10 billion U.S. dollars in assets are selected.