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Cross-Border Transactions and Network Analysis: Evidence from Turkey

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Abstract: Funding from foreign banks in repo, deposit and loan type is an important financing channel for Turkish banks. For hedging currency risk, Turkish banks are also making derivative transactions with foreign counterparties. In this paper, we study on-balance and off-balance sheet relations between Turkish banks and foreign-domiciled banks for 2014-2018 period using network analysis techniques. We group banks according to their business models (islamic vs conventional) and ownership structure (related vs unrelated) and document the evolution of cross-border relationships. We find that islamic domestic banks prefer islamic counterparties in on-balance sheet transactions, however they also work with the conventional banks in the derivative transactions. Additionally, we show that the share of funding from foreign domiciled banks is higher for the domestic subsidiaries of foreign banks. Finally, we find that the currency movement in 2018 seems to change some of the cross-border relations.

Keywords: Cross-border bank lending, Network analysis, Financial interconnectedness

JEL Codes: G21, L14, F34, G15

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Non-technical Summary

A proper functioning of interbank market is important for financial intermediation. The importance of understanding interbank relations and risks stemming from too connected banks has been underscored until the recent global financial crisis in 2008. Failure of several large financial institutions during the crisis has motivated researchers to investigate the association between network structure and resilience of the system. However, since interbank transaction details are generally stored in the regulatory authorities and/or central banks, there is still little evidence on network structure of these transactions.

In this paper, we examine the interbank relations between banks resident in Turkey and foreign-domiciled banks for 2014-2018 period to understand network characteristics and relations with banking groups based on ownership structure and business models. While the interbank network studies in the literature focus on mostly relations between domestic banks, there are a few studies that investigate cross-border interbank relations due to lack of data. Most widely used data sources for studying interbank relations in a global scale are BIS statistics and syndication loan database. BIS statistics allow studying interbank relations aggregated in country level. While syndication loan database lets to study interbank relations on bank basis, only interbank relations in loan type are available in that dataset. In this paper, we aim to contribute to the literature via investigating cross-border interbank relations of a well connected emerging economy, Turkey.

The borrowings of Turkish banks in repo, deposit and loan type from international financial institutions constitute approximately 20 percent of their total liabilities during the sample period. Derivatives market has grown strongly over the past years and Turkish banks become densely connected to the international banks to hedge for currency risk. In this study, first, we analyze several network statistics to investigate the characteristics of network relations. We observe cyclical movements in average loan and derivative degree due to syndication loan renewals. Moreover, we show that bank rankings based on degree and strength statistics are highly correlated. Second, we investigate over time and between instrument similarity using both binary and weighted interbank relations. We observe that over time similarity is lowest in repo transactions which is a short-term financing source and highest in derivative transactions in which larger foreign banks act as counterparty continuously. Second, by using several group definitions, we investigate the concentration of exposures between different groups. Some foreign banks have shares in domestic banks and some foreign banks operate according to islamic principles. We find that islamic

domestic banks prefer islamic counterparties in on-balance sheet transactions, however they also work with the conventional banks in the derivative transactions. Additionally, we show that the share of funding from foreign domiciled banks is higher for the domestic subsidiaries of foreign banks. Turkish lira followed a volatile trend in the third quarter of 2018 and we examine the effect of this volatility on interbank relations as well. We find that domestic banks increased deposit and repo receivables from foreign banks after this movement to stay liquid. Moreover, we observe a decrease in the number of foreign banks that act as counterparty especially in loan and derivative transactions. More broadly, we believe that this paper contributes to the cross-border interbank literature by investigating different types of relations of a well connected country.

1 Introduction

The 2007-2009 global financial crisis has drawn considerable attention and created greater concern about the complex interconnections between financial institutions. Cassola et al. (2009) show that global financial crisis exacerbated the problems of cross-country information asymmetry and caused a decline in cross-border transactions especially within the euro area. Glasserman and Young (2016) point out that intricate nature of interbank networks pose challenges to fully understand risks from interbank relations even at a theoretical level. Due to lack of data and of adequate analysis techniques, the interconnectedness of the global financial system has not been studied extensively at the empirical level as well. While the interbank network studies in the literature focus on mostly relations between domestic banks¹, only a few studies investigate cross-border interbank relations. In this paper, we aim to contribute global interbank network literature by analyzing the bilateral transactions between foreign lenders (unrelated arm's length foreign banks and related foreign banks) and domestic banks (either by foreign-owned or domestically owned banks) through different type of contracts using a unique data set within the Turkish interbank market.

BIS consolidated and locational banking statistics is one of the key data sources to study global interbank networks. Although the BIS statistics capture outstanding interbank claims and liabilities of banks, they give a partial description of cross-border networks due to some large data gaps. The data rely on aggregated information at the level of countries, and hence overlook bank-level heterogeneity. Nevertheless, in the literature, there are several recent papers using BIS data that greatly enhance our understanding of cross-border interbank relations and financial crisis. For example, Minoiu and Reyes (2013) analyze interbank relations between countries for an extensive period of time, 1978-2010, and show that global interbank network has unstable properties in terms of network statistics and structural breaks occur in cross-border interbank relations after financial crises. Using the same data set, Cerutti and Claessens (2016) find that unrelated cross-border lending is more sensitive to supply factors during crises times compared to lending by foreign affiliates of the same bank. Cerutti and Zhou (2017) document that the size of cross-border claims decreased after the global financial crises and this change is due to decreasing interbank relations between core banks. They show that some parts of the network became even more interlinked compared to before global crisis period.

¹See e.g. Furfine, 2003; Degryse and Nguyen, 2007; Lelyveld and Liedorp, 2006; Upper and Worms, 2004; Sümer and Özyıldırım, 2019.

Another strand in the literature examines global banking networks using syndicated loan relations. Hale (2012) shows that recessions and banking crises have an important effect in the formation of new interbank relations and the distribution of the connections using syndicated loan agreements for 7,938 banks from 141 countries. Moreover, Hale et al. (2019) present evidence using syndicated loan deals of 6,083 banks during 1997-2012 that cross-border interbank exposures cause banks to tighten credit conditions in crisis times and hence result in significant reduction in the firm-level investment and asset growth.²

The literature suggests that a contraction in cross-border interbank lending may trigger a shock to local banks' funding and destabilize the financial system. After the global financial crisis, there is a clear recognition especially among emerging market economies that risk accumulation in the interbank relations has to be closely monitored considering the fact that the financial systems of these countries become substantially interconnected. Among these emerging economies, Turkey which is financially well-integrated into the global financial system, is a good example to study interbank relations. The borrowings of Turkish banks from foreign countries in repo, deposit and loan type constitute approximately 20 percent of their total assets. Moreover, domestically operating banks in Turkey have a growing share of derivative transactions to hedge currency risk with foreign counterparties.

In this paper, we examine the network relations between Turkish domestic banks and foreign-domiciled banks for 2014-2018 period using granular information such as type of the interbank contract.³ First, we calculate several network statistics and document

²In a related but different vein, other studies present single-country evidence on the role of interbank relations to transmit shocks to the real economy. Cetorelli and Goldberg (2012) show that during the global financial crisis, foreign banks withdrew 12 percent internal fund from an averaged-sized US branch and one dollar fund withdrawal lowered loan supply of US branches 40 to 50 cents. Cingano et al. (2016) document for Italy that banks which heavily relied on interbank borrowing before the global financial crisis reduce lending to firms more with the contraction in the interbank markets. Additionally, they show that investments of bank-dependent firms decrease by 20 percent due to tightening credit conditions during the financial crisis and this effect is stronger for small and young firms which are more dependent on bank credit. Iyer et al. (2013) examine the effect of freeze in interbank markets after global financial crisis using Portuguese bank data and show that banks that are more dependent on interbank borrowing decrease their lending more strongly. Schnabl (2012) provides evidence that domestic banks which use international bank borrowing channel reduce lending more than foreign banks that continue to have access to international funds after the exogenous shock provided by the Russian crisis of 1998.

³In the literature, there are evidence that network structures vary across different layers such as maturity, the nature (secure/unsecured) and the type of the contracts.(see e.g., Langfield et al., 2014 for UK; Sun and Chan-Lau, 2017 for Chile; Bargigli et al., 2015 for Italy; Sümer and Özyildirim, 2019 for

the evolution of these statistics. Among cross-border transactions, syndication loans originated by large foreign banks to local banks are a significant source of foreign financing. We show that degree of loan and derivative instruments has a cyclical pattern due to syndication loan renewals. Network statistics also show that bank rankings based on degree (number of connections) and strength (size of connections) are highly correlated. Second, we investigate the similarities between different instrument-level networks and over time similarities in each network. We show that in over time similarity, highest similarity is in derivative instruments and lowest is in repo transactions. In derivative transactions, generally larger banking groups act consistently as a counterparty since derivatives require specialized pricing. On the other hand, depending on the short-term liquidity needs, a bank may be net receiver or net seller of money which changes over time similarity of repo transactions. For between instrument similarity, highest is between derivative and loan transactions if similarities are calculated using adjacency matrices. When banks renew their syndication loan, not to carry on-balance sheet open FX position, they also renew derivative positions which increases similarity between these instruments.

Increased Turkish Lira exchange rate volatility during our sample period allows us to study the the effect of this volatility on interbank relations. We hypothesize that increased exchange rate volatility may have a diminishing effect on demand and supply of loans. We observe that due to slowdown in loan supply and loan demand, banks had excess FX liquidity and used these sources as repo or deposit in foreign-domiciled banks. We next find a decrease in the number of foreign banks that act as counterparty especially in loan and derivative transactions.

Finally, we analyze the concentration of exposures between different groups of banks. First, we classify foreign banks as related and unrelated based on having shares in domestic Turkish banks or not. We use a hand-collected matching table that links each foreign institution to its ultimate parent institution. A few recent studies examine related and unrelated bank behaviors using cross-border transactions. For example, Gambacorta et al. (2019) present evidence that cross-border funding from unrelated banks, i.e, the banks that are not in the same group, decreased after the crisis and intragroup cross-border liabilities increased using sample of 12 advanced economies. We show that relations between foreign banks that have shares in Turkish banks (related) and domestic Turkish banks is less volatile compared to the relations between other foreign banks and domestic Turkish banks which is in line with Cerutti and Claessens (2016). Second, we classify banks that work according to islamic principles. Islamic banks are interest sensitive banks

Turkey; Aldasoro and Alves, 2018 and Montagna and Kok, 2016 for EU banks).

and make transactions that are verified by their Shariah board. By grouping foreign banks as islamic foreign and conventional foreign banks, we present evidence that islamic Turkish banks borrow from foreign islamic banks and mostly invest to other islamic domestic banks. One interesting result is that since derivative transactions require specialized pricing and swap transactions are Shariah-compliant products, conventional banks form the most important counterparty for islamic Turkish banks for this group of transactions. Also, in line with Cerutti and Claessens (2016), we show that relations between foreign banks that have shares in Turkish banks and domestic Turkish banks is less volatile compared to the relations between other foreign banks and domestic Turkish banks.

The remainder of the paper is organized as follows: In Section 2, we introduce the data set and highlight the Turkish banking structure as well as important features of the interbank market. In Section 3, we analyze the relations between different banking groups. In Section 4, we document several network statistics and in Section 5, we investigate over time and between instrument similarities. Section 6 concludes the paper.

2 Data Description

In this study, we use two unique datasets that are collected by Banking Regulation and Supervision Agency of Turkey (BRSA). The first dataset contains repo, deposit and loan type transactions (on-balance sheet items) that are reported in a monthly frequency for 2003-2018 period, whereas the second dataset contains daily derivative transactions (off-balance sheet items) for 2014-2018 period. Thus, we limit our sample period to 2014 through 2018 in order to study network structures for all types of instruments together.⁴ In the sample, there are different types of financial institutions acting as counterparty; however, we use the term “bank” throughout the paper for all types of financial institutions since an important share of these institutions are banks.

Figure 1 shows the breakdown of stock exposures over January 2014 to December 2018 in both datasets.⁵ In Figure 1a, we present the composition of receivables in currency

⁴We use outstanding derivative balances at the end of each month to make datasets compatible. In the first dataset, there might be missing observations due to transactions that are entered into and closed within the same month. We verify that most of the transactions in the first dataset during our sample period are in loan type with a longer maturity structure. Thus, we expect to have very limited number of missing transactions.

⁵As of December 2018, total on-balance sheet receivables of Turkish banks from banks (both domestic and foreign) amount to 164.8 billion TL (31.2 billion USD) and share in total assets is 4.3 percent. Share

(Turkish lira, TL and foreign currency, FX) and counterparty (foreign vs domestic) breakdowns. As expected, the share of receivables from foreign banks in domestic currency is close to zero, whereas the share of other receivables ranges between 0.5 and 2 percent. FX receivables from foreign banks exhibit an upward trend after May 2018, at which time CDS of Turkey started to increase and reached over 300 bps from the level of 200 bps (Figure 2b). CDS levels are used as trigger points for recalling FX debt of banks, which may incentivized Turkish banks to ensure foreign lenders that they have enough FX liquidity to repay their FX debt and increased their receivables in these banks.⁶

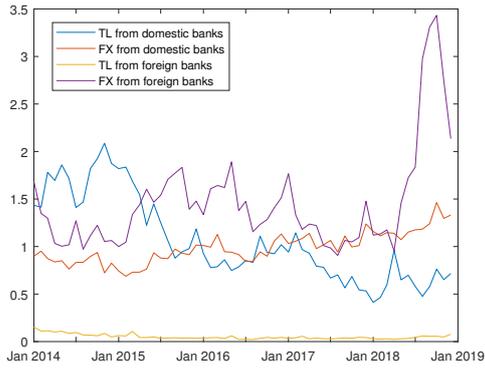
As of December 2018, total on-balance sheet payables to banks (both domestic and foreign) amount to 593.6 billion TL (112.4 billion USD). The share of total payables in the total assets is 15.3 percent as of the last observation and this share is minimum 15.3 and maximum 19.2 percent in the analysis period (Figure 1b). The composition of payables shows that an important share of these liabilities are to the foreign banks in FX currency. The payables to foreign banks in TL and FX currency over total assets in the analysis period is minimum 13.3 percent and maximum 17.1 percent. After the currency movement in August 2018, FX payables to foreign banks started to decrease mainly due to decreasing FX loan appetite of Turkish corporates which will be discussed further below.⁷

Figure 1c shows the volume of traded derivatives. The derivative volume seems to boom in August 2018 and then decreased sharply due to exchange rate movement in August 2018. As of December 2018, the volume is 1141 billion TL (216 billion USD). On the other hand, the volume of derivative transactions is nearly stable in terms of USD until June 2018. Afterwards, Turkish banks lowered borrowing in FX from abroad which caused a decrease in open on-balance sheet FX position and derivative volume in USD terms turned into a downward trend. As of December 2018, 56 percent of the derivative transactions is in currency swap type (Figure 1d). Turkish banks are mainly using derivative transactions to hedge currency risk via making the currency of liabilities and the assets same.

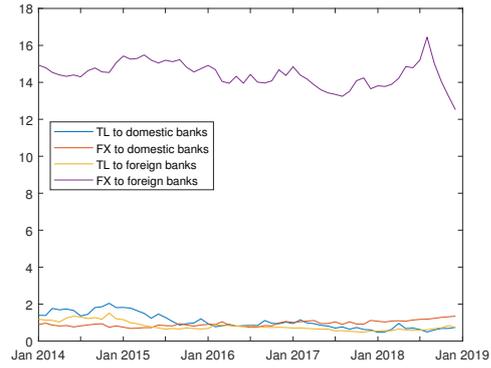
of total receivables to total assets range between 2.6 and 5.7 percent between January 2014 and December 2018.

⁶See also Appendix Figure A1 for the instrument breakdown of receivables. As of December 2018, the share of deposit, repo and loan type instruments are 64, ten and 25 percent respectively and the increase in the FX receivables from foreign banks are in deposit type.

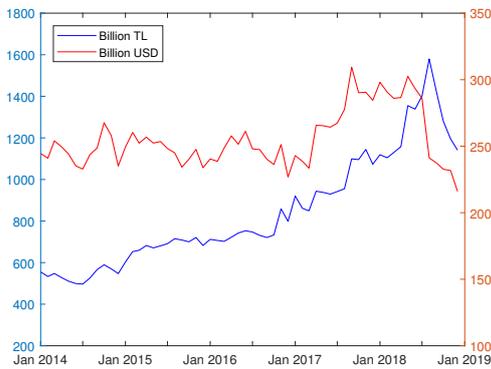
⁷As of December 2018, the composition of payables is as eight percent repo, 19 percent deposit and 72 percent loan (Appendix Figure A1).



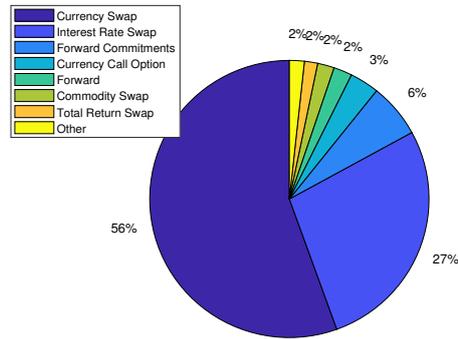
(a) On-balance sheet receivables over total assets



(b) On-balance sheet payables over total assets

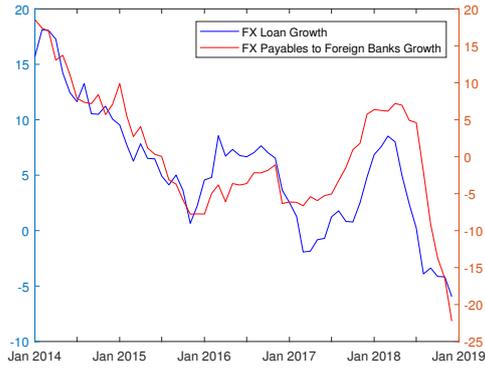


(c) Traded volume in derivatives

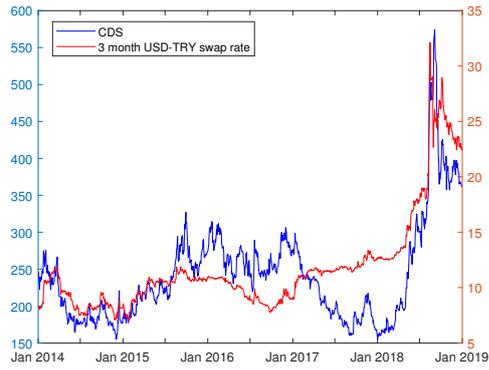


(d) Breakdown of derivative types in December 2018

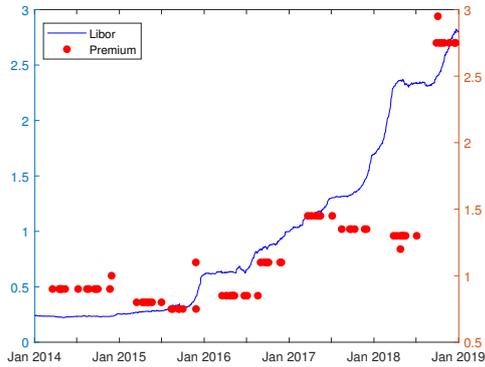
Figure 1: Breakdown of Transactions in the First and Second Dataset. The amounts in the Figures 1a-1c show the outstanding balances at the end of each month.



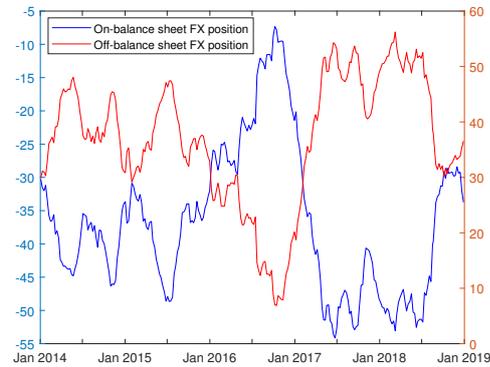
(a) Growth of FX loan and FX payables to foreign banks



(b) CDS and swap



(c) Libor rates and risk premium in syndication loans



(d) FX Position of Turkish banks (Billion USD)

Figure 2: Risk premium data in Figure 1c is collected from syndication loan announcements of 14 banks between 2014-2018 from Public Disclosure Platform.

As summarized in Figure 1, Turkish banks have been a net borrower from foreign countries. While external borrowings from foreign banks contribute to extension of credit by domestic banks, abrupt reversals in these financing may force sharp declines in credit to the private sector. Therefore, it is essential for the regulatory authorities to closely monitor the interbank activities of Turkey.

In Figure 2, we provide additional information regarding the factors that may drive movements in the interbank relations. As seen in Figure 2a, there is a strong co-movement between annual FX loan growth and FX payables to foreign banks. Increasing risk premium of Turkish banks starting in August 2016 accompanied by the increase in LIBOR rates caused syndication loan rates to go up (Figure 2c). After the August 2018 shock, risk premiums increased from 130 bp to 275 bp. Higher FX loan rates due to increasing FX syndication loan costs led FX loan demand to decrease which became apparent in 2018. Increasing CDS levels and 3 month USD-TRY swap rates make extending TL loans

Table 1: Turkish Lira (TL) and Foreign Currency (FX) Composition of Assets and Liabilities of Turkish Banking Sector as of December 2018

| Assets (percentages) | | | Liabilities (percentages) | | |
|------------------------|-------------|-------------|---------------------------|-------------|-------------|
| | TL | FX | | TL | FX |
| Liquid Assets | 0.7 | 1.2 | Deposits | 26.9 | 25.7 |
| Required Reserves | 1.3 | 7.9 | Payables to Banks | 1.4 | 13.2 |
| Securities | 8.6 | 3.8 | Bond Issuances | 1.0 | 3.5 |
| Loans | 37.2 | 24.5 | Payables in Money Markets | 3.7 | 1.2 |
| Receivables from Banks | 0.8 | 3.5 | Other Liabilities | 6.3 | 6.2 |
| Other Assets | 7.8 | 2.8 | Equity | 10.9 | 0.0 |
| Total Assets | 56.3 | 43.7 | Total Liabilities | 50.2 | 49.8 |

Notes: The table is prepared using December 2018 balance sheet of Turkish banking sector. The numbers show the share in total assets/liabilities. Liquid assets show the sum of cash, receivables from money market, receivables from securities interbank market, receivables from reverse repo. Required reserves also cover receivables from CBRT. Loans include performing and non-performing loans less allowances for credit losses. Payables in money markets is the sum of payables to money market, payables to securities market and funds from repo transactions.

using cross currency swaps more expensive (Figure 2b). Turkish banks carry nearly zero net FX position thanks to the regulation limiting net FX position over regulatory capital. In June-December 2018, while FX payables to foreign banks decreased by 27.8 billion USD, FX loans decreased about 9.8 billion USD and this caused on-balance sheet FX open position of Turkish banks to decrease (Figure 2d). Since, banks conduct off-balance sheet transactions mainly to close their on-balance sheet FX position, the sharp decline in the total derivative volume in USD terms after 2018 (Figure 1c) can be explained by the declining need of domestic banks to hedge. Increase in 3 month USD-TRY swap rates in 2018 also confirms the appetite of banks to use swaps less in that period.

Table 1 provides a snapshot of TL and FX composition of assets and liabilities of Turkish banking sector. As of December 2018, the share of FX denominated assets and liabilities in total assets are 43.7 and 49.8 percent respectively. The share of FX denominated deposits and borrowing from banks constitute almost 40 percent of the total assets. However, FX loan demand of Turkish corporates is limited especially in recent years. Moreover, as part of macroprudential surveillance, households are not allowed to use FX loans since 2009. As a result of all these developments, Turkish banks enter into currency swaps with foreign banks to be able to extend TL loans to corporates and households. However, the increased cost of swaps as seen in Figure 2b accompanied by increased syndication cost demotivates banks to borrow in FX from foreign banks and extend TL loans since the mid of 2018. Deposits constitute an important share of total liabilities for Turk-

ish banks which has a short-term structure. On the other hand, loans on the asset side have longer maturities. Banks use interest rate swaps to protect themselves from changes in the interest rate. As seen in Figure 1d, interest rate swaps form the second important share in derivative transactions. Besides currency and interest rate swaps, Turkish banks also use forwards and options as derivative instruments.

2.1 Data Cleaning and Identification of Counterparties

Before starting the analysis, we verify the data for misreportings. According to the reporting standards, there must be double-entry bookkeeping for a single derivative transaction. For example, let's assume that two parties enter into a currency swap agreement to buy USD and sell TL in the forward date. This transaction should be reported as shown in Table 2 as a double entry and both entries should have the same transaction number which would be unique for each bank. However, we observe that not all derivative transactions are reported as a double entry due to misreporting. In particular, there are transactions without a transaction number or different transaction numbers are given to the records of the same transaction. We follow a three step matching algorithm to obtain matched data for our analysis:

- Step 1: Among all unmatched transactions, if there is only one record having same counterparty, opening date, maturity date, transaction number and transaction type (e.g. currency swap, interest rate swap) with the record that we search for its couple, we take these transactions as matched transactions.
- Step 2: Among remaining unmatched transactions in Step 1, we search for the entries without a transaction number or with an incorrect transaction number. In that step, we match the entries having only one couple with the same counterparty, opening date, maturity date, and transaction type.
- Step 3: It appears that some entries have more than one couple in terms of having same counterparty, opening date, maturity date, transaction number and transaction type, so cannot be matched in the first step. Thus, in the last step, among unmatched transactions, we try to match even number of registries having same bank, counterparty bank, opening date, maturity date, transaction number in which amounts of couple registries are close.

By following these steps, we are able to match almost 99 percent of the transactions

Table 2: An Example for Double Entry Reporting of a Derivative Transaction

| Transaction | Bank | Counterparty | Currency | | Opening | Maturity | Transaction |
|----------------------|--------|--------------|----------|-----|------------|------------|-------------|
| Type | | Bank | #1 | #2 | Date | Date | Number |
| Currency Swap (Buy) | Bank A | Bank B | USD | TRY | 15.12.2018 | 23.03.2019 | DT112 |
| Currency Swap (Sell) | Bank A | Bank B | TRY | USD | 15.12.2018 | 23.03.2019 | DT112 |

Notes: Table shows how an example derivative transaction should be reported as a double entry correctly. The example derivative transaction is opened on 15th of December, 2018 with a maturity date of 23th of March, 2019. Bank A has entered in a currency swap transaction with Bank B to buy TRY and sell USD in the spot lag and do the reverse in the forward lag. In the correct reporting, these two entries should be reported with the same transaction number.

both in number of observations and size. After that, we aim to identify counterparty financial institutions uniquely from the transaction level reporting. In the datasets that are used in this study, counterparty financial institutions are reported with their swift-codes and names. While, swiftcodes enable to identify counterparties uniquely, same counterparty financial institution may be reported with many different names. So, for the transactions that swiftcodes of the counterparties is reported, we use swiftcodes, in other cases, we used names to identify the counterparties.

In our analysis period, we count 1047 swiftcodes belonging to different counterparties (including domestic Turkish banks) in the first dataset. We sort the counterparty swiftcodes according to the frequency of reporting and size of the exposures and exclude the swiftcodes that are below certain thresholds. We exclude swiftcodes whose frequency of reporting is less than 30 and whose total size is less than 500 million TL for 5 year analysis period. The excluded swiftcodes constitute 0.37 percent in terms of frequency and 0.17 percent in terms of size. In the second dataset, we count 245 different swiftcodes reported. We include 227 of these swiftcodes and exclude swiftcodes whose frequency of reporting is less than 10 and whose total size is less than 250 million TL for 5 year analysis period. The ratio of excluded counterparties is 0.06 percent in terms of frequency and 0.02 percent in terms of size.

We hand-match banks on both datasets into banking groups in terms of ownership structure and business models. While grouping according to the ownership structure, we aimed to differentiate foreign banks according to the criteria of whether they hold considerable shares of Turkish banks, specifically more than 40 percent or not.⁸ We make another group according to the business model of the bank which are conventional or islamic banking model. In our analysis, we use several sources to make a list of islamic

⁸There are only two banks in the shareholder banks set that have 8-9 percent share in Turkish banks.

banks. First, we search several websites and academic papers documenting the lists of islamic banks.⁹Then, we verify each listed islamic bank’s business model from their websites by controlling whether there is a menu regarding islamic banking or Shariah board.¹⁰ We also aimed to group subsidiaries of the same parent bank together. For example, there are 23 swiftcodes belonging to a large banking group operating in different countries and we group all of these banks under the same banking group. Table 3 presents the number of banks in six different banking groups. There are 53 resident banks in Turkey in our dataset. Subsidiaries of these banks in foreign countries has also been grouped together with Turkish shareholders and assigned the same bank identifier number.¹¹There are in total 33 foreign banks that have shares in Turkish banks of which only seven of them are islamic banks. There are also 14 central banks that have lending/borrowing relationships with Turkish banks and these banks are grouped separately in our sample. Most of the banks, specifically, 427 banks, are in other conventional foreign banks type which do not have any shares in Turkish banks.

We exclude the non-bank financial institutions operating in Turkey as the counterparty from the analysis since these institutions have borrowing and lending relationships mostly with their parent banks in Turkey. There are also domestic banks that have established special purpose vehicles (SPVs) for the purpose of utilizing diversified payment rights (DPR) or issuing sukuk bonds. We exclude these transactions from the analysis as well, since the SPV which is the subsidiary of the reporting bank is specified as the counterparty in these transactions.

2.2 Construction of Interbank Networks

In this section we explain how to construct network matrices between banks from the transaction-level data. First, we form flow exposure matrices using opening dates of transactions in the reporting to examine the changes in the network structure between 2014 and 2018. For example, a transaction entered on 6th of January 2014 with a maturity

⁹See the following websites: The World’s Largest Islamic Banks, www.theasianbanker.com, Islamic Banks and Financial Institutions, <http://www.islamicline.com/islamicbanks.html>, World Database for Islamic Banking and Finance, http://www.wdibf.com/islamic_banks.html

¹⁰Several large foreign banks such as HSBC, Barclays and Deutsche Bank have islamic banking teams. However we were not able to group these banks as islamic separately from their headquarter banks in the analysis. So, islamic subsidiaries of large banking groups are grouped together under the banking group.

¹¹Since, subsidiaries of Turkish banks are generally connected with their shareholders, diagonal entries of interbank matrices is not zero.

Table 3: Banking Groups in the Analysis

| Group | Number of swiftcodes | Number of banks |
|--|----------------------|-----------------|
| | in the group | in the group |
| Conventional foreign banks having shares in domestic banks | 121 | 26 |
| Islamic foreign banks having shares in domestic banks | 17 | 7 |
| Resident banks in Turkey and subsidiaries | 71 | 53 |
| Other conventional foreign banks | 513 | 427 |
| Other islamic foreign banks | 83 | 75 |
| Foreign central banks | 13 | 14 |
| Total | 793 | 602 |

Notes: “Conventional foreign banks having shares in domestic banks” are the banks that have shares in domestic banks and that do not operate according to islamic principles. “Islamic foreign banks having shares in domestic banks” are the banks that work according to islamic principles and have shares in domestic banks. “Resident banks in Turkey and subsidiaries” cover both Turkish banks operating in Turkey and their subsidiaries abroad. “Other conventional foreign banks” are the conventional banks that do not have shares in domestic banks. “Other islamic foreign banks” are the islamic banks that do not have any share in domestic banks. “Foreign central banks” are the central banks of foreign countries. The sum of the swiftcodes in the rows does not give the swiftcode number in the total row. Due to merger or acquisitions, some swiftcodes fall into different groups in different time periods.

date of 6th of March 2014 is accounted both in January 2014 and February 2014 reporting. By keeping transactions whose opening month and year is equal to reporting month and year, we form flow exposure matrices and count this transaction only in January 2014 period.¹²In this way, we form 20 quarterly networks using monthly flow relations during the sample period of January 2014 and December 2018. We use these flow matrices in the rest of the analysis.

Foreign-domiciled banks are not required to report to the domestic regulatory authorities. Hence, we use the receivables and payables of resident banks (domestic banks) to form networks for the first dataset. To illustrate how we construct networks among domestic banks and between domestic and foreign-domiciled banks, we have the following example: Suppose that $Bank_1$, a domestic bank, reports that it has 10 TL receivable from $Bank_{n+1}$, a foreign-domiciled bank and 5 TL payable to the same bank. Then the receivable amount, 10 TL, is registered as the receivable of domestic bank, $Bank_1$, from foreign domiciled bank, $Bank_{n+1}$, and 5 TL is registered as the receivable of $Bank_{n+1}$ from $Bank_1$. Since the relations between foreign-domiciled banks are missing, we assign zero to the associated entries. In the second dataset, derivative volume reported with domestic

¹²We exclude all of the transactions not having an opening date.

Table 4. Network Construction

| | domestic banks | | | | foreign-domiciled banks | | | |
|---------------------|--------------------|--------------------|-----|--------------------|-------------------------|---------------------|-----|-------------------|
| | Bank ₁ | Bank ₂ | ... | Bank _n | Bank _{n+1} | Bank _{n+2} | ... | Bank _m |
| Bank ₁ | x _{1,1} | x _{1,2} | ... | x _{1,n} | x _{1,n+1} | x _{1,n+2} | ... | x _{1,m} |
| Bank ₂ | x _{2,1} | x _{2,2} | ... | x _{2,n} | x _{2,n+1} | x _{2,n+2} | ... | x _{2,m} |
| ⋮ | ⋮ | ⋮ | | ⋮ | ⋮ | ⋮ | | ⋮ |
| Bank _n | x _{n,1} | x _{n,2} | ... | x _{n,n} | x _{n,n+1} | x _{n,n+2} | ... | x _{n,m} |
| Bank _{n+1} | y _{n+1,1} | y _{n+1,2} | ... | y _{n+1,n} | 0 | 0 | ... | 0 |
| Bank _{n+2} | y _{n+2,1} | y _{n+2,2} | ... | y _{n+2,n} | 0 | 0 | ... | 0 |
| ⋮ | ⋮ | ⋮ | | ⋮ | ⋮ | ⋮ | | ⋮ |
| Bank _m | y _{m,1} | y _{m,2} | ... | y _{m,n} | 0 | 0 | ... | 0 |

Notes: Let's have n domestic banks and m foreign-domiciled banks in the dataset. For the first dataset, $x_{i,j}$ shows the receivables of the domestic banks and $y_{i,j}$ shows payables of domestic banks which is also the receivables of the foreign-domiciled banks. For the second dataset, derivative volume between two banks are registered as the receivable of both banks. We have no data for the transactions among foreign-domiciled banks since they do not report to the local banking authority.

bank, Bank₁, and foreign-domiciled bank, Bank_{n+1}, are registered both as the receivable of Bank₁ from Bank_{n+1} and receivable of Bank_{n+1} from Bank₁. Thus, domestic bank to foreign bank and foreign bank to domestic bank regions in derivative network are mirror of each other. Due to the unavailability of derivative transactions among foreign-domiciled banks, we again assign zero to the associated entries. Using this procedure, we construct the networks between domestic banks and between domestic and foreign-domiciled banks (Table 4).

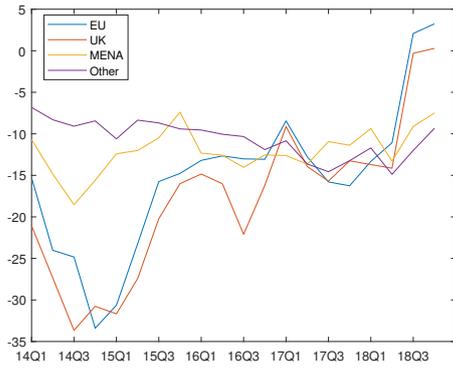
2.3 Geographical Distribution of Interbank Relations

In this section, we analyze the geographical distribution of financial institutions that act as a counterparty to domestic banks in interbank relations. We identify four geographical regions for the counterparty banks. These are European Union (EU), Middle East and North Africa (MENA), United Kingdom (UK) and others. In Figure 3a, we report net receivables (receivables minus payables) of domestic banks for repo, loan and deposit type relations from these regions. While, Turkish banks have payables in netted terms

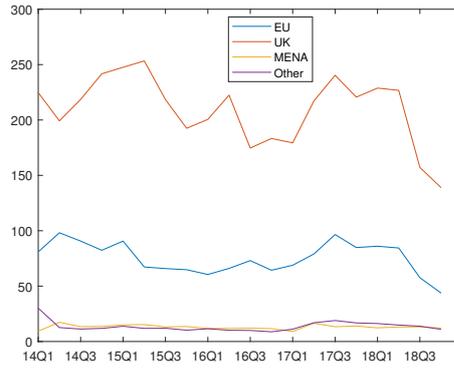
to all country groups (negative net receivable) in the beginning of the analysis period, we observe that the net positions change in the last two quarters. After the currency movement in August 2018, Turkish banks increased receivables and decreased payables from foreign banks and this change is clearly seen for the exposures to the regions EU and UK. While Turkish banks had been borrowing considerable amounts from the countries in EU and UK, with the currency movement, they stopped borrowing from these regions and became net lender for these regions. Net flow receivables from MENA and other countries also decreased in the last quarter but the change is not clear as for EU and UK.¹³

When we analyze the counterparty countries of Turkish banks in the derivative transactions (Figure 3b), it is found that about 65 percent of these transactions are carried through UK. While Turkish banks have also significant amount of derivative transactions with EU countries, the volume of these transactions with MENA and other regions are limited. As seen in the figure, off-balance sheet transactions of Turkish banks with both EU and UK regions drop substantially after the second quarter of 2018. As explained above, high cost of borrowing from abroad lessened the need for making derivative transactions and extending TL loans and caused these drops.

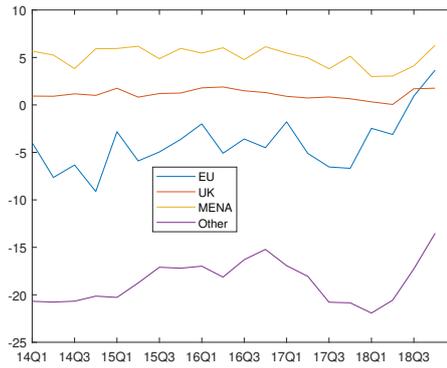
¹³Turkey is top country in terms of receivable and payable amounts, however since receivable of a domestic bank is the payable of the other domestic bank, net receivables from Turkey is close to zero. Except Turkey, the receivables of domestic banks from other countries is rather limited.



(a) Net receivables in the first dataset



(b) Derivative volume in the second dataset



(c) Net exports

Figure 3: Country Breakdown in Interbank and Trade Relations of Turkey (Billion USD). Net receivables and derivative volume in Figure 3a-b reported in TL is converted to USD equivalent by using the average of USD/TL exchange rate in the related quarter. Net export amount in Figure 3c is the sum of related amounts in the related quarter.

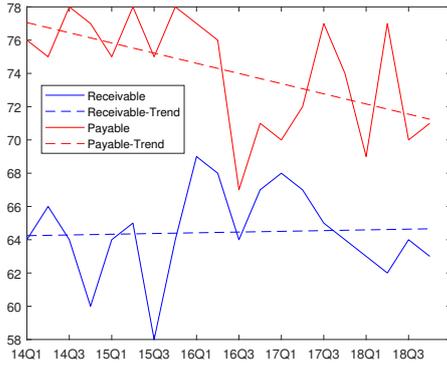
Caballero et al. (2018) study the association between interbank and trade relations and show that if interbank relations between two countries in a period increase, then trade between these countries increases in the following period due to reducing export risk. In Figure 3c, we present net exports of Turkey to countries in our four regions to visualize whether there is some similarity between interbank transactions and trade relations. First, we find that while the share of “Other” region in interbank relations is smaller, due to considerable trade relations with USA, China and Russia, net exports from other countries constitute an important share in trade relations. Second, we observe some contradictory and some supporting signs on the existence of relation between interbank and trade activities during the time period under review. Turkey is net exporter to MENA countries in all periods and also net importer from EU countries until the second quarter of 2018 but has net interbank receivable from both country groups in these periods. In contrast to these contradictory signs, we see some supporting indications. In the last two

quarters of 2018 in trade relations, Turkey became net exporter to EU while Turkey was net importer from EU in the previous periods. Similarly, in interbank relations, while Turkey has net payable to EU countries, became net receiver from EU countries in the last two quarters of 2018. Although, Figure 3 presents some similarities between trade and interbank relations during the sample period, this topic worths to be investigated further.

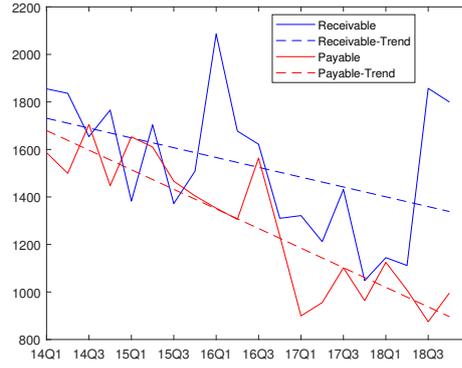
Finally, we analyze the concentration of foreign counterparty countries using both the number of counterparty countries and Herfindahl-Hirschman Index (HHI).¹⁴ We exclude Turkey from the country list in order to analyze the concentration for the foreign parties. In the paper, we use flow exposure relations and the series are bouncing. Thus, we add linear trend lines to derive some inferences. For the on-balance sheet items (repo, deposit and loan), while the number of foreign countries that Turkish banks have receivables are on average stable, number of foreign countries that Turkish banks borrowed decreased in the analysis period (Figure 4a). The HHI ranging between 875 and 2086 for on-balance sheet items implies a competitive to moderately concentrated market (Figure 4b).¹⁵ HHI for on-balance sheet items indicate a decrease in the market concentration for both payables and receivables. We explain the decrease in concentration with the decreasing share of some counterparty countries that have significant shares of interbank relations in the beginning of the analysis period. Similar to the on-balance sheet items, number of foreign counterparty countries in the derivative transactions show a decrease (Figure 4c). HHI for off-balance sheet items ranging between 4185 and 5705 indicates a highly concentrated market which is supported by the fact that UK having nearly 65 percent of all derivatives (Figure 4d). Highly concentrated nature of derivative transactions also implies a nearly stable trend for the analysis period.

¹⁴The index for each quarter is calculated by summing the square of the share of each country's lending/borrowing in total lending/borrowing.

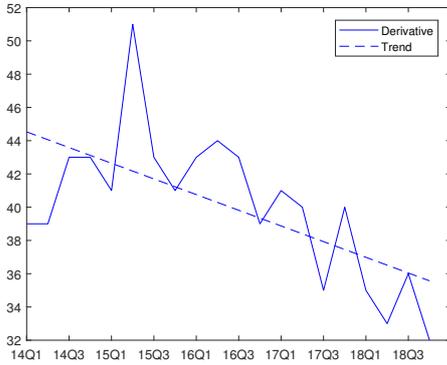
¹⁵A market with an HHI of less than 1500 is considered to be a competitive marketplace, an HHI of 1500 to 2500 to be a moderately concentrated marketplace, and an HHI of 2500 or greater to be a highly concentrated marketplace.



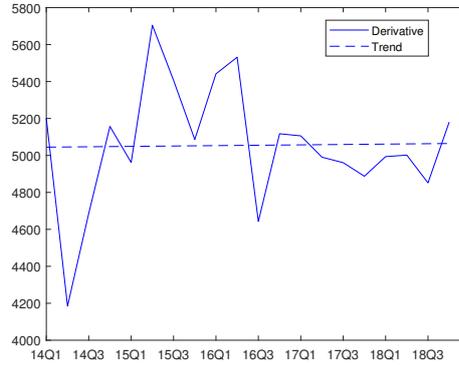
(a) Number of counterparty countries in on-balance sheet items



(b) HHI for country breakdown in on-balance sheet items



(c) Number of counterparty countries in off-balance sheet items



(d) HHI for country breakdown in off-balance sheet items

Figure 4: Geographical Concentration in Interbank Relations of Turkey. In all sub-figures, Turkey is excluded from country list in order to see concentration of interbank relations with foreign counterparties. Linear trend line of series are added to see the tendencies in the analysis period.

3 Banking Group Relations

In this section, we group banks according to the business model (conventional or islamic banks) and ownership structure (related/intragroup or unrelated banks) to study whether there is a concentration and persistence in interbank relations across different types of banks. It seems obvious that islamic banks¹⁶ prefer to have a relationship with other islamic banks. However, in the literature, there are evidence that the differences among islamic and conventional banks might be smaller than expected. For example, Beck et al. (2013) discuss that many of the conventional products can be redrafted as

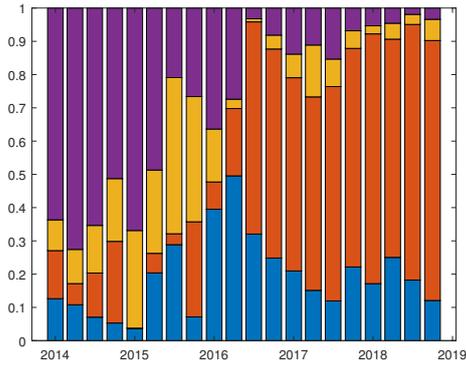
¹⁶Islamic banks are responsible of complying with the rules of their Shariah board (see Hamza, 2013 for a discussion on Shariah governance in islamic banks).

Shariah-compliant products and hence islamic banks are close to conventional banks in terms of efficiency, asset quality and stability. Moreover, in the recent literature, there are evidence that interbank funding between unrelated banks is more vulnerable to global shocks whereas intragroup funding between related banks can be rather stable. For example, Reinhardt and Riddiough (2015) show that related banks in emerging economies continue intragroup funding even when the average profitability of banks in the local economy is low. Thus, in this section, we aim to explore whether some banking groups prefer to lend or borrow from some other banking groups.

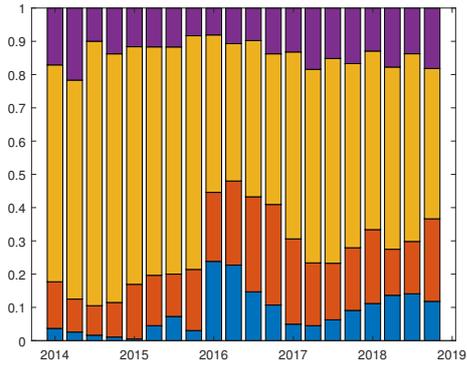
As of December 2018, there were 52 banks operating in Turkey of five works according to islamic principles and hold about five percent of the total Turkish banking sector assets. Although, islamic domestic banks constitute a limited share in Turkey, our findings suggest interesting relationships between banks. As documented in Figure 5b and 5d, difference between domestic islamic banks and domestic conventional banks become more apparent in on-balance sheet payables of these banks. While foreign islamic banks are the major counterparty for domestic islamic banks, foreign conventional banks are the major counterparty for domestic conventional banks. The share of islamic counterparties (both domestic and foreign) ranges between 56 and 81 percent in total payables of domestic islamic banks in the analysis period. On the other hand, the share of conventional counterparties ranges between 93 and 99 percent in total payables of domestic conventional banks. We see a consistent funding/payables structure from 2014 to 2018 for both conventional and islamic domestic banks.

The on-balance sheet receivables of conventional domestic banks from conventional counterparties constitute between 97 and 99 percent of total receivables (Figure 5a and 5c). Different from the payables, the share of conventional counterparties is larger for the on-balance sheet receivables of islamic banks nearly in all quarters. Two of the five domestic islamic banks are subsidiaries of domestic conventional banks. Detailed analysis of the increasing share of domestic conventional banks in the total receivables of domestic islamic banks since 2016 shows that this increase is mainly due to the relations between domestic islamic banks and their parent domestic conventional banks. While Figure 5b, 5c and 5d suggest a preference by conventional (islamic) banks conventional (islamic) counterparties in lending/borrowing relations, subsidiary/parent relationship between islamic and conventional domestic banks dominate the business model relation in Figure 5a.

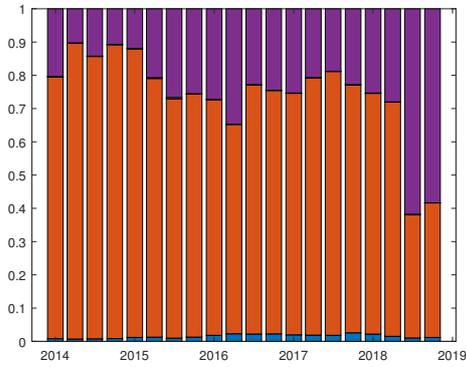
When we analyze the derivative transactions (Figure 5e and 5f), conventional foreign and conventional domestic banks are found to be major partner for both domestic



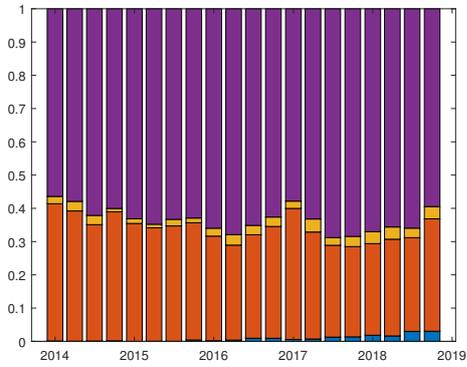
(a) On-balance sheet receivables of domestic Islamic banks



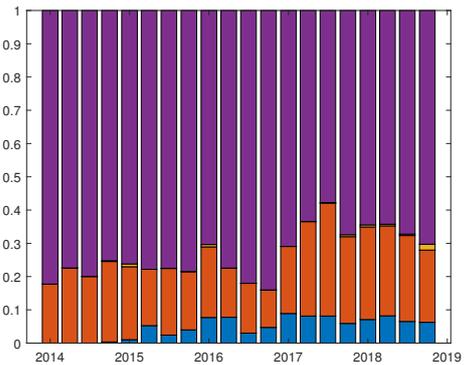
(b) On-balance sheet payables of domestic Islamic banks



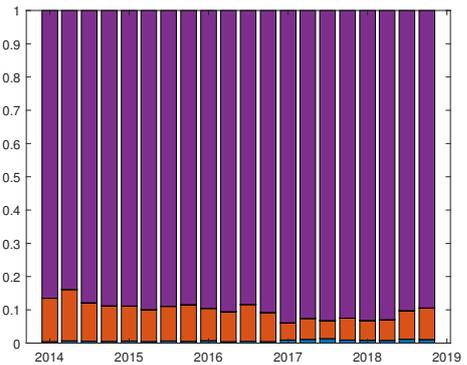
(c) On-balance sheet receivables of domestic conventional banks



(d) On-balance sheet payables of domestic conventional banks

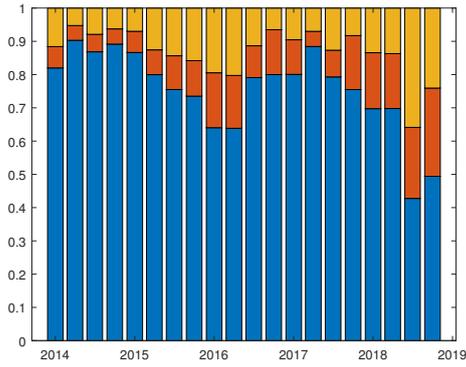


(e) Volume in off-balance sheet of domestic Islamic banks

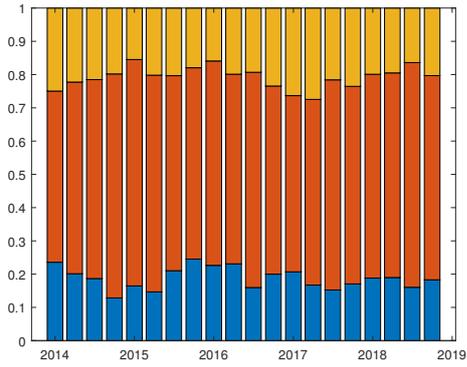


(f) Volume in off-balance sheet of domestic Islamic banks

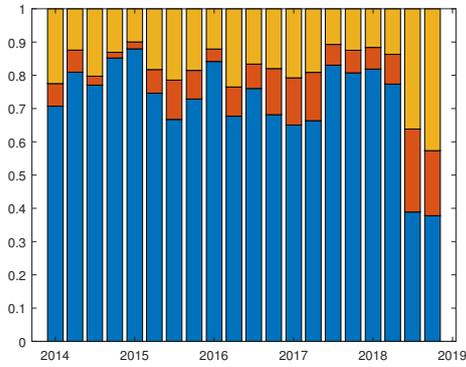
Figure 5: Percentage share of receivable/payable exposures between banking groups when banks are grouped as Islamic or conventional banks. Blue bar shows domestic Islamic, orange bar shows domestic conventional, yellow bar shows Islamic foreign, purple bar shows conventional foreign counterparties.



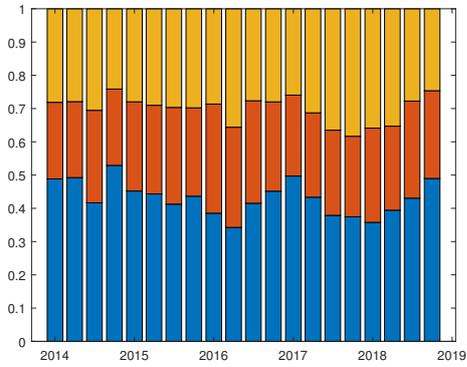
(a) On-balance sheet receivables of foreign-owned domestic banks



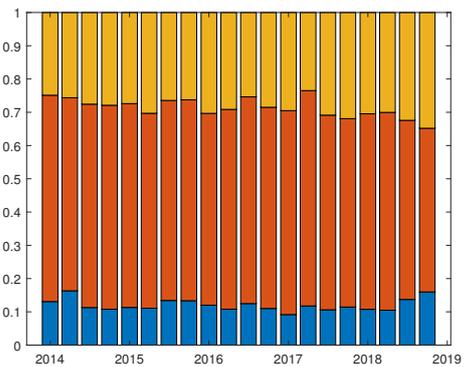
(b) On-balance sheet payables of foreign-owned domestic banks



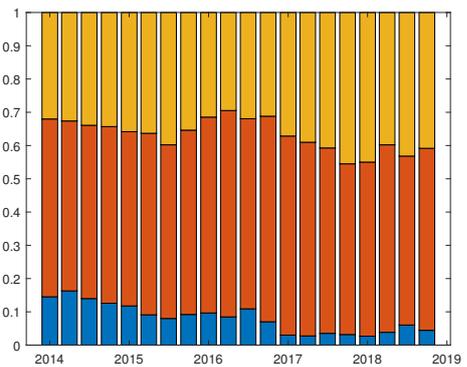
(c) On-balance sheet receivables of other domestic banks



(d) On-balance sheet payables of other domestic banks



(e) Volume in off-balance sheet of foreign-owned domestic banks



(f) Volume in off-balance sheet of other domestic banks

Figure 6: Percentage share of receivable/payable exposures between banking groups when banks are grouped as related/unrelated. Blue bar shows domestic counterparties, orange bar shows foreign counterparties having shares in domestic banks, yellow bar shows foreign counterparties not having shares.

conventional and domestic islamic banks. As presented in Figure 1d, swaps constitute an important share of derivative transactions of domestic banks. Since swaps rely on the exchange of the assets at the spot and forward dates, this product is accepted as a Shariah-compliant product and islamic banks can conduct swap transactions without considering the business model of the counterparty bank. Moreover, derivative transactions require specialization for making correct pricing and closing positions with other banks not to carry any financial risks. Thus, the concentration in derivative market is higher and larger banks in UK act as counterparty in these transactions for both domestic conventional and islamic banks.

For the analysis of related and unrelated banks, we similarly examine the receivable and payable exposures of banks based on shareholder information (Figure 6). We classify domestic banks as domestic banks with foreign partners (foreign-owned domestic banks) and without foreign partners (other domestic banks) and foreign banks as banks with shares in Turkish banks and other foreign banks. Using these classifications, we observe that there is no significant difference for the counterparties of domestic banks in on-balance sheet receivables but there are differences in the on-balance sheet payables. As seen in Figure 6a and 6c, most of the on-balance sheet receivable transactions of foreign-owned domestic banks and other domestic banks are conducted with domestic banks. From on-balance sheet payables, we find that foreign banks having shares in Turkish banks has a higher preference in terms of granting funds to their subsidiaries (foreign-owned domestic banks) compared to other domestic banks (Figure 6b and 6d). While the share of the funding from foreign banks that have shares in domestic banks in the total payables of their subsidiaries ranges between 51 and 68 percent in the analysis period, this share ranges between 23 and 33 percent for other domestic banks. Moreover, the share of cross-border borrowing in total borrowing shows that this share is larger for foreign-owned domestic banks compared to other domestic banks. While the share of cross-border borrowing in total borrowing ranges between 75 and 85 percent for the foreign-owned domestic banks this share ranges between 47 and 64 percent in the analysis period.

Another interesting observation is that, while the share of cross-border borrowing for other domestic banks decreases with the increasing volatility in the markets starting in the second quarter of 2018, the share for foreign-owned domestic banks is found to be more stable. This finding is compatible with Cerutti and Claessens (2016) showing cross-border lending to other banks is more sensitive to supply factors compared to the lending to the foreign affiliates of the same bank. For the derivatives, we do not observe a significant difference for the counterparty concentration of domestic banks (Figure 6e and 6f).

4 Network Statistics

In this section, we present several network statistics for each instrument to understand the characteristics and evolution of interbank relations. In the banking literature, network statistics are employed to identify systemically important banks in terms of having higher number of connections, having connections in larger volume or being on the intermediation flow of other banks. Understanding the network structure such as whether only a few banks are highly interconnected or whether the banking system is highly interconnected helps the regulators to focus their attention to more risky institutions. Before starting to explain network statistics in detail, we present number of links and number of active banks in each instrument.

Figure 7a shows link breakdown in each instrument. Similar to the share in total size, repo type instruments has minimum share in the link breakdown. The number of links in repo type instruments opened in the last quarter of 2018 amount to 97 which is nearly half of the links in the beginning of the analysis period.

Deposit and loan type instruments have similar number of links. The number of links entered into into in the last quarter of 2018 are 606 and 589 respectively for these instruments. Although, there are smaller number of banks that are active in derivative transactions, derivative instruments have higher number of links. While the opened number of links in the first quarter of 2014 is 2980, the size of these links decreases to 2020 in the last quarter of 2018.

During the sample period, not all banks are active in each type instrument in all quarters. For example, there are foreign banks that resident banks in Turkey establish interbank links via only derivative transactions and do not have any on-balance sheet receivable or payable with resident banks in Turkey. Moreover, all banks may not enter into transaction with resident banks in Turkey in each quarter. In Figure 7b, we document the number of active banks in different type of instruments. Active banks are the banks having total degree different than zero, in other words having at least one payable or receivable relation with another bank in the network. Figure 7b shows that number of active banks in repo transactions range between 42 and 55, which is smaller compared to other instruments. Figure 7b also shows that number of active banks in all type of instruments decreases in the last quarter compared to the first period of the analysis. An interesting finding is that number of banks that lend in loan type decreases by 53 banks in the third quarter of 2018 compared to the second quarter of 2018.

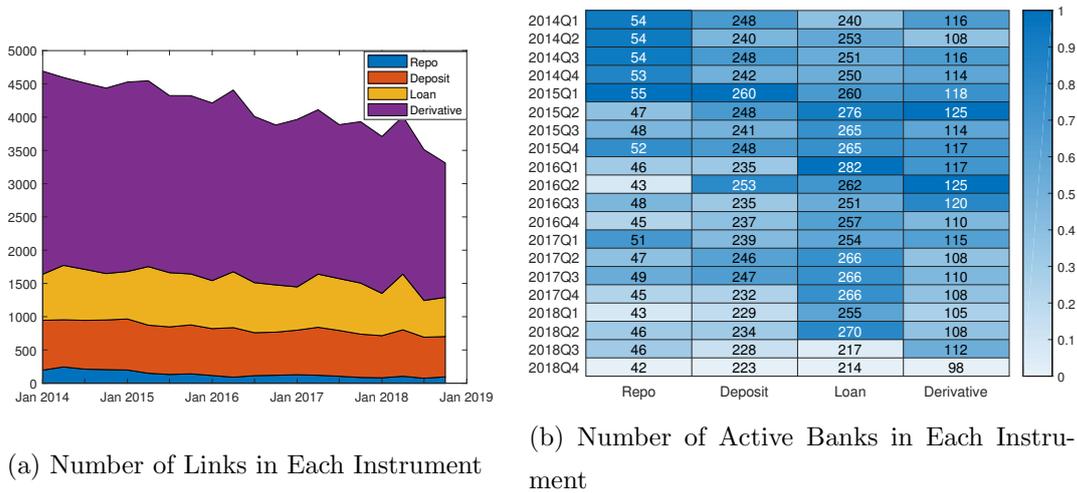


Figure 7: Number of Links and Active Banks. The figure on the right shows the number of active banks in terms of having at least one receivable or payable link with any other bank in the specific quarter. This figure is coloured based on the number of banks in each column where higher number of banks is shown with darker blue.

One of the network statistics that is extensively studied in the literature is degree, which shows the number of connections of a bank. More specifically, in-degree shows number of incoming links to the bank and out-degree shows number of outgoing links of the bank. Total-degree is the sum of in-degree and out-degree which shows the number of lending and borrowing relations of a bank. Degree is formulated mathematically based on the elements of adjacency matrix A , where a_{ij} takes value of 1 if bank i is lending to bank j and 0 otherwise.

$$\text{In-degree} = k_i^{\text{in}} = \sum_j a_{ji}$$

$$\text{Out-degree} = k_i^{\text{out}} = \sum_j a_{ij}$$

In Figure 8, we present average degrees for resident banks in Turkey, i.e., total number of degrees of resident banks divided by the number of resident banks. For repo transactions, in-degree and out-degree move similarly. Since domestic banks enter into transaction with each other in most of the time compared to entering into transaction with foreign banks in repo contracts, their comovements are understandable. Since in-degree is higher than out-degree, domestic banks receive more frequent compared to lending money in repo transactions. Average degree in deposit type instruments is higher compared to repo transactions and in-degree and out-degree does not move similarly compared to repo transactions. For loan transactions, in-degree shows a seasonal pattern increasing in the second quarter of the years. Domestic banks make syndication loan agreements with foreign-domiciled banks and renew some percent of these loan each year at the current

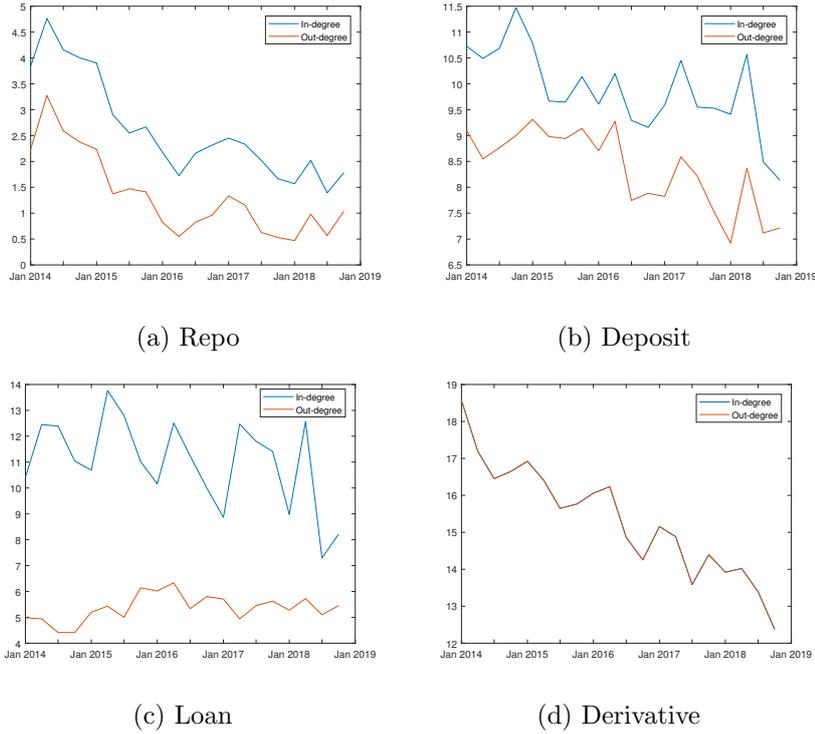


Figure 8: Average in-degree and out-degree for domestic banks.

market rates. Depending on the FX fund need, Turkish banks either renew the contracts above/below or at 100 percent. Since renewing these contracts is perceived in the market that banks are sound enough to find funds, even though the interest rate of syndication loans is higher compared to alternative funding sources, banks prefer to renew these loans. Thus, in-degree increases seasonally and then decreases until the new rollover date of syndication loans. For derivative transactions, since each transaction is registered as a double entry, in-degree equals out-degree. Degree in derivative instruments also show a cyclical behaviour similar to loan transactions. Since banks are using derivative transactions to hedge currency risk and to be able to lend loans in domestic currency, they renew derivative transactions when they open a FX loan. However, peak points are observed in derivative transactions more often compared to loan transactions due to the need of other derivative operations such as hedging of interest rate risk. Moreover, we also observe that there is a decreasing trend in the average degree of derivative transactions.

Another network statistic is strength which is similar to degree, however calculated using weighted matrix. In-strength of the bank shows the total amount of credit it receives and out-strength shows the total amount of credit it lends. Strength is formulated mathematically based on the elements of weighted matrix W , where w_{ij} shows amount of credit given by node i to node j .

$$\begin{aligned} \text{In-strength} &= s_i^{\text{in}} = \sum_j w_{ji} \\ \text{Out-strength} &= s_i^{\text{out}} = \sum_j w_{ij} \end{aligned}$$

Network statistics can also be used to identify systemically important banks in terms of being most connected. By calculating the rankings of banks in each instrument for each quarter, we analyze the change in the rankings of banks based on both degree and strength of the bank. If a bank has zero degree or zero strength in the related period and instrument, then we do not assign any ranking to the bank. Using correlation coefficient of rankings for the consecutive quarters, we investigate the change in bank rankings. Since any ranking is not assigned for inactive banks, in the correlation coefficient calculation only active banks in both consecutive periods is taken into account. We document descriptive statistics in Table 4 and 5 for degree-based and strength-based rankings respectively. Since correlation coefficient is calculated for banks opening transaction in both periods, we observe very high correlations. In other words, if a bank is entering into a transaction in consecutive periods, the significance ranking of that bank does not change significantly. Mean value of correlation coefficients is lower and standard deviation is higher for repo transactions due to shorter maturity structure of these transactions. Since repo is a source of short-term financing, relative importance of the banks that are entered into relation in these transactions changes easier. The importance of counterparties seems to be not essential in the short-term transactions for banks in liquidity need. Minimum value of correlation coefficient in repo transactions is found to be 0.28 when comparing the rankings of second and third quarter of 2018, which is the period that exchange rate volatility is observed (Table 4). A detailed analysis shows that some Turkish banks increased their rankings for in-degree statistic of repo transactions and some decreased their rankings which changed rankings of banks in that period. On the other hand, we have not observed any significant change of the rankings in repo transactions based on strength when the second quarter of 2018 is compared with the third quarter of 2018.

Table 4: Descriptive Statistics for Rank Correlation of Degree in the Consequent Quarters

| | In-degree | | | | Out-degree | | | |
|------|-----------|---------|------|------------|------------|---------|------|------------|
| | Repo | Deposit | Loan | Derivative | Repo | Deposit | Loan | Derivative |
| Mean | 0.79 | 0.91 | 0.81 | 0.96 | 0.77 | 0.92 | 0.84 | 0.96 |
| Min | 0.28 | 0.87 | 0.76 | 0.93 | 0.57 | 0.89 | 0.79 | 0.93 |
| Max | 0.92 | 0.94 | 0.88 | 0.98 | 0.92 | 0.95 | 0.92 | 0.98 |
| Std | 0.15 | 0.02 | 0.04 | 0.02 | 0.09 | 0.01 | 0.03 | 0.01 |

Notes: The table shows descriptive statistics of rank correlations of banks based on their degree. First, rank of each bank for the related quarter and instrument is calculated based on its degree. A bank having zero degree in the related period is not assigned any rank. Then rank correlations between period t and period $t+1$ is calculated and then descriptive statistics is calculated based on pair correlations over 20 periods.

Table 5: Descriptive Statistics for Rank Correlation of Strength in the Consequent Quarters

| | In-degree | | | | Out-degree | | | |
|------|-----------|---------|------|------------|------------|---------|------|------------|
| | Repo | Deposit | Loan | Derivative | Repo | Deposit | Loan | Derivative |
| Mean | 0.87 | 0.90 | 0.85 | 0.97 | 0.85 | 0.92 | 0.82 | 0.97 |
| Min | 0.70 | 0.86 | 0.79 | 0.94 | 0.68 | 0.90 | 0.77 | 0.94 |
| Max | 0.96 | 0.93 | 0.91 | 0.98 | 0.96 | 0.95 | 0.87 | 0.98 |
| Std | 0.07 | 0.02 | 0.03 | 0.01 | 0.07 | 0.01 | 0.03 | 0.01 |

Notes: The table shows descriptive statistics of rank correlations of banks based on their strength. First, rank of each bank for the related quarter and instrument is calculated based on its strength. A bank having zero strength in the related period is not assigned any rank. Then rank correlations between period t and period $t+1$ is calculated and then descriptive statistics is calculated based on pair correlations over 20 periods.

While degree statistics is based on number of links, strength is proportional to the size of these links. We also examine the correlation coefficients between rankings based on total degree and rankings based on total strength for each instrument. Although the correlation coefficients between strength and degree are found to be high in each instrument, highest correlation coefficient is observed for derivative network. In derivatives, larger foreign banks are active and there is a concentration in terms of number of active banks in that market. Since larger banks make transactions in larger amounts, correlation coefficient between rankings based on degree and strength becomes higher. However, in repo transactions, smaller banks are also active and the value of transactions varies in magnitude for many banks in the market. Thus, correlation coefficient is both volatile and relatively small for repo transactions (Figure 9).

We could not calculate standard network statistics as betweenness centrality or closeness centrality, since foreign bank-foreign bank region of the networks are missing. Due

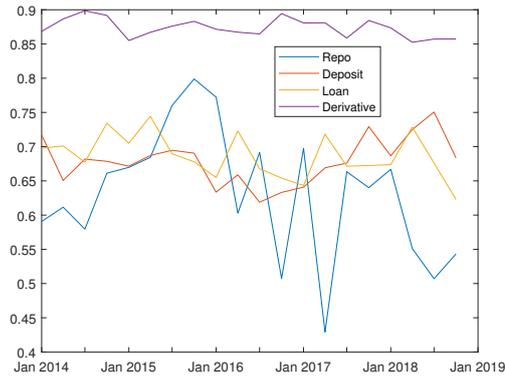


Figure 9: Correlation between rankings based on total degree and rankings based on total strength, where total degree shows the sum of in-degree and out-degree and total strength shows the sum of in-strength and out-strength.

to unobserved links between some banks, possible triad structures in the network would be restricted. For example, foreign banks that are connected with only one Turkish bank would have zero betweenness centrality.¹⁷

5 Similarity Analysis

In this section, we analyze similarities in the networks using Cosine and Jaccard indexes. While Jaccard index calculates similarity over adjacency matrix, Cosine index calculates over weighted exposures matrices. Cosine similarity index is a point-wise similarity measure and computes the angle between two vectors. If two vectors are same or a multiple of each other, then Cosine similarity between these two vectors are one. So, if all relations in the network is multiplied with the same constant such as inflation rate or exchange rate and a new matrix is created, Cosine similarity between these two networks will be same. Cosine similarity between networks, say W and Z , which are both weighted exposures matrices, is calculated with the following formula which is the ratio of dot product of two vectors over the multiples of the lengths of these vectors:

$$\text{Cosine similarity index} = \frac{W \cdot Z}{\|W\| \|Z\|}$$

Jaccard index between networks, say X and Y , which are adjacency matrices, is calculated

¹⁷Same argument was also raised in Cerutti and Zhou (2017) due to missing periphery-core and periphery-periphery regions in their networks. They call reporting lender countries as core and other borrower countries as periphery.

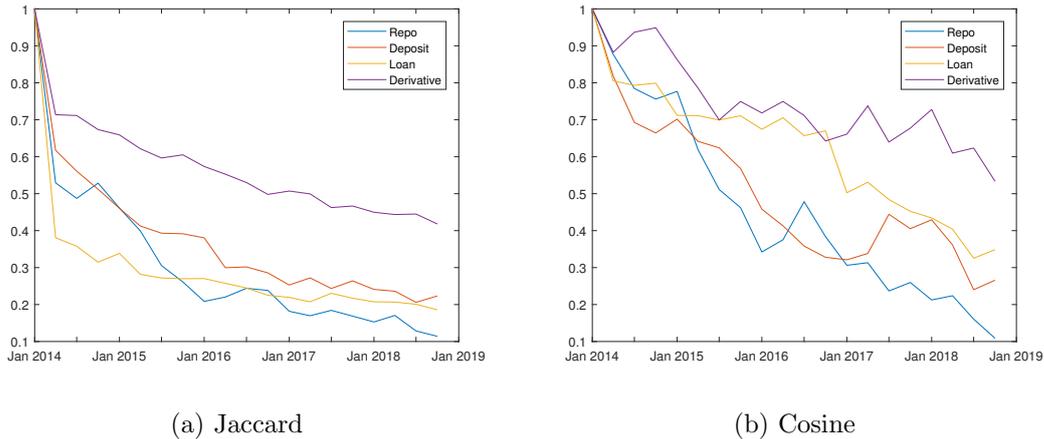


Figure 10: Over time similarity of instrument-level networks. The figure on the left shows calculated similarity index via Jaccard index and on the right with Cosine index. 2014Q1 is selected as the base quarter and networks in the following quarters are used to calculate the similarity.

as the intersection of two vectors over the union of these networks.

$$\text{Jaccard similarity index} = \frac{|X \cap Y|}{|X \cup Y|}$$

Recently, a number of papers compute similarity indexes to examine interbank markets. For example, Aldasoro and Alves (2018) investigate the similarity between different type of instruments and maturities of large European banks. Bargigli et al. (2015) analyze time persistence in Italian interbank market using these indexes. In this paper, we calculate over time similarity in each instrument level network. By taking the network in the first quarter of 2014 as the base year network, we compare the similarity with the networks in the following quarters. Thus, similarity index in the first quarter of 2014 takes value 1.

As seen in Figure 10, both Jaccard and Cosine similarity index show that similarity in derivative network is higher compared to other instrument level networks. In derivative transactions, domestic banks interact with larger foreign banks consistently that are specialized in these transactions which makes over time similarity in derivative networks higher. Higher correlation in derivative transactions that is presented in Table 4 and Table 5 in terms of ranks of banks also confirm higher similarity found for these transactions. On the other hand, we find that the smallest over time similarity is for repo transactions. These transactions are conducted for short-term liquidity needs and banks may have repo receivable or payable depending on the liquidity need in that period which makes similarity over time smaller.

We also investigate the similarity between different instrument-level networks. We find

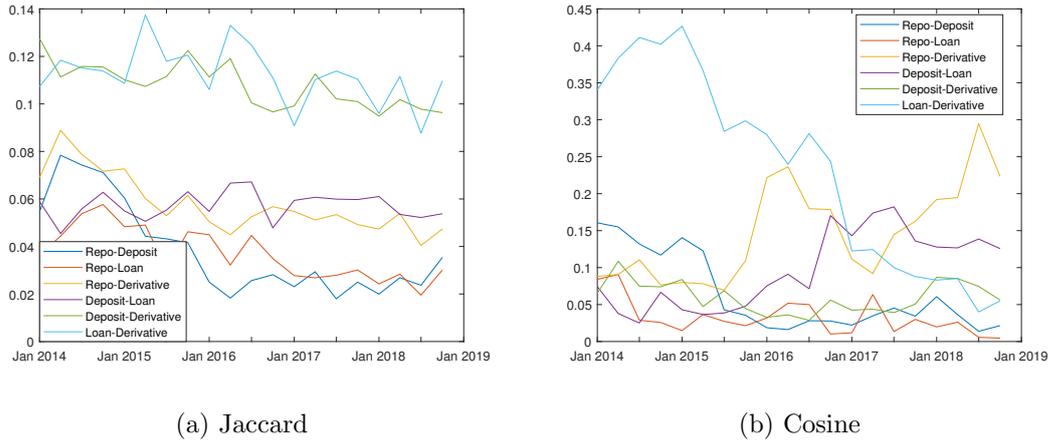


Figure 11: Between similarity of instrument-level networks. The figure on the left shows calculated similarity index via Jaccard index and on the right with Cosine index.

that between similarity is higher for loan and derivative transactions if adjacency matrices is taken into account, in other words similarity is calculated with Jaccard index (Figure 11). Moreover, if weighted exposures are taken into account, while in the first three quarters of 2014, the highest similarity is again between derivative and loan networks, their similarity decreased in the following quarters. Detailed analysis of similarity between derivative and loan networks show that while some larger foreign banks that have shares in domestic banks gave loans in larger amounts to their subsidiaries in 2014, they decreased their lending in type of loan. Yet, these banks continued to be a significant counterparty in derivative transactions, which decreased the similarity between loan and derivative networks when weighted matrices are considered.

6 Conclusion

In the literature, there is a growing interest on studying interbank transactions using network theory especially after the global financial crisis in 2007-2009. However, due to data limitations, there are still many interesting research questions not explored, especially interbank network relations in a global perspective. In this paper we aim to contribute to this literature by analyzing the relations of a globally interconnected emerging economy. We study the interbank relations between resident banks in Turkey and foreign-domiciled banks for the 2014-2018 period via considering instrument-level networks such as loan, repo, deposit and derivative. Balance sheet composition of domestic banks makes Turkey interesting for studying interbank relations. Syndication loan received from foreign countries in foreign currency (FX) is an important financing source for Turkey, however since

FX loan demand from Turkish corporates is not enough, domestic banks need to make cross currency swaps to be able to lend local currency loans. This structure increases the interbank relations of domestic banks with foreign counterparties.

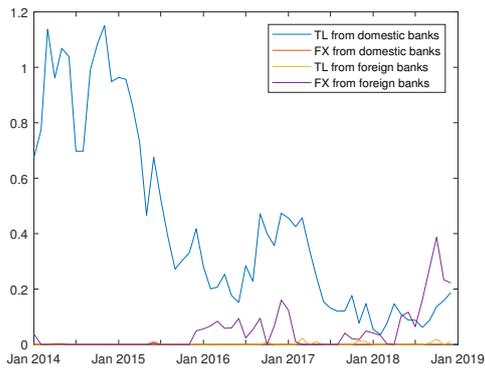
In our analysis, we use several network statistics to examine the characteristics of interbank relations of Turkish banks. We see cyclical movements in loan and derivative degree distributions due to syndication loan renewals. We show that ranks of borrower/lender counterparties of Turkey is highly correlated if these banks are determined using degree or strength statistics. We also analyze over time and between instrument similarities for instrument-level networks using both Jaccard and Cosine similarity indices and find that over time similarity is lowest for repo transactions due to being a short-term financing source and between instrument similarity is highest between loan and derivative instruments.

In Turkey, there are different types of banks in terms of their business models and/or their ownership structures. There are subsidiaries of foreign banks or greenfield banks as well as banks without any or significant foreign shares. Some domestic and foreign banks operate according to conventional banking principles but some according to islamic principles. We group banks according to having shares in domestic banks or not and the ones that are islamic and conventional and analyze the relations between these banking groups. We find that islamic domestic banks prefer to invest excess funds or receive loan from islamic counterparties, however since derivative transactions require specialized pricing and the nature of swap transactions are Shariah-compliant, in derivative transactions they transact with conventional banks. We also show that foreign banks having shares in domestic banks prefer to lend to their subsidiaries in Turkey since most frequent counterparty in loan payables of domestic banks that have shares of foreign banks is the foreign banks having shares in domestic banks.

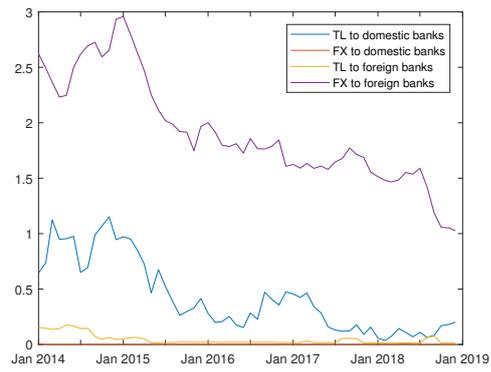
Turkey has experienced an exchange rate volatility in the third quarter of 2018, in which currency depreciated significantly. We investigate the effects of this currency movement in interbank relations as well. We document that banks used their excess FX liquidity as repo or deposit in foreign banks due to slow-down in economic growth. Then, we observe a decrease in the number of foreign banks that act as counterparty especially in loan and derivative transactions. Interbank relations may deteriorate after a country facing with financial crisis and may have widespread effects in the credit supply to the real economy of other countries. Therefore, regulatory authorities should be aware of the risks that may stem from interbank relations, concentration in these relations, comovement

between different type of relations and possible effects of crisis in interbank relations. We believe that this study sheds light on important characteristics of interbank relations of Turkish banks which is not explored before.

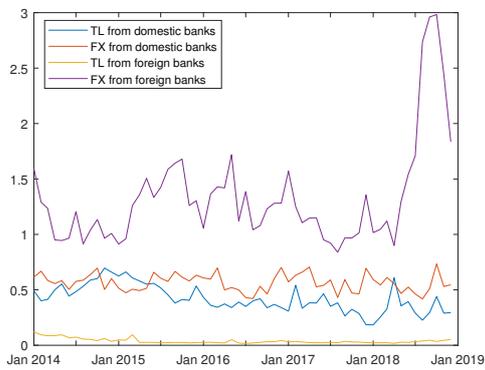
Appendix



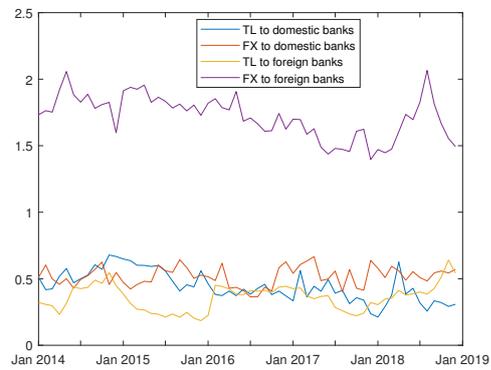
(a) Repo receivables over total assets



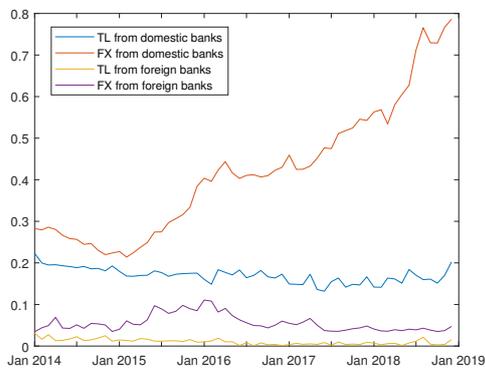
(b) Repo payables over total assets



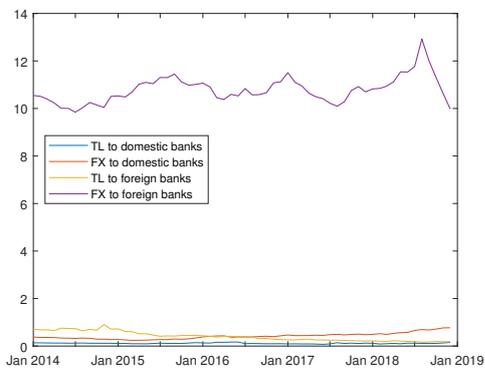
(c) Deposit receivables over total assets



(d) Deposit payables over total assets



(e) Loan receivables over total assets



(f) Loan payables over total assets

Figure A1: Instrument Breakdown of On-balance Sheet Receivables and Payables

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