

SYSTEMIC RISK AND FINANCIAL NETWORKS

A Ph.D. Dissertation

by

TUBA PELİN SÜMER

The Department of Management
İhsan Doğramacı Bilkent University
Ankara

December 2019

TUBA PELİN SÜMER

SYSTEMIC RISK AND FINANCIAL NETWORKS

Bilkent University 2019

To my family

SYSTEMIC RISK AND FINANCIAL NETWORKS

The Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

by

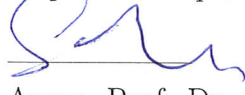
TUBA PELİN SÜMER

In Partial Fulfillment of the Requirements for the Degree of
DOCTOR OF PHILOSOPHY IN MANAGEMENT

THE DEPARTMENT OF MANAGEMENT
İHSAN DOĞRAMACI BİLKENT UNIVERSITY
ANKARA

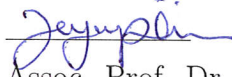
December 2019

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Finance.



Assoc. Prof. Dr. Süheyla Özyıldırım
Supervisor

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Finance.



Assoc. Prof. Dr. Zeynep Önder
Examining Committee Member

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Finance.



Asst. Prof. Dr. Çağın Ararat
Examining Committee Member

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Finance.



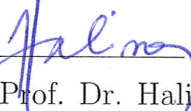
Prof. Dr. Erol Taymaz
Examining Committee Member

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Finance.



Asst. Prof. Dr. İlkey Şendeniz Yüncü
Examining Committee Member

Approval of the Institute of Economics and Social Sciences



Prof. Dr. Halime Demirkan
Director

ABSTRACT

SYSTEMIC RISK AND FINANCIAL NETWORKS

Sümer, Tuba Pelin
Ph.D. in Department of Management
Supervisor: Assoc. Prof. Dr. Süheyla Özyıldırım

December 2019

This thesis investigates the interbank relations of Turkish banks with each other and foreign banks abroad. In the first chapter, we focus on the interbank relations between domestic banks and study the effects of bank ownership structure on the interbank network structure. During the sample period of 2003-2017, we observe that foreign and state-owned banks play dominant role in shaping the network structure. Foreign banks, in particular, have a higher coreness vector in derivative exposures through their comparative advantage in offsetting derivative transactions. Moreover, our findings indicate that when a foreign investor acquires a domestic bank, the network structure of the acquired bank changes considerably. We also present evidence that local and Basel III regulations play a significant role in the formation of the network structure through liquidity channel. In the second chapter, we focus on the interbank relations between banks in Turkey and foreign banks abroad for 2014-2018 period. Funding from foreign banks in repo, deposit and loan type is an important financing channel for domestic banks. For hedging currency risk, domestic banks are also making derivative transactions with foreign counterparties. We document several network statistics and analyze the similarities of bank rankings in these statistics. Moreover, we examine the similarities between different instrument-level networks as repo, loan, deposit and derivatives. By differentiating foreign banks as

the banks having shares in domestic banks and others and the banks that work according to islamic principles and others, we investigate the evolvement of interbank relations between these groups.

Keywords: Core-periphery, Cross-border Bank Lending, Interbank Markets, Network Analysis, Ownership Structure

ÖZET

SİSTEMİK RİSK VE FİNANSAL AĞLAR

Sümer, Tuba Pelin
Doktora, İşletme
Tez Danışmanı: Doç. Dr. Süheyla Özyıldırım

Aralık 2019

Bu tez, Türkiye'deki yerli bankaların birbirleri arasındaki ve yurt dışındaki yabancı bankalarla olan borç/alacak ilişkilerini incelemektedir. Birinci bölümde, yerli bankalar arasındaki ilişkilere odaklanılmakta ve banka sahipliği yapısının bankalararası ağ yapısı üzerindeki etkileri analiz edilmektedir. 2003-2017 analiz döneminde, yabancı ve kamu bankalarının ağ yapısını şekillendirmede önemli rol oynadığı gözlenmektedir. Yabancı bankaların türev işlemlerini yurt dışı bankalar ile kapatmada diğer bankalara göre avantajlı olmaları nedeniyle, türev işlemlerdeki sistemik önemlerinin daha yüksek olduğu görülmektedir. Ayrıca, yabancı yatırımcının Türk bankasını satın almasından sonra, satın alınan bankanın ağ yapısının önemli ölçüde değiştiği bulunmaktadır. Yerel ve Basel III düzenlemelerinin, likidite kanalıyla ağ yapısının oluşumunda önemli bir rol oynadığı gözlenmektedir. İkinci bölümde, 2014-2018 dönemi için Türkiye'deki bankalar ile yurtdışı bankalar arasındaki bankalararası ilişkiler incelenmektedir. Yabancı bankalardan repo, mevduat ve kredi şeklinde sağlanan fonlar Türkiye'de yerleşik bankalar için önemli bir finansman kanalıdır. Türkiye'deki bankalar, kur riskinden korunmak için aynı zamanda yabancı taraflarla türev işlemler yapmaktadır. Öncelikle, bazı ağ istatistiklerini raporlayarak bu istatistiklerdeki banka sıralamasının benzerliklerini analiz ediyoruz. Ayrıca, repo, kredi, mevduat ve

türevler gibi farklı enstrüman düzeyindeki ağlar arasındaki benzerlikleri inceliyoruz. Yabancı bankaları Türkiye'deki bankalarda pay sahibi olan bankalar ve diğerleri ile islami ilkelere göre çalışan bankalar ve diğerleri olarak ayırarak bu gruplar arasındaki ilişkilerin gelişimini inceliyoruz.

Anahtar Kelimeler: Ağ Analizi, Bankalararası Piyasalar, Merkez-çevre, Sahiplik Yapısı, Sınır Ötesi Banka Kredileri

ACKNOWLEDGEMENTS

I would like to express my gratitudes to the people who have supported me during this tiring and long-lasting PhD process.

First of all, I would like to thank to Assoc. Prof. Dr. Burçhan Sakarya who supported me for starting PhD in the first year of my professional life in Banking Regulation and Supervision Agency. Without him, I may not have chance to start PhD in the early years of my career, since he persuaded our director that I can manage to conduct both academic and job-related duties. He will always be a role model for me with his enthusiasm, kindness and determination to work.

Foremost, I would like to express my sincere thanks to my advisor, Assoc. Prof. Dr. Süheyla Özyıldırım for her encouragement, guidance and availability when I need her. She devoted great time for me via meeting with me after work or on the weekends without complying, since I couldn't leave work on working hours most of the time. She always made me feel that I can do the better and extended my vision. With her suggestions, I had a chance to present our studies in two good international conferences which affected my future plans.

I am very grateful to Assoc. Prof. Dr. Zeynep Önder and Assist. Prof. Dr. Çağın Ararat for being member of my thesis committee meetings, their suggestions, support and guidance for four years. I am also indebted to Assoc. Prof. Dr. Fehmi Tanrıseven for attending to my all thesis committee meetings without having a voting right and giving valuable contributions. It was a nice coincidence to be in Bilkent University after supervised by him in my master study in Eindhoven University of Technology and I felt his continuous support during six years.

I am grateful to Prof. Dr. Erol Taymaz and Assist. Prof. Dr. İlkey Şendeniz Yüncü for accepting to read my thesis and participating in my thesis defense committee. Their interest, comments, positive attitude and support in my defense was invaluable.

I am very thankful to Assist. Prof. Dr. Ahmet Şensoy for reviewing our article and giving suggestions for the publication process. I think that most weary part of PhD life in Bilkent University is the publication requirement and without his guidance waiting time for the publication would be much longer.

I feel lucky that I have taken main finance courses from Prof. Dr. Kürşat Aydoğan and Prof. Dr. Aslıhan Salih who are excellent scholars of Bilkent University that increase desires of students to learn and make you feel that you are on the correct way. I am also grateful to the faculty staff, especially Remin Tantoğlu for her help and constant support.

I would like to thank to the people with whom I shared this PhD process namely Müge Demir, Süleyman Serdengeçti, Utku Bora Geyikçi, Murat Tiniç, İdil Ayberk, Sevcan Uzun, İhsan Bozok, Alper Ali Hekimoğlu, Aylin Aslan and Zeynep Baktır. Their support and encouragement was very valuable while taking courses, preparing for the qualifier exam and sharing difficulties in the publication process. I am very grateful to Ayça Topaloğlu Bozkurt, that I felt her support especially in the last one year. I found myself asking for her advice when I felt indecisive and upset in both academic and professional life. I will miss our nice lunches and gatherings with our common advisor, Süheyla Özyıldırım.

I am also indebted to my colleagues in the Central Bank of the Republic of Turkey. During my six year PhD journey, I had stressed times due to coincidence of unexpected overtime work with my lectures, exams and deadlines in the thesis. Without their understanding, I may not accomplish to complete PhD. First of all, I

thank to the Director of Financial Stability Division, Hasan Erol, for his support and positive attitude for my last minute take day offs for PhD. I am very grateful to my dearest specialist Gülcan Yıldırım Güngör for her kindness and endless support during all my stressed times. While I am struggling to catch the lectures or meetings with my advisor after delivering the required job-related duties, I always found her either helping me to finish the required job or undertaking my jobs to be able to leave on time. I am grateful to Emine Özgü Özen Çavuşođlu, Ayşe Karasoy and Merve Demirbař Özbekler for sharing this journey with me, their help in my stressed times and encouragement for doing the better. I am also thankful to the other employees of Financial Stability Division for always cheering me up.

I thank to Merve Özkardeř, Demet Duman, Duygu Sinem Kılıboz and Elif Akman İzciler for their close friendship, their wishes and encouragement. Our travels and gatherings enabled me to take a breath. I am thankful for their understanding and their efforts to make plans according to my deadlines since I spent nearly all my weekends and holidays in the last two years via studying. I am grateful to Ezgi Deryol, Güzide Merve Öztürk, Zehra Çavuşođlu, Zeliha Fakılı and Neslihan Kurt for always making me feel that they are with me.

Last but not the least, I would like to thank my big family for encouraging me during the whole process. They always trust in me and feel proud with my successes. I am grateful to my mother, Kamile Sümer, and my father, Mehmet Sümer, for raising me and being with me in all my difficult times. While I am postponing the life for studying, I found them trying to ease things for me. I couldn't forget my mother's being more excited than me while waiting for my defense presentation. I feel lucky that I have a smart, thoughtful and eager-to-please brother, İbrahim Sümer, who became my closest friend and made me feel that he will stand by me when I need him. I am very grateful to my aunts Gönül Kaydırođlu, Hayriye Kılıç and Havva Kılıç for always cheering me up and

being a role model for me. I am especially thankful to my grandmother, Cennet Kılıç, who raised me and always prayed for my goodness and success.

TABLE OF CONTENTS

ABSTRACT	iii
ÖZET	v
ACKNOWLEDGEMENTS	vii
TABLE OF CONTENTS	xi
LIST OF TABLES	xiii
LIST OF FIGURES	xv
CHAPTER I: INTRODUCTION	1
1.1 Overview	1
CHAPTER II: INTERBANK NETWORK BETWEEN TURKISH BANKS	5
2.1 Introduction	5
2.2 Data Description	10
2.2.1 Network Statistics	16
2.3 Network Structure	22
2.3.1 Discrete CP Structure Analysis	22
2.3.2 Continuous CP Structure Analysis	27
2.3.3 Commonality of Core Banks in Instrument-based Networks	30
2.4 Banking Group Networks	32
2.4.1 Determinants of Coreness Measure	37
2.4.2 Change in Banking Group Networks	45
2.4.3 Effect of Foreign Bank Purchases on Network Structure	49
2.5 Conclusion	52

CHAPTER III: CROSS BORDER INTERBANK NETWORK OF TURKISH	
BANKS	55
3.1 Introduction	55
3.2 Data Description	61
3.3 Banking Group Relations	76
3.4 Network Statistics	82
3.4.1 Degree and Strength	82
3.4.2 Herfindahl-Hirschman Index (HHI)	91
3.5 Similarity Analysis	95
3.6 Conclusion	98
CHAPTER IV: CONCLUSION	101
REFERENCES	103
APPENDICES	108

LIST OF TABLES

2.1	Number of Transactions	12
2.2	Core Banks and Error Scores for Instrument-based Networks	24
2.3	Commonality of Core Banks in Instrument-based Networks	31
2.4	Panel Estimations for the Determinants of Total Coreness Measure	40
2.5	Panel Estimations for the Determinants of Derivative Coreness Measure	43
2.6	Panel Estimations for Determinants of Security Coreness Measure	46
2.7	Cosine Similarity Index of the Networks Before and After Foreign Purchases.	51
3.1	An Example for Double Entry Reporting of a Derivative Transaction	63
3.2	Turkish Lira (TL) and Foreign Currency (FX) Composition of Assets and Liabilities of Turkish Banking Sector as of December 2018	66
3.3	Banking Groups in the Analysis	68
3.4	Country Breakdown in the First Dataset	70
3.5	Country Breakdown in the Second Dataset	72
3.6	Network Construction	73
3.7	Descriptive Statistics for Rank Correlation of Degree in the Consequent Quarters	88
3.8	Descriptive Statistics for Rank Correlation of Strength in the Consequent Quarters	89
3.9	Descriptive Statistics of HHI	95

A1	Descriptive Statistics and Correlations	112
A2	Foreign Purchases of Turkish Banks	113

LIST OF FIGURES

2.1	Network Relations	13
2.2	Breakdown of Interbank Exposures	15
2.3	Density of Interbank Transactions	16
2.4	Network Statistics of Turkish Interbank Market	20
2.5	Error Scores and Number of Core Banks under Discrete CP Structure	23
2.6	Relation Between Asset Ranks and Percentage of Assignment as a Core Bank in Discrete CP Analysis	26
2.7	Coreness Measures under Continuous CP Structure	28
2.8	Continuous CP Model-Incoreness vs Outcoreness	29
2.9	Network Relations Between Banking Groups	35
2.10	Interbank Repo Amount and Interest Rate Differential	36
2.11	Average Coreness Measure in Derivative Exposures for Banking Groups	41
2.12	Cosine Similarity Index Between Banking Groups.	48
3.1	Breakdown of Transactions in the First and Second Dataset	64
3.2	Receivables and Payables in Type of Repo, Deposit and Loan	69
3.3	Traded Volume in Derivatives	71
3.4	Exposures in the Related Quarters	74
3.5	Number of Links and Active Banks	75
3.6	Relations between Banking Groups	78

3.7	Percentage Share of Receivable Exposures between Banking Groups when Banks are Grouped as Islamic or Conventional Banks	80
3.8	Percentage Share of Payable Exposures between Banking Groups when Banks are Grouped as Islamic or Conventional Banks	81
3.9	Percentage Share of Receivable Exposures between Banking Groups when Banks are Grouped according to Shareholder Structure	83
3.10	Percentage Share of Payable Exposures between Banking Groups when Banks are Grouped according to Shareholder Structure	84
3.11	Average in-degree for All Banks	85
3.12	Average in-degree and out-degree for Domestic Banks	87
3.13	Correlation between Rankings based on Total Degree and Total Strength	91
3.14	Average in-strength and out-strength according to Bank Groups . . .	92
3.15	Number of Active Banks in the Related Instrument	93
3.16	Through Time Similarity of Instrument-level Networks	97
3.17	Between Similarity of Instrument-level Networks	98
A1	Network Relations Between Banking Groups for Deposit and Loan Type Exposures in Currency Breakdown	111
A2	Histograms for in-degree Distributions	114

CHAPTER I

INTRODUCTION

1.1. Overview

Banks establish interbank links mainly to protect themselves from random liquidity shocks, for maturity transformation and to increase the share of their funds held in long-term assets. However, establishment of interbank links has also some drawbacks such as increase in contagion risk. Global financial crisis in 2007-2009 has shown the importance of understanding the network structure of interbank relations for a properly functioning market. Paul Volcker, former chairman of Fed, stated in one of his speeches in 2012 that the risk of failure of large, interconnected firms must be reduced, whether by reducing their size, curtailing their interconnections, or limiting their activities. In this study we focus on the interbank relations between banks resident in Turkey and foreign banks abroad. Using several network analysis techniques, we investigate the factors shaping interbank network relations. The findings of this study contribute to the literature by showing the role of bank ownership structure, business models of banks and nature of interbank contracts in forming the network structure. We believe that this study sheds light on important characteristics of interbank relations of Turkish banks which are not explored before. It is very important in an emerging economy such as Turkey to have deep and liquid interbank market. In case of unexpected

shocks, the ability of banks to provide loans depends on the availability of interbank sources. Given bank-based financial system in Turkey, the identification of network structure may help smooth functioning of interbank transactions and conduct of successful monetary policy.

In the next chapter of this thesis, we focus on the interbank relations between domestic Turkish banks for 2003-2017 period. Several network structures are proposed in the literature to explain interbank relations. First, we show that core-periphery (CP) structure, in which core banks are highly interconnected with each other and periphery banks connected to core banks but not connected with each other, gives a better fit to the Turkish interbank network compared to the random and scale-free structures. Second, we compare the set of core banks identified under different interbank contracts, such as repo, deposit, loan, and observe that set of core banks differs suggesting the existence of instrument-based networks. Third, we study the effect of bank ownership structure on interbank relations. There are different types of banks operating in Turkey such as state-owned deposit banks, foreign banks, participation banks and development banks. We find that foreign banks play an important role especially in shaping the derivatives markets. We observe that development banks, which are generally state-owned, invest their excess funds in state-owned deposit banks in terms of deposit and state-owned banks prefer to invest in government bonds instead of bank bonds, increasing the concentration of risks in the state-owned institutions. Fourth, we investigate the effect of foreign acquisitions on interbank relations. Over the last two decades, foreign banks have significantly increased their participation in Turkey similar to other emerging markets. We find that before the global financial crisis, after foreign purchases, a change in the controlling shareholders in the purchased bank caused the network to change for most of the banks. However, after the global crisis, the purchase of existing foreign banks by another foreign

bank or increasing shares of foreign stakes in the existing banks did not significantly change the existing network structure. Fifth, we investigate the interaction between financial regulations and interbank relations. In this chapter, we contribute to the literature via investigating the role of bank ownership structure, bank business model, financial regulations and foreign acquisitions in shaping the network structure which is not explored in the literature before to the best of our knowledge.

In the third chapter of the thesis, we examine the interbank relations between banks resident in Turkey and foreign banks abroad for a relatively short time period, 2014-2018 to understand network characteristics and relations with banking groups based on ownership structure and among banking groups with different business models. The size of interbank derivative market with foreign counterparties has grown very fast in Turkey as in most of the emerging economies. In this chapter, we confine our analysis period based on the availability of derivative reportings in Turkey. 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 chapter, 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 foreign countries constitute approximately 20 percent of their total liabilities and Turkish banks are making derivative transactions for hedging currency risk with foreign counterparties. 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 through time and between instrument similarity using both binary and weighted interbank relations. We observe that through 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. Third, 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 observe that islamic domestic banks seem to invest their excess funds more in islamic banks and borrow from foreign islamic banks most of the time during the analysis period. On the other hand, since derivative transactions requires specialized pricing, conventional banks form the most important counterparty for islamic domestic banks. We also present evidence that relations between foreign banks that have shares in domestic banks and domestic banks with foreign ownership is less volatile compared to the relations between other foreign banks and domestic banks. Turkey experienced a currency shock in August 2018, in which currency depreciated about 20 percent. Finally, we search for the effects of this shock in interbank relations as well. We find that domestic banks increased deposit and repo receivables from foreign banks after the shock to stay liquid. Moreover, rankings based on degree in the repo market, which is a short-term financing market, changed significantly in the crisis period. We believe that in that chapter we contributed to the cross-border interbank literature by investigating the relations of a well connected country which faced a local shock in different types of interbank contracts.

CHAPTER II

INTERBANK NETWORK BETWEEN TURKISH BANKS

2.1. Introduction

Banks rely on interbank links to protect themselves from random liquidity shocks as well as to increase the proportion of their assets held in long-term high profit assets. However, interbank relations may cause solvent banks to become insolvent due to the contagion effect. Also, an insolvent bank may be rescued since some part of the losses are transferred to the other banks which would bring about inefficiency and create moral hazard problems (Allen and Babus, 2009; Freixas et al., 2000). Despite its obvious relevance to policymakers, empirical research on the interconnectedness of the banking system had been underscored up until the recent global financial crisis.

Theoretical literature focuses on understanding of the relationship between the structure of the interbank network and the propagation of contagion. Allen and Gale (2000) show that in a structure that is “complete”, in which banks are all linked to each other, the system is less prone to contagion. In another words, in the case of the failure of a bank due to a higher than expected liquidity shock, it is argued that the remaining banks in the system insure themselves better against

liquidity shocks since their losses are shared with more banks; in this way, they can absorb the impact of the failure. They also introduce two highly stylized network structures, i.e., incomplete and disconnected market structures, and show the non-monotonic relationship between the network structure and the resilience of the network. Freixas et al. (2000) introduce another network structure in which there are money centers or core banks and the remaining banks in the periphery are linked to these core banks, but not to each other. They argue that this network structure may have a susceptible mechanism for the propagation and amplification of shocks.

Following the theoretical models, a strand of empirical studies explored the contagion effect of the failure of a bank or a banking group on the system via simulations (see e.g. Cont et al., 2010; Degryse and Nguyen, 2007; Furfine, 2003; Lelyveld and Liedorp, 2006; Upper and Worms, 2004). In addition to the contagious failure studies, the newly evolving literature investigates whether some “typical” network structures explain the actual networks in the banking systems using unique bilateral interbank data. In the literature, the typical financial network structures proposed are random networks, scale-free networks, core-periphery model and nested-split graph which are based on random interaction, preferential attachment, intermediation and counterparty reliability concepts respectively.¹

These seminal theoretical papers take the structure of financial networks as exogenously given and do not explicitly focus on the formation of financial networks. Acemoglu et al. (2015), however, emphasize the importance of the endogenous formation of strategic interbank linkages between different types of institutions, such as deposit-taking institutions, investment banks, and other

¹For detailed information on random networks see Erdős and Rényi (1959), for scale-free networks see Barabási and Albert (1999), for core-periphery networks see Craig and von Peter (2014) and for nested-split graphs see König et al. (2014)

specialized financial institutions in different interbank lending forms and maturity. In this paper, we aim to contribute to this literature by empirically investigating how the network structure between banks is shaped using a unique data set from Turkey. We rely on the importance of different interbank contracts as well as financial institutions with different ownership and business models in influencing the network structure.

In the literature, there is a paucity of studies showing the existence of multi-layer network structures according to the maturity, the nature (secure/unsecured) and/or the type of the contracts due to lack of data availability (Aldasoro and Alves, 2018; Bargigli et al., 2015; Langfield et al., 2014; Montagna and Kok, 2016). However, it is well-recognized that macro prudential policies benefit from the consideration of subnetworks and the extent that transmission channels across layers. In this paper, we examine the multi-layer network structure according to bank ownership in order to address the impact of a strong presence of foreign and state-owned banks on the network of the interbank activities. Turkey is an interesting country to study the network structures of several interbank contracts among different financial institutions since there are state-owned, private and foreign banks as deposit collecting institutions; investment and development banks as non-deposit collecting institutions; and participation banks collecting deposits (deposits are called as “participation fund” and these banks work according to Sharia rules). Turkish banks have learned the importance of establishing sustainable interbank lending relationships since the last banking crisis in 2001 which ended with the collapse of 18 banks one of which was a medium-size bank (the ninth largest), Demirbank (Dornbush, 2001; Akyüz and Boratov, 2003). Demirbank was holding 15 percent of total government bonds and funding these investments in the overnight interbank market. The failure of interbank borrowing and the increase of interest rates to 7000 percent caused the collapse of the bank

(Gençay and Selçuk, 2006). After the crisis, the regulatory framework was strongly improved and different banking groups formed interbank lending relationships to manage their liquidity and currency risks, using several new interbank contracts.

First we show that similar to previous evidence,² the core-periphery (CP) structure, with a number of highly interconnected (core) banks holding the market together, gives a better fit to the Turkish interbank network compared to the random and scale-free structures. The existence of CP structure might be expected for any emerging country considering that a few large banks tend to dominate these markets. Nevertheless, it is interesting to observe how large banks in the core set care their link formations to have sustainable and long-term funding relationships even if their exposures might be small compared to the more advanced countries. Second, commonality analysis shows that the set of core banks identified vary under different interbank contracts, suggesting the existence of instrument-based networks.

This chapter contributes to the literature in three ways. We study for the first time networks between different banking groups. To our knowledge, previous studies do not show whether certain banking groups have a comparative advantage in offsetting exposures under different interbank contracts. For example, we find that foreign banks play an important role, especially in shaping the over-the-counter (OTC) FX derivatives markets. One of the key lessons from the failure of Lehman Brothers in the unsecured interbank market, the repurchase market and the OTC derivatives markets is that a great deal of damage to the financial system might be inflicted in the absence of transparency in bilateral transactions. So, a closer look at the formation of interbank network structure would then be very important in

²See e.g. Craig and von Peter (2014) for Germany; Fricke and Lux (2015) for Italy; in't Veld and Van Lelyveld (2014) for Netherlands; Langfield et al. (2014) for UK; Silva et al. (2016) for Brazil; Martinez-Jaramillo et al. (2014) for Mexico and Aldasoro and Alves (2018) for a group of European countries.

countries that have seen a significant increase in foreign bank presence.

Development banks, which are generally state-owned, invest their excess funds in state-owned deposit banks in terms of deposit and state-owned banks prefer to invest in government bonds instead of bank bonds, increasing the concentration of risks in the state-owned institutions. A move to support state-controlled banks may lead to waste and slow growth as well as a raise in systemic risk as Fannie and Freddie, and the Spanish cajas so clearly show (Calomiris, 2011).

Our second contribution is the finding that the entry of foreign banks seems to change the overall network structure. Over the last two decades, foreign banks have significantly increased their participation in the emerging markets raising questions about their potential benefit especially in the credit markets. Since the global financial crisis of 2007, global banks have attracted marked interest from policy makers, researchers, and other financial sector stakeholders. We found that before the global financial crisis, there was intense foreign interest in the Turkish interbank market, and that after foreign purchases in that period, a change in the controlling shareholders in the purchased bank for most of the banks caused the network to change. However, after the global crisis, the purchase of existing foreign banks by another foreign bank or increasing shares of foreign stakes in the existing banks did not significantly change the existing network structure. To our knowledge, this is the first time that the effect of foreign bank purchases on the change in network relations has been analyzed.

As a final contribution, we present evidence that the local and international regulatory rules seem to shape the network structure. Banks having lower loan to deposit ratio, or higher liquidity coverage ratio (LCR) (defined according to Basel standards), make more investments in bank bonds since they have ample sources that can be used in bond investments. We find that there is a close relationship between the interbank repo amount and interest rate differential in the market

since some banks find an arbitrage opportunity due to the bank limits in repo transactions with the Central Bank. Our findings on the relation between regulations and interbank relations is also consistent with the literature as documented by Gabbi et al. (2015) for the effects of regulatory leverage ratio and Bonner (2016) for the increased preference for government bonds after capital and liquidity regulations.

The remainder of the chapter is organized as follows: In Section 2.2, we introduce the data set and highlight the Turkish banking structure as well as important features of the interbank market. Section 2.3 summarizes the CP network structure analysis, using all types of banks and financial instruments in Turkey. Section 2.4 discusses the network structure of instrument-based relations when banks are grouped according to their banking groups. The factors prevalent in explaining the coreness of a bank and the effect of foreign bank entries are analyzed in this section. Section 2.5 concludes the chapter.

2.2. Data Description

In this study, we use monthly transaction-level data that are collected by the Banking Regulation and Supervision Agency of Turkey. In the analysis, we cover different types of interbank contracts namely repo transactions, deposits, loans, securities, derivatives and other off-balance sheet items. Derivatives are swaps, forwards, futures and options used by banks to hedge interest rate and currency type risks. Other off-balance sheet items are the ones that are accounted in off-balance sheet other than derivatives such as letters of guarantee, bank acceptance, letters of credit and other guarantees. Securities refer to bond issuances, equity investments and credit-linked notes. Deposits cover both time and demand deposits. Loans include syndication loans, securitization loans,

subordinated loans, foreign trade financing loans and other loans. Repo transactions are used to borrow or lend short-term liquidity in exchange for securities.

The interbank data is based on individual bank reporting where reasonable doubts exist as to the correctness or the completeness of the data. A bank may report the exposure amount or type of exposure in an incorrect way, which is a common problem for all countries collecting transaction level data. In the network analysis, it is extremely important to use of a matching algorithm to obtain pairwise transaction data. In our dataset, since most of the transactions are reported as double entry, i.e., banks are reporting both their receivables and payables; we are able to use this matching algorithm. We match more than 70 percent of the available transactions since the beginning sample period of January 2003 (see Table 1).³ After, matching receivable and payable reportings of banks, we form monthly networks between banks from interbank transactions. There may be many transactions between a lender bank and a borrower bank in a specific month and interbank contract. For example, bank A may have opened a time deposit account on July 15, 2009 and a demand deposit on July 22, 2009 in Bank B. So, we band together the matched transactions between the same borrower/lender set for each month and instrument to form monthly networks between banks.

There are three main counterparties for the interbank exposures of banks. These are central banks, foreign banks abroad, and domestic banks. In this study, we only examine the exposures among banks that are operating in the Turkish domestic

³While the share of matched transactions in total transactions was 50 percent in the beginning of the analysis period, this ratio increased in the following years due to improvement in reportings. We find that share of matched transactions is smaller for deposit type relations. Detailed analysis showed us that while a bank in a deposit/loan type transaction is reporting this transaction as deposit, the other party in the relation is reporting as loan instrument. Since in the matching algorithm, we force also type of instrument reported to be same, we identify these transactions as unmatched.

Table 2.1: Number of Transactions

Transaction Types	Reporting Period	Number of Transactions	
		Before Match	After Match [†]
Repo	2003:1-2017:12	56,813	47,624
Deposit	2003:1-2017:12	159,166	87,341
Loan	2003:1-2017:12	1,552,545	1,138,541
Security	2007:1-2017:12	64,138	64,138
Derivative	2014:1-2017:12	40,133	40,133
Other Off-Balance Sheet	2003:1-2017:12	2,419,150	2,419,150
Total		4,291,945	3,796,927

Notes: Source of the data is the Banking Regulation and Supervision Agency of Turkey. Reporting period for interbank contracts are different due to data gaps. Total number of transactions in the dataset are reported in the table. [†]After match data show the available data after the cross-check procedure is carried out. The counterparty banks are determined using their tax numbers, swift codes or if they are not available in the data set using their names (this is a daunting task because a counterparty name can be written in many different formats, shortcuts or extensions). Interbank loan, deposit and repo transactions are reported in one dataset which is available for the period 2003-2017 in a monthly frequency. In that dataset domestic banks are reporting their receivables and payables, which helps to match the reporting of lender/borrower banks. To exemplify, if Bank A is reporting a receivable of \$100 from Bank B in loan type, Bank B should report this as \$100 payable to Bank A in loan type for an accurate reporting. Since this dataset covers a big portion of total interbank exposures, it is important to match the lender/borrower bank reporting and work with correct networks. The transactions that have same borrower/lender bank set, exposure type (loan/deposit/repo), exposure origination date \mp 2 day, exposure maturity date \mp 2 day, exposure amount up to 1% error and currency are assumed matched. In all the analysis these matched transactions are used.

market. For the last ten years, the Central Bank of Turkey has been the main liquidity provider, i.e., the average net funding of central bank is on average four percent of the total banking asset. As emphasized by Allen et al. (2009), the role of central banks in the interbank markets has changed since the global crisis and has become massively intervening. Considering the other motivations of the Central bank in the financial network such as restoring the normal functioning of the short-term interbank markets, we exclude the Central Bank of Turkey in our analysis. The foreign banks abroad are also excluded due to the unavailability of data between these and banks operating in the domestic market.

As of December 2017, there are 50 banks operating in Turkey (three state-owned

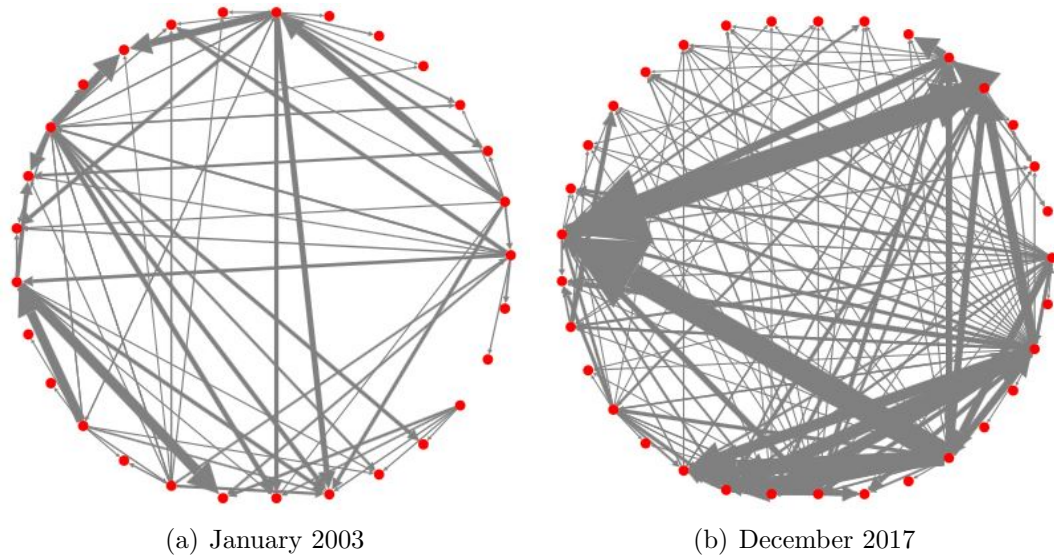


Figure 2.1: Network Relations

Notes: The relations at the beginning of the available data (January 2003) and at the end of the data (December 2017), excluding investment and development banks are shown. Arrow size shows the comparative weight of the relation compared to other relations.

deposit banks, 10 private deposit banks, 20 foreign deposit banks, five development banks, seven investment banks, and five participation banks). The top seven banks, three of which are state-controlled deposit banks, hold more than 70% of the banking sector's total assets, loans and deposits in Turkey. The current fragmented structure shaped slowly over the last fifteen years although the number of banks operating in Turkey has been nearly stable. As in most of the emerging economies, foreign deposit banks have expanded their presence since 2005 through acquiring private deposit banks rather than greenfield investments. They hold almost half of the banks in numbers but only have a 24 percent market share just after the Spanish BBVA Group acquired one of the largest private deposit banks in 2015.

The privately-owned deposit banks comprise the largest share of total banking assets (i.e., 34.7 percent in 2017). Another large banking group is that of the state-owned deposit banks, which has held almost 30 percent of the total banking assets for the last fifteen years. The number and size of participation banks are also very stable over the sample period. These banks hold less than five percent of the

banking sector assets. Up to 2016, only three foreign and one private participation banks had been operating in the market, however, in that period, two state-owned participation banks (which are subsidiaries of state-owned deposit banks) entered the market, changing the presence of state-owned in the industry both in size and its structure. There was only one private participation bank operating in Turkey until July 2016, and their operations were ceased due to a failure to comply with the regulatory procedures.⁴The last group, that of investment and development banks, is also very stable in number and share of asset size of the industry. While development banks are generally state-owned, investment banks have either private or foreign ownership.

Figure 2.1 presents all of the interbank relations between domestic Turkish banks at the beginning of the sample period (January 2003) and the ending (December 2017). As time evolved, the interbank network became more connected and the comparative edge weights for some bank relations became stronger. The total interbank exposures among banks was 80 billion Turkish Lira (TL) or the equivalent of 21.2 billion US dollar as of December 2017, which accounts for about two percent of the total banking assets. Figure 2.2 shows the amount of total lending (sum of each bank's interbank lending) and the total number of links in the Turkish interbank market, which has been growing rapidly especially since 2010. At the end of 2017, the instrument-based breakdown of interbank exposures was as follows: 31 percent deposit, 20 percent security,⁵ 18 percent derivative, 15 percent loan, 11 percent other off-balance sheet items and six percent repo. The breakdown based on number of links changes a little, mainly due to mainly a higher number of

⁴Participation banks are grouped as state-owned participation banks and foreign participation banks. Not to reveal information about the private participation bank by grouping alone, we decided to group this bank with the other foreign participation banks.

⁵Before October 2010, only investment and development banks could issue bonds. This limited the size of bank bond issuances and security type exposures were mainly in type of equity investments and credit linked notes. After the change of regulation allowing bond issuance of other banks, bank bond issuances has started to increase.

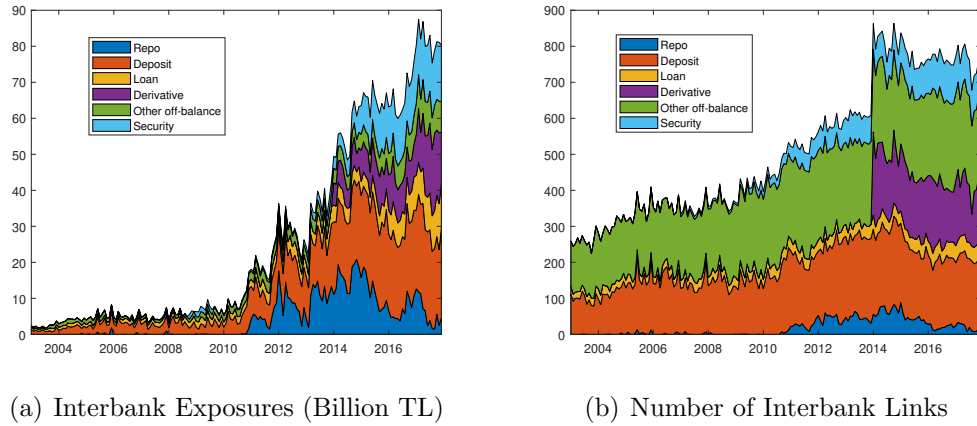


Figure 2.2: Breakdown of Interbank Exposures

links in smaller amounts in some type of instruments: 32 percent other off-balance sheet items, 25 percent deposit, 21 percent derivative, 13 percent security, seven percent loan, and two percent repo.

Figure 2.3 shows network density (ratio of the total number of actual links in the interbank market over the total number of possible links) through time in Turkey. While Figure 2.3a shows the density of total network which is constructed by summing all exposures in the instrument-based networks, density of each instrument-based network is given in Figure 2.3b. The density of Turkish interbank network has increased through time, with on average density becoming 14 percent and reaching 18 percent as of December 2017. The number of banks, business models, and/or types of banks are important determinants of the density of a network. Since there is no regional bank in Turkey, the number of banks is relatively small but the network density seems to be comparable to the other countries.⁶ In terms of the density of interbank instruments, other off-balance sheet items have the highest density. This suggests that many banks to be connected

⁶Fricke and Lux (2015) study Italian interbank market, in their sample there are about 120 banks and network density is calculated as about 15 percent. For Mexico, the number of banks is 46 and the density is 26 percent (Martinez-Jaramillo et al., 2014). The study for German interbank market covers on average 1732 banks, which are mainly in type of savings banks and credit unions and the network density is calculated as 0.66 percent. Langfield et al. (2014) document the network density for UK as three percent, which is composed of 176 banks.

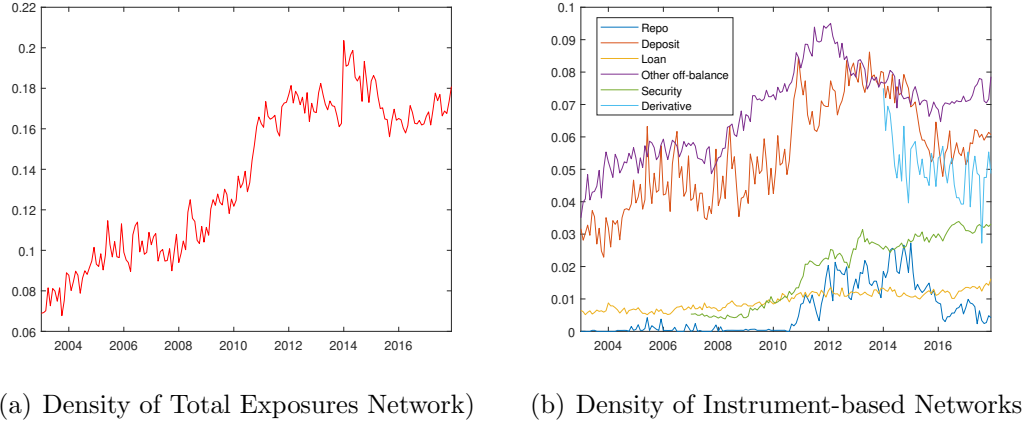


Figure 2.3: Density of Interbank Transactions

over these instruments (Figure 2.3b). Moreover, the densities of deposits and derivatives are relatively higher than the densities of repo, securities and loan contracts during the sample period.

2.2.1 Network Statistics

In this section, we report key network statistics for Turkish interbank market for 2003-2017 (see Figure 2.4). In this way, we aim to give insights about the network structure of Turkish interbank market. While some network statistics help to understand total number of connectivity and clustering structure in the market, centrality measures are used extensively to identify systemically important or larger banks in the literature.

Degree

The element of adjacency matrix A , a_{ij} takes value of 1 if node i is lending to node j and 0 otherwise. Out-degree shows a node is lending to how many nodes, while in-degree shows from how many nodes a node is borrowing. Total degree is the sum of in-degree and out-degree of a node, in other words total degree shows how many lending and borrowing relations a bank has. Total degree is also the most simple

measure of network centrality since as a node increases its number of connections it becomes more important since its failure will affect more nodes.

$$\begin{aligned} \text{In-degree} &= k_i^{\text{in}} = \sum_j a_{ji} \\ \text{Out-degree} &= k_i^{\text{out}} = \sum_j a_{ij} \end{aligned}$$

To calculate the average degree in the network in the related period, only the degrees of the banks that are active in that period are considered and averaged. Average total degree statistic shows that the number of counterparties of banks has increased continuously through time although the total number of banks in the system did not change significantly (see Figure 6a). There is a break in the series when derivative transactions started to be reported.

Clustering coefficient

Clustering coefficient (C_i) of a node shows the probability of being connected of two other nodes that are connected to this node. This measure is calculated as the total number of links between the neighbors of the node over total number of connections that is possible between these neighbor nodes:

$$C_i = \frac{\sum_{jk} a_{ij} a_{ik} a_{jk}}{k_i(k_i - 1)}$$

where k_i denoting total degree of node i and a_{ij} is the element of adjacency matrix showing whether there is a link going from i to j . Since neighbors of node i has already established relations, a node having a large clustering coefficient means that indeed this node is substitutable.

Average clustering coefficient of the graph is calculated by dividing the sum of clustering coefficient of each node over total number of nodes, N . After calculating

clustering coefficient of each node, we take the averages separately for seven largest banks and the remaining banks. Figure 2.4b shows that clustering coefficient of large banks are smaller meaning that their counterparties are generally not connected with each other and for that reason they are less substitutable.⁷

Assortativity

Assortativity measure shows the tendency of banks to connect with banks having similar vertices. It is indeed a correlation coefficient between the degrees of all nodes on two opposite ends of an edge and takes values between [-1 1]. A positive assortativity coefficient indicates that nodes tend to link to the other nodes with similar degree, on the other hand a negative assortativity coefficient shows that nodes tend to link to the other nodes with dissimilar degree. Assortativity measure is calculated as follows where l denoting the total number of edges, i_e and j_e showing the number of degrees of node i and j on the same edge, e (Newman, 2002).

$$r = \frac{l^{-1} \sum_{e \in E} i_e j_e - [\frac{l^{-1}}{2} \sum_{e \in E} (i_e + j_e)]^2}{\frac{l^{-1}}{2} \sum_{e \in E} (i_e^2 + j_e^2) - [\frac{l^{-1}}{2} \sum_{e \in E} (i_e + j_e)]^2}$$

Compatible with the literature, Turkish domestic interbank market has a negative assortativity measure and assortativeness became more negative through time.

Degree and assortativeness measures together show that Turkish interbank market became more connected through time but these connections are between banks having smaller number of links and larger number of links (see Figure 2.4c).

While the assortativeness measure is negative for total exposures, we also check that measure for each type of instrument network. Negative assortativeness is observed in all type of instruments except security. For security, positive assortativeness is increasing through time. Nature of security type exposures are

⁷Silva et al. (2016) show for Brazil interbank market that from the borrower perspective, large banks have less clustering coefficient compared to non-large banks for all the periods, however from the lending perspective the comparison result changes depending on the analysis period.

different than other types, because generally larger banks having more connections are issuing bonds (borrowing) and larger banks aiming to diversify their portfolios are investing (lending) in these issuances. So, generally more connected banks have these links causing assortativeness measure to be positive.

Closeness centrality

Distance of a bank can be defined as the sum of the shortest path distance to all the banks in the network. Closeness centrality is the inverse of that total distance. For example, if a bank is directly linked to another bank, then their distance is 1, if they are not directly connected but there is only one bank intermediating between these banks, then their distance is 2. Closeness centrality for bank i is calculated as follows where d is denoting the shortest path distance between bank i and bank j .

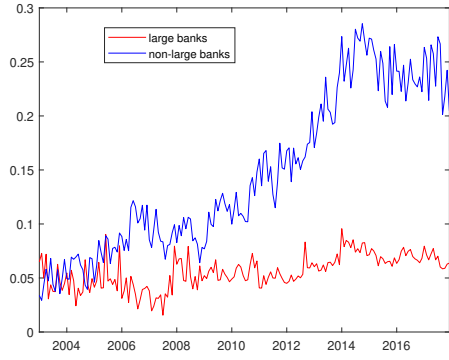
$$C_C(i) = \left[\sum_{j=1}^g d(i, j) \right]^{-1}$$

If there are some disconnected banks in the system, then the distance of other nodes to these disconnected banks become infinity and calculation of closeness centrality with the above formula becomes impossible. Since, there are also disconnected banks in Turkish interbank market, as a solution, the following formula is used, where inverse of the distances are summed and then to normalize, sum is divided by the total number of banks.⁸

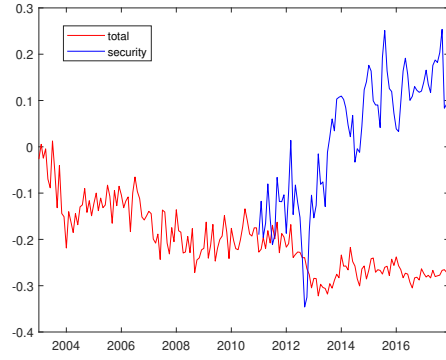
$$C_C(i) = \left[\sum_{j=1}^g 1/d(i, j) \right]^{-1}$$

A bank that has higher closeness centrality means that bank is closer to the other banks in the network and this bank is important in terms of transmitting the shock to the other banks. Similar to clustering coefficient, average of closeness centrality

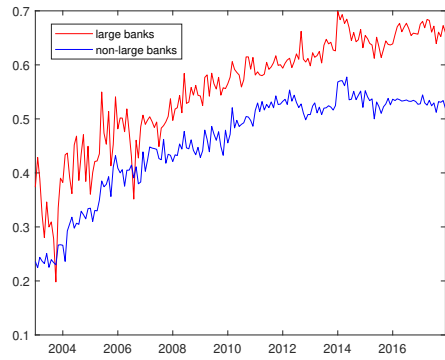
⁸The formula is modified as suggested by Opsahl et al. (2010).



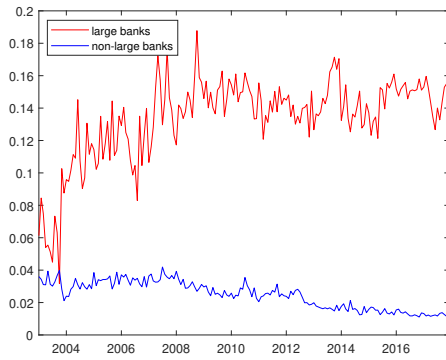
(a) Clustering Coefficient



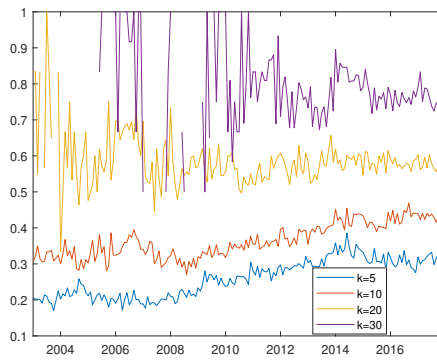
(b) Assortativity



(c) Closeness Centrality



(d) Betweenness Centrality



(e) Rich-club Coefficient

Figure 2.4: Network Statistics of Turkish Interbank Market

measure is taken over large banks and non-large banks. It is seen that large banks are on average more close to other banks compared to non-large banks (see Figure 2.4d).

Betweenness centrality

Betweenness centrality increases in relation to the importance of the bank for the money flow between banks. In other words, a bank that is between the flow path of many other banks is a central bank since the removal of that bank from the network would distort the flow that passes through it:

$$C_b(i) = \sum_{s \neq t \neq i} \frac{\sigma_{st}(i)}{\sigma_{st}} \quad \text{and} \quad C_b^* = \frac{2}{(n-1)(n-2)} C_b(i)$$

where σ_{st} denotes the number of shortest paths going from node s to t and $\sigma_{st}(i)$ is the number of shortest paths from s to t that passes through node i . Betweenness centrality is normalized by dividing with the number of two-pair combinations. Similar to closeness centrality, betweenness centrality is also higher for large banks and this relation is valid for all type of exposures (see Figure 2.4e).

Rich-club coefficient

Rich-club coefficient shows the extent of high degree nodes to connect with each other and calculated with the following formula where $E_{>k}$ shows the number of edges between $N_{>k}$ nodes having degree more than k .

$$\theta(k) = \frac{2E_{>k}}{N_{>k}(N_{>k} - 1)}$$

Silva et al. (2016) suggest that if a network is showing negative assortativity indicating that large degree nodes (core banks) are connected with small degree nodes (periphery banks) and a high rich-club coefficient is present showing that

large degree nodes are connected with each other, then the network shows a core-periphery structure. Rich-club coefficient estimation for Turkish interbank market shows that if as a threshold $k = 5$ is used, then only the 20-30% of links that is possible between the banks having more than 5 degrees are present in the actual network. As k increases, rich club coefficient increases and if $k = 30$ is used, then coefficient increases to 80% showing the presence of rich-club effect (see Figure 2.4f). Thus, $\theta(k)$ suggests the presence of core-periphery structure in Turkish interbank market.

2.3. Network Structure

2.3.1 Discrete CP Structure Analysis

Interbank markets are often characterized in terms of core-periphery (CP) structure, with a highly interconnected (core) banks holding the market together and a periphery of banks, which are connected to the core but not to each other. In this paper, we examine whether CP structure fits the Turkish interbank market based on total exposures and instrument based exposures using adjacency matrices. We use Craig and von Peter (2014) algorithm, which partitions banks in two groups as core and periphery. This algorithm aims to minimize the error score based on the violation of three characteristics, e.g., bilateral links of core banks; no internal links of periphery banks; and core banks with at least one borrowing and lending link with periphery bank.⁹ Figures 2.5a and 2.5b present error scores and the number of core banks identified using interbank network data between all banks and only between deposit collecting banks excluding investment and development banks. Our findings show that the error score of fitting the Turkish interbank market to a CP structure using total interbank exposures decreased over time, especially after

⁹See Appendix for the details of CP model and estimation approaches.

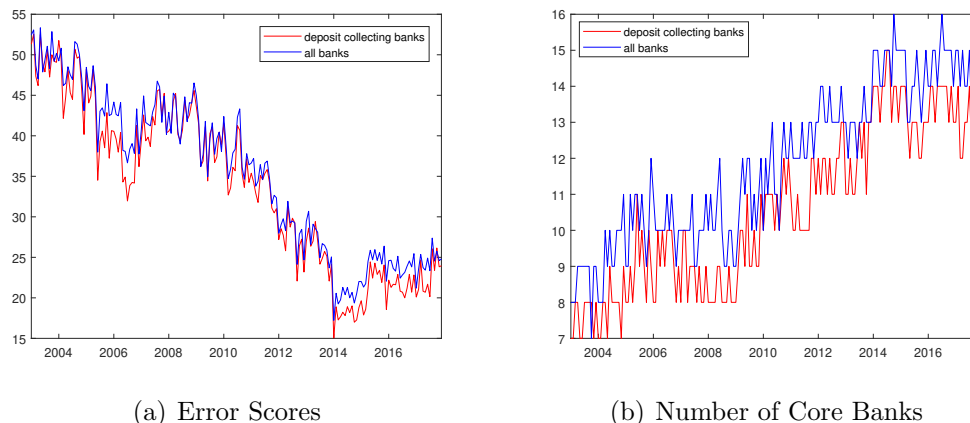


Figure 2.5: Error Scores and Number of Core Banks under Discrete CP Structure
Notes: Error scores and number of core banks are calculated using Craig and von Peter (2014) algorithm. Deposit collecting banks refer to the banks excluding investment and development banks.

the global financial crisis and stabilized around 25 percent since 2015.¹⁰ During the global financial crisis period, the decrease in the error score has nearly disappeared, which is a similar finding to the literature documenting whether a change in the network density or fitness to CP structure happened after the crisis.¹¹

As seen in Figure 2.5b, the number of core banks increased from nine banks in 2003 to 15 banks in 2017. Among 15 core banks, there are seven large banks, three medium-sized banks and five small/micro-scaled banks. As it may be expected, all of the large banks and some of the medium-sized banks (i.e., 3 out of 9 in our case) are in the core. However, since discrete CP uses only binary links among banks, it appears that five out of 36 small/micro-scaled banks in Turkey are in the core.

Similar to our findings, in't Veld and van Lelyveld (2014) document that the core of the Netherlands interbank system always includes all of the large banks, but some

¹⁰As mentioned in Section 2.2, with Italy, Mexico and Turkey having similar network densities, they also have a similar outlook in terms of fitness of the CP structure. Error scores are 47 percent for Italy (Fricke and Lux, 2015) and 25 percent for Mexico (Martinez-Jaramillo et al., 2014) using the same algorithm.

¹¹Fricke and Lux (2015) find that there is a structural break in the network density after the global financial crisis. Martinez-Jaramillo et al. (2014) show that while the interbank Mexican market used to fit a CP model more as compared to random and scale-free networks before the failure of Lehman Brothers, after this event the network structure changed to more resemble a scale-free network.

Table 2.2: Core Banks and Error Scores for Instrument-based Networks

	2003-2006	2007-2010	2011-2013	2014-2017
	Error Scores (percent)			
Deposit	56	54	47	47
Derivative	-	-	-	19
Other off-balance sheet	51	49	43	43
Security	-	-	55	46
Total Exposures	46	41	30	23
	2003-2006	2007-2010	2011-2013	2014-2017
	Number of Core Banks			
Deposit	5	5	7	6
Derivative	-	-	-	8
Other off-balance sheet	7	8	9	9
Security	-	-	4	5
Total Exposures	10	11	13	15

Notes: Repo and loan contracts did not fit to the CP structure and hence they are not reported. Due to a limited number of links in the repo and loan contracts, we could not search for another network structure for these contracts. Derivatives and securities contracts have been reported since 2014 and 2011 respectively in the Turkish interbank market.

small banks are also part of the core. Upper (2011) also states that the criticality or coreness of a bank is not only the function of its size, but also the magnitude of its interbank liabilities as well as its precise location in the market, so small banks can be identified as core. We also find a similar structure holds for the sample set with only deposit collecting banks (i.e., excluding investment and development banks).¹²

In our instrument-based analysis, we find that except repo and loan contracts, the CP structure seems to hold for deposits, derivatives, and other off-balance sheet items as well as securities contracts (Table 2.2). The error score of fitting CP structure to the derivative exposures is significantly smaller for the last four years (19 percent) as compared to the other instruments. The error score of fitting total exposures network to the CP structure decreases considerably over time mainly due

¹²We also group transactions into maturity brackets as short-term, long-term, and total, then compare the fitness of the networks. We did not find any significant difference in terms of fitness to CP structure. However since for short-term contracts, deposit, derivative, and repo have a significant share, and since for long-term contracts, other off-balance sheet, loan and security have a higher portion and different relations and factors are prevalent in each type of contract, core banks identified under different maturity structures are different.

to the inclusion of derivative contracts in the total exposures which has a better fit to the CP structure and decrease in the error scores of other instruments.

To test goodness of fit of the CP model to the actual interbank network, we follow the Monte-Carlo simulations as suggested by Craig and von Peter (2014), in't Veld and Van Lelyveld (2014) and Fricke and Lux (2015). The aim of these simulations is to show that the fit (error score) of Turkish interbank market to the core-periphery model is tight (small) enough to conclude that the interbank market has a tiered core-periphery structure. In that approach, basically first random and scale-free networks are created having similar network properties with the actual network. Then, the error scores of fitting these artificially created networks to CP model is compared with the error scores of fitting actual network to CP model. This approach is indeed the test of a null hypothesis stating that the interbank market fits to a random or scale-free structure. If the error scores of fitting CP model to the actual network is below a certain percentile of the error scores of fitting CP model to the artificial random or scale-free networks having similar network properties with the actual network, then we can reject the null hypothesis with a significance level. We find that the average error score of fitting a CP structure to a random network having similar properties with total exposures network is 69.1 percent, and the error score for fitting to a scale free network is 50.1 percent. The error score for fitting the CP model to the actual network is found as 25 percent as of the latest period data (Figure 2.5a). Indeed, all error scores of fitting CP model to random and scale-free networks are above 25 percent. So, we conclude that CP structure gives a better fit to the Turkish interbank network compared to the random and scale-free structures and the average error score of fitting CP model to the actual network is approximately $1/3$ times of the average error score of fitting CP model to a random structure and $1/2$ times of the average error score of fitting CP model to a scale-free structure. For the goodness

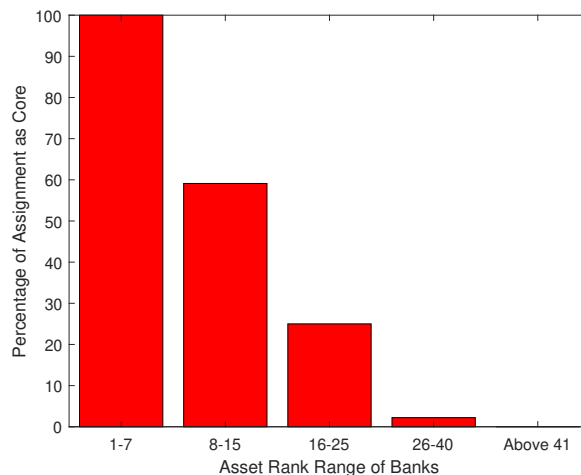


Figure 2.6: Relation Between Asset Ranks and Percentage of Assignment as a Core Bank in Discrete CP Analysis

Notes: The figure is plotted using core-periphery assignment and asset rank relations over 2014-2017 period. X-axis shows the range of rankings of the banks according to their asset size. The bank which is largest by asset size takes ranking of one. Y-axis shows the percentage of the months*banks instances in the 2014-2017 period that the banks in the related asset rank range is identified as a core bank.

of fit of instrument-based networks, while deposit, derivative, security and other off-balance sheet item networks all fit to CP model significantly better compared to a random network, except for the derivative network there is no significant difference of the fitness of scale-free and actual networks to the CP model.

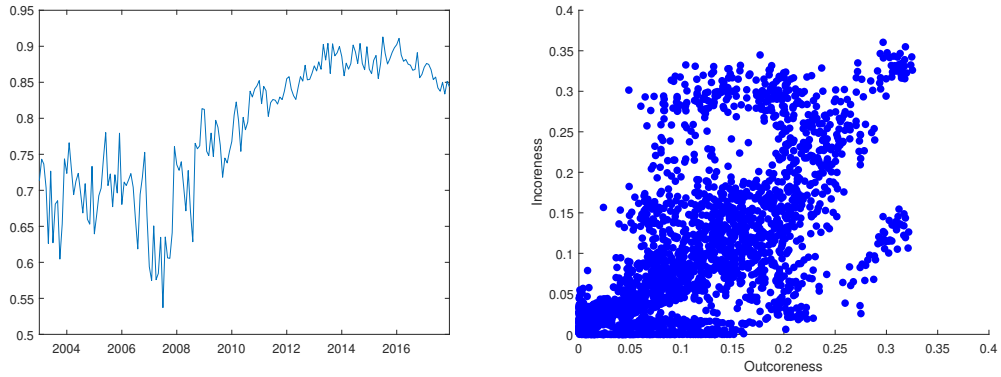
Finally, we aim to analyze whether larger banks in terms of their asset size are identified as a core bank. We focus on the period that starts in 2014 to compare the core-periphery assignments found by Craig and von Peter (2014) approach and asset rankings of the banks. This time period allows us to make use of interbank relations in all types of instruments. Moreover, CP structure fits to the actual interbank network with the least amount of error score during the 2014-2017 period. In Figure 2.6, we group banks in five groups according to their asset ranks. Then, we calculate the percentage of the months in the 2014-2017 period that the banks in the related asset rank range is identified as a core bank. In the first asset rank range “1-7”, there are 7 banks and there are 48 months between 2014-2017

period. The analysis shows that the banks in that range are identified as a core bank in each of the 48x7 instances, so the percentage is 100 percent. The banks in the asset rank of “8-15” are identified as core bank 59 percent of the instances and the percentage decreases as the asset rank of the banks increase. The analysis shows that larger banks are never identified as periphery bank; however some smaller banks can be identified as core banks since they have many links in the discrete CP analysis.

2.3.2 Continuous CP Structure Analysis

One limitation of the discrete CP approach for interbank relationship analysis among banks is to consider every interaction, i.e., link, with an equal weight. Considering the nature of the transactions in the banking industry and the heterogeneous size distribution of Turkish banks, we also study continuous CP structure for the Turkish interbank market using the approach introduced by Boyd et al. (2010). In that approach, a coreness measure is assigned to each bank showing the strength of the bank in the market using weighted network exposures. More precisely, we estimate two coreness measures for each bank namely incoreness and outcoreness respectively showing the importance of the bank in terms of receiving and distributing money in the market.

Similar to the discrete CP analysis, we examine the relationship between the total coreness measure (the sum of incoreness and outcoreness measures) and the asset size of the banks for the continuous CP structure. The analysis shows that the correlation coefficient increases over time, suggesting larger banks to be more active/connected in the Turkish interbank market (Figure 2.7a). For the sake of illustration, we focus on the incoreness and outcoreness values of banks during the period of 2014-2017, each dot showing the values of a bank in a certain period (Figure 2.7b). Out of 2625 incoreness/outcoreness values in total exposures, we



(a) Correlation between Bank Asset Ranking and Total Coreness Ranking (b) Total Exposures Incoreness vs Outcoreness

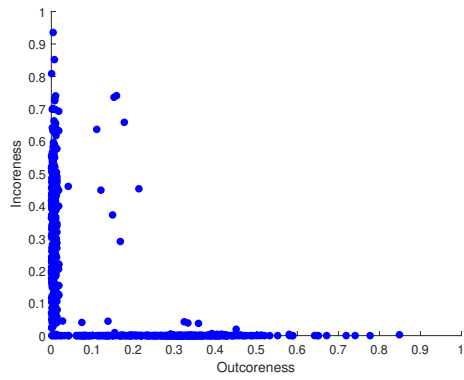
Figure 2.7: Coreness Measures under Continuous CP Structure

Notes: Incoreness and outcoreness vectors are found using Fricke and Lux (2015) algorithm for the total exposures network. Total coreness is the sum of incoreness and outcoreness vectors. See Appendix for the details of the estimation of continuous CP structure.

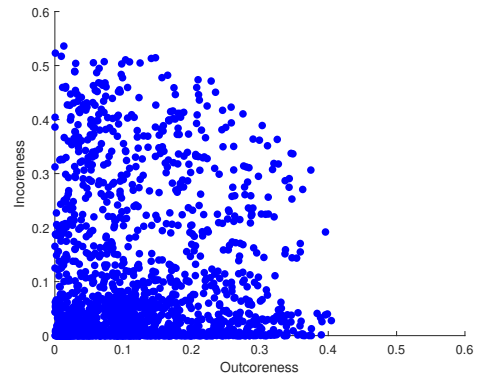
find that there is a high correlation (68 percent) between interbank receivables and payables of the banks in the interbank market.

Figures 2.8a-2.8f present the incoreness and outcoreness values of each bank based on interbank instruments. Different from Figure 2.7a, the linear relationship between incoreness and outcoreness vectors varies if the networks of specific instruments are considered. Instrument-based incoreness and outcoreness measures indicate the first signs of how bank ownership may shape the interbank network structure in Turkey. For example, in repo transactions, since banks in general have either repo payable or repo receivable, they are located on the x-axis or y-axis most of the time. The banks generally appear either on the short or long side of the repo transaction mainly due to the arbitrage opportunity in the market which will be discussed further in Section 2.4. Moreover, participation banks have no links in repo transactions since these transactions are not accepted according to Sharia rules.

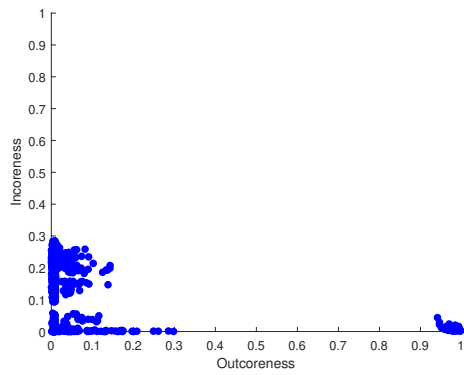
For deposit exposures, some banks have only deposit receivable, and some have both deposit receivable and payable, but most of the banks have both deposit



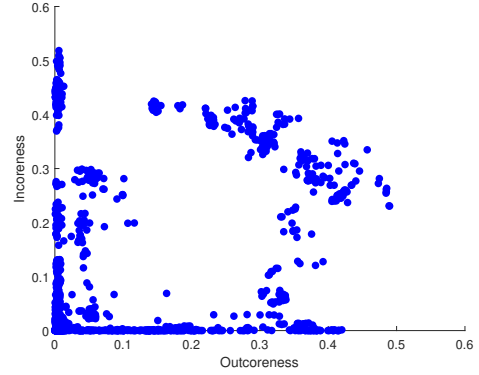
(a) Repo



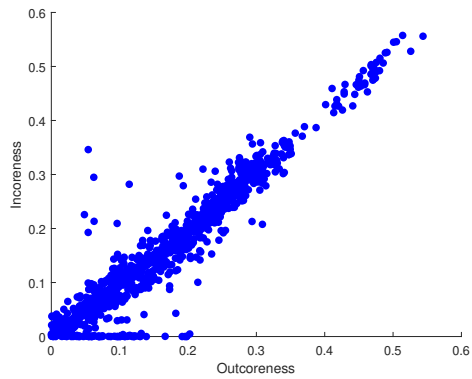
(b) Deposit



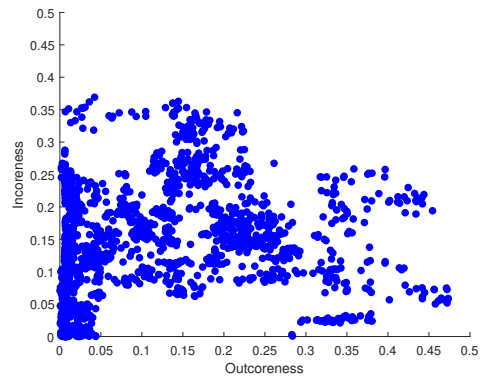
(c) Loan



(d) Security



(e) Derivative



(f) Other off-balance

Figure 2.8: Continuous CP Model-Incoreness vs Outcoreness

Notes: Each dot shows the incoreness and outcoreness values of a bank in a month during the period of 2014-2017.

receivable and payable. In general, development and investment banks are on the x-axis, since they are not allowed to collect deposits; however they invest their funds in other banks to generate income. For loan type exposures, a bank is an important fund supplier for many banks; not so many banks are both fund receiver and fund payable. The general fund supplier bank is on the further point on the x-axis. In security relations, state-owned banks fall into on y axis, since generally other banks hold their issuances; however, they do not hold issuances of other banks. The banks on the x axis are generally smaller banks that do not issue bonds but holding issuances of larger banks for diversification of their portfolio. There are some banks that are issuing bonds and holding bonds of other banks. There is a linear relationship between incoreness and outcoreness vectors in derivative exposures due to the structure of these transactions.¹³ Finally, in other off-balance sheet transactions there are many banks acting as fund receiver and fund payable, so banks are located inside the graph not on the axis.

2.3.3 Commonality of Core Banks in Instrument-based Networks

In this section we examine whether the same banks are identified as core banks in different instrument-based networks. Table 2.3 presents the commonality of core banks for different instruments identified, using either discrete or continuous CP approaches. We conduct this analysis for deposits, securities, derivatives and other off-balance sheet instruments during the period of 2014-2017 (due to the availability of sufficient observations in these instruments). A commonality analysis shows that the banks that are found as core in different instruments are not so similar, suggesting the existence of different factors in each of them, e.g., ownership

¹³For example, in a forward transaction, while a bank has TL receivable and USD payable in the agreed forward date, other bank has USD receivable and TL payable. So, the banks entering into a derivative transaction have both receivable and payable.

Table 2.3: Commonality of Core Banks in Instrument-based Networks

	Deposit	Security	Derivative	Other off-balance	Total
Deposit		36.6	32.1	23.1	42.3
Security	48.2		33.3	22.5	27.8
Derivative	34.4	45.6		26.9	40.7
Other off-balance	20.1	22.1	17.0		51.8
Total	51.6	65.4	47.7	33.9	

Notes: The upper triangle of the table shows the commonality (in percent) between instruments for the 2014-2017 period for discrete CP analysis, and the lower triangle shows for continuous CP analysis for the same period. Repo and loan contracts did not fit the CP structure and hence they are not reported. Since the number of banks identified as core banks can change for different instruments in discrete CP analysis, we adopt the following: assume that in the discrete CP analysis, banks {A,B,C} are identified as core banks in the deposit network, and banks {B,G} are found to be core banks in the security network for a period. In that example, there is one common core; however, the size of the core banks identified in security and deposit instruments are different, so computation of the commonality is puzzling. As a solution, first we calculate the union of these two arrays which is {A,B,C,G} and the length of this array is four, then we compute the intersection of the arrays which is {B} and length is one, so commonality for deposit and security network in that example is 1/4. The approach is similar in the continuous CP analysis, first we rank the coreness of the banks and the banks having highest five rank are selected as core. We repeat the same approach via identifying the banks ranking in the highest ten as core banks; however, the implications do not change significantly. The average of the commonality ratio as found in the example for each month in the analysis period is reported in the table.

structure may shape the network structures.

Among four instrument types, we find that that the core banks identified in the other off-balance sheet items are less similar to the core banks found in the other instrument-based networks. Other off-balance sheet network is the one having the highest density among the instruments, so many banks are connected in that network and banks that are not identified as core in the other networks appear to be core in the other off-balance sheet items network. For the commonality between the other instruments for the discrete CP analysis, we see that the maximum commonality is 36.6 percent and this is between deposit and security instruments. If we focus on the similarity between total exposures, since the share of other off-balance sheet and deposit exposure links are higher in the total exposures, the similarity in terms of commonality of core banks is higher for those networks with the total exposures network. Commonalities found using continuous CP analysis

are higher compared to the discrete analysis, since larger banks having more intermediation power due to their larger balance sheet size become core bank more frequently in continuous analysis. While the similarity between security and total exposures is the lowest in the discrete analysis, it is highest in the continuous analysis. While the share of links of a specific instrument in the total exposures is important for the commonality with the total exposures for discrete CP analysis, for continuous analysis the share in the total exposures is not so important. Continuous and discrete CP analyses tell us different stories, so in the analysis of the networks, both approaches seem to contribute to better understanding the network structure.

2.4. Banking Group Networks

In this section, we analyze how the interactions among banking groups (state, private, foreign, state participation, foreign participation, development, and investment banks) shape the network structure under different interbank contracts. First, we limit the time period that the interbank relations are rather stable in the discrete CP model and calculate the network averages using the monthly data for the 2014-2017 period. As seen in Figure 2.9, we document interesting interactions among banking groups in the Turkish interbank market.

First, we observe that in the repo transactions, foreign deposit banks are the main fund lenders and state and private deposit banks are the main fund borrowers. These interactions are partly explained by the efforts of the Central Bank (CBRT) to restore the financial intermediation in Turkey. After the global financial crisis, the disruptions in the short-term funding markets prompted central banks worldwide to provide unusual amounts of funds to the real economy. Similarly, CBRT has increased its presence in order to fund the market and become a major

fund provider for domestic banks in the open market repo transactions.¹⁴ However, instead of providing unlimited amounts, Central Bank restricts funding amounts for individual banks. Thus, large banks such as state or private deposit banks that cannot satisfy all of their funding needs from Central Bank since they reach their borrowing limits, access to the repo market on the exchange market (BIST interbank market) and meet their uncovered funding needs from other banking groups such as foreign deposit banks with less constrained balance sheets. In particular, by the emergence of a wide interest rate spread between Central Bank average funding rate¹⁵ and BIST interbank market repo rate (see Figure 2.10), foreign deposit banks borrowed from Central Bank at a cheaper rate and sold these funds to the state and private deposit banks and hence they appeared to be more active in the repo market especially in 2014 and 2015. By the end of 2015, Central Bank changed its liquidity strategy increasing the limit for the use of FX collateral in repo transactions and stopped funding via auctions in 2017. This caused a huge decrease in domestic interbank repo transactions due to the disappearance of arbitrage in the market. Overall, amendments in the local regulations implemented by Central Bank seem to affect the interbank relations in the repo market in Turkey. In repo contracts, participation banks do not create any interactions due to Sharia rules.

In derivative exposures, the concentration of transactions is among foreign deposit banks, private deposit banks, and foreign participation banks. Since foreign banks have the advantage of reaching foreign funding reserves, the network relations between these two groups of foreign banks can be predictable. However, there is another strong network among foreign and private deposit banks that may concern policy makers or central bankers. The substantial growth of derivative activities

¹⁴CBRT has mainly two ways of funding: (i) funding via auction, in generally, one week term with a stable funding rate, and (ii) funding via quotation on the exchange market or Central Bank interbank money market on a daily term with marginal funding rate.

¹⁵Central Bank announces CBRT average funding rate since 2011.

has made monetary policy design and short-term exchange rate management increasingly dependent on the interaction between domestic and foreign institutions in the derivative market. Eichengreen et al. (2011) emphasize the need to identify institutions where derivative activity is disproportionately concentrated in emerging economies. In the following section, we examine whether foreign banks have a higher coreness measure in derivative type exposures using panel data. In Turkey, foreign banks are generally medium-size, but there are also very large ones, and very small ones. Some of them operate as branches and some as participant banks. Moreover, some private domestic banks have considerable foreign shares. In section 2.4.1, we examine these different types of foreign banks in a simple regression to test whether the globalization of the domestic banks and the disproportional concentration of these banks in the derivative transactions are related statistically.

In Turkey, before October 2010, only investment and development banks issued bonds; for that reason the size of the interbank bond market was small. Since Capital Markets Board has changed the regulations to allow other banks to issue bonds, the market has grown significantly and accounted for about 5.5 percent of total banking sector assets as of December 2017. As of the most recent data, nearly half of the banks in Turkey have issued bonds, and an important portion of these bonds is issued by state-owned and largest private deposit banks. As seen from the directions of the interactions in Figure 2.9, in security type exposures, state-owned deposit banks are at the core of the network structure in terms of receiving funds. Moreover, we observe that while bonds issued by state-owned deposit banks are held by the other banks, state-owned deposit banks do not hold bonds issued by the other banks.

We argue that both liquidity risk management practices according to the Basel regulations implemented after the recent financial crises and the capital adequacy

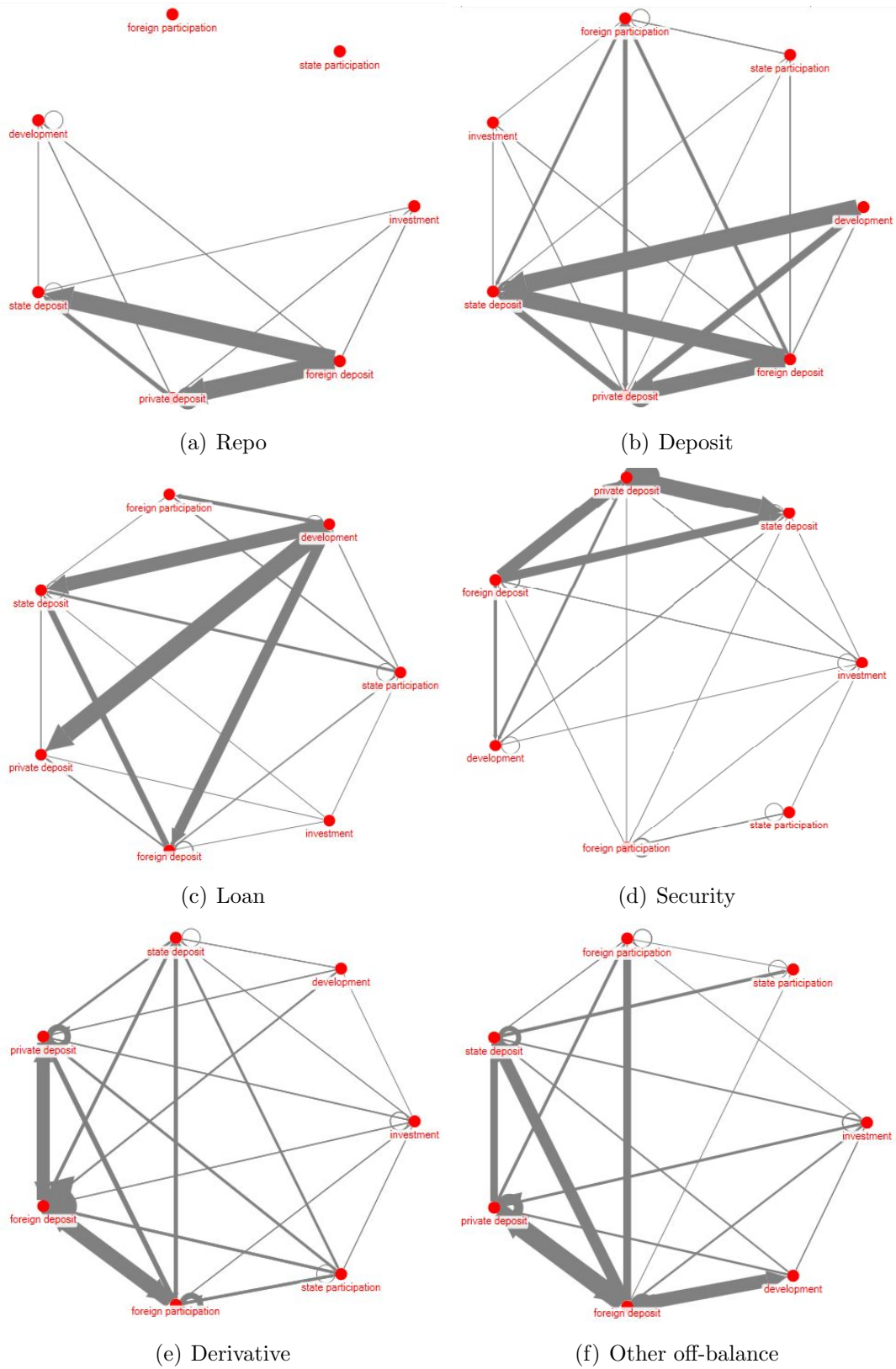


Figure 2.9: Network Relations Between Banking Groups

Notes: Arrow size shows the comparative weight of the relation compared to other relations. A circle type relation shows intra-group relations

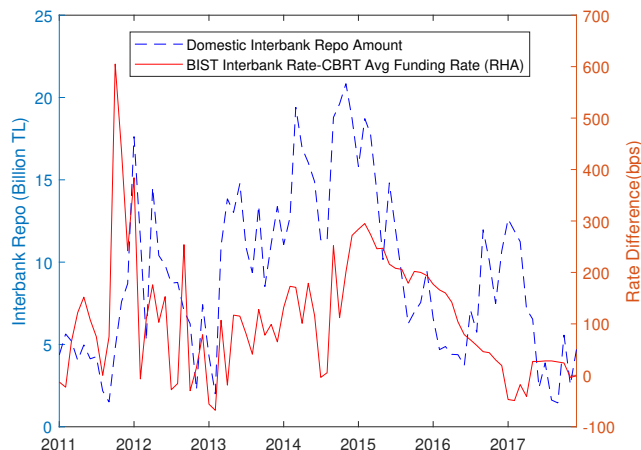


Figure 2.10: Interbank Repo Amount and Interest Rate Differential

framework may play role in the shape of the network in security-type transactions (see also Bonner and Eijffinger, 2016; Bech and Keister, 2017). For a bank, the alternative investment to bank bond investment is government bond investment. While government bond investments are assumed as risk-free, investing in bank bonds are riskier so yields higher returns; however both investments have secondary markets, so they can be liquidated easily and may be thought of as substitute investment vehicles. However, government bonds and bank bonds are treated differently in Basel regulations and this may affect bank bond investments. Securities issued by banks are not considered as high liquid assets in the Basel liquidity coverage ratio (LCR), on the other hand government bonds are considered as high liquid assets. A bank that fails in fulfilling LCR prefers to hold government bonds instead of bank securities. However, banks with high liquidity coverage ratio or high loan-to-deposit ratio may have enough liquidity to cover any unforeseen fund requirements and prefer to invest in securities issued by other banks.

Moreover, we argue that well-capitalized banks may invest in bank bonds. While the risk weight of bonds issued by a bank depends on the rating of the bond-issuing bank, TL government bonds have zero risk weight. Bonner (2016) shows that after

capital and liquidity regulations implemented, banks become more interested in government bonds instead of other bonds. Overall, the network structure of securities in the 2014-2017 period suggests that we should inquire further into the impact of Basel requirements on the identification of the core banks in the security network and we test our hypothesis statistically in the following section.

We observe that development banks are more active in deposit and loan interbank markets. However, when we break down the deposit and loan exposures according to local and foreign currencies, we find that, especially in the Euro transactions, foreign deposit banks are still major players in shaping the network structure.¹⁶ In the deposit exposures, about 57 percent of total deposit exposures belong to local currency (TL) deposits. The structure of TL and USD deposit networks is similar to the total deposit network. On the other hand, in the Euro type deposits, the importance of foreign participation banks increases and the network changes. About 35 percent of the loan type exposures are in local currency during our truncated sample period. Similar to the deposit contracts, the network structure between banking groups is similar in TL and USD type loans, but in Euro type loans, foreign deposit banks still have an important role in funding especially state-owned deposit banks. Finally, in the other-off balance sheet items, foreign deposit banks have an important share of receivable from private deposit banks and development banks.

2.4.1 Determinants of Coreness Measure

In this section, we conduct several panel regressions to further understand the factors that are associated with the coreness of a bank. In the beginning of section 2.4, while explaining the concentration of interbank relations between banking

¹⁶Network relations for deposit and loan exposures in currency breakdown is given in the Appendix.

groups, we raise a number of questions. First, we question whether foreign banks have higher importance in derivative contracts when different foreign bank definitions are considered. Secondly, we question whether liquidity and capital requirement regulations play a role in bond investments. Therefore, after examining total interbank exposures, we focus on derivative and security type relations and inquire factors that might influence the coreness of a bank. We use coreness measures that are calculated from continuous CP structure analysis as our dependent variables. First, we study the association between total coreness in total interbank exposures during the 2003-2017 period, controlling for bank size and network statistics of a bank as in Craig and von Peter (2014). We have two size measures: the natural logarithm of total assets of a bank (*Asset Size*) and a dummy variable for the seven largest banks in Turkey (*Large Bank Dummy*). The seven banks that are referred to as the largest banks in Turkey account for almost 75 percent of the banking assets. We use either betweenness centrality (characterizes the structural role of a bank in the market) or closeness centrality (represents the average shortest distance in terms of links) to all the other banks in the network as our network statistics as defined in Section 2.2. As the explanatory variables of total coreness measure we use several bank characteristics such as *CAR* (capital adequacy ratio which is the regulatory capital over risk weighted assets), *Liquidity Coverage Ratio* (the share of high quality liquid assets over net cash outflow in the 30-day period), *Loan to Deposit Ratio*, and dummy variables for foreign and state banking groups. We report summary statistics and pairwise correlations of variables in Table A.1 in the Appendix.

As seen in Table 2.4, there is a positive and significant association between bank size indicators and the total coreness measure, supporting the previous evidence that larger banks tend to be more active in the interbank market (e.g. Cocco et al. 2009; Craig and von Peter, 2014). Similarly, network statistics (both betweenness

and closeness centrality) are positively associated with coreness. Banks that are more central in the network either in terms of being closer to the other banks (*Closeness-T*) or in that they are on the intermediation path of the other nodes (*Betweenness-T*), have a higher coreness measure in the Turkish interbank market. Since centrality measures and coreness measures are both calculated from interbank relations, a positive relation between these variables may be expected naturally. However, while coreness measure is calculated from weighted interbank relations, centrality measures are calculated from 0-1 relations. If a bank is connected to many other banks and between the money flows of other banks, but the size of these relations is so small, then the bank will have a large centrality measure and small coreness measure. We show that this example is not the case for Turkey and the size of the interbank relations of the banks that are connected to many other banks are also large. Moreover, as seen in the fifth and sixth columns, there is a negative association between the capitalization of bank and its coreness measure suggesting that banks having a lower capital adequacy ratio are more important in the interbank market. Another interesting finding is that the liquidity of a bank has no significant association with its coreness measure. Finally, we find that state and foreign banking groups have positive and significant association with coreness measure.¹⁷

In the paper, we emphasize that each interbank contract seems to have its own network relationships among different banking groups. As we document in Figure 2.9, foreign banks transact actively in most of the interbank contracts, but their importance in the derivative transactions seems to be more salient. As also seen in Figure 2.11, foreign deposit banks and, very recently, foreign participation banks, have a higher than average total coreness in the derivative exposures.¹⁸ Similar to

¹⁷As seen in Table A.1 in the appendix, asset size and other independent variables have a high correlation and for that reason we preferred not to keep asset size in models 3-6.

¹⁸The bank groups are the same as those defined in Section 2.2 except for foreign banks. Since

Table 2.4: Panel Estimations for the Determinants of Total Coreness Measure

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Asset Size (in logarithm)</i>	0.0242*** (0.005)					
<i>Large Bank Dummy</i>		0.2263*** (0.041)				
<i>Betweenness-T</i>			0.8098*** (0.124)			
<i>Closeness-T</i>				0.2757*** (0.038)		
<i>CAR</i>					-0.4025** (0.165)	-0.3947** (0.161)
<i>Loan/ Deposit</i>					0.0044 (0.007)	0.0044 (0.007)
<i>Liquidity Coverage Ratio</i>					-0.0022 (0.007)	-0.0023 (0.007)
<i>Foreign Banks</i>					0.0684*** (0.017)	0.0668*** (0.015)
<i>State Banks</i>					0.1483*** (0.035)	0.1473*** (0.035)
<i>Constant</i>	-0.3208*** (0.120)	0.1750*** (0.017)	0.1731*** (0.015)	0.0801*** (0.018)	0.3445*** (0.046)	0.3400*** (0.043)
N	8481	8481	8480	8480	1171	1171
R-squared	0.5348	0.2321	0.4698	0.3964	0.0225	0.0227

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard deviations are in parenthesis. Dependent variable is the total coreness measure calculated from total interbank exposures. *Asset Size* is the natural logarithm of a bank's total assets. *Large Bank Dummy* is a dummy variable that has the value 1 for the largest seven banks according to their asset size. *Betweenness-T* and *Closeness-T* are betweenness and closeness centrality calculated using total interbank exposures. *CAR* ratio is the regulatory capital over risk-weighted assets. *Loan/Deposit* is the ratio of total loans over total deposits; since investment and development banks cannot collect deposits, they don't have Loan to Deposit Ratio. *Liquidity Coverage Ratio* is calculated according to Basel standards and defined as the share of high quality liquid assets over net cash outflow in the 30-day period. This ratio has been reported since 2014. Fifth and sixth models are run after 2014 excluding investment and development banks for consistency, so the number of observations in these models is smaller compared to models 1-4. *Foreign Banks* represents the foreign deposit and foreign participation banks. *State Banks* is a dummy variable that has the value 1 for the three state-owned deposit banks. For *CAR*, *Loan/Deposit* and *Liquidity Coverage Ratio*, values smaller than the 5th percentile and larger than the 95th percentile are replaced by 5th percentile and 95th percentile values.

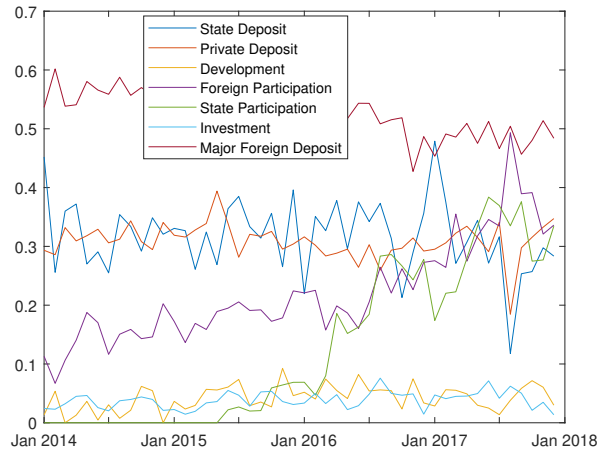


Figure 2.11: Average Coreness Measure in Derivative Exposures for Banking Groups
Notes: Coreness measures are calculated from derivative networks and the averages of these measures are taken over the banks in the related banking group for each period.

the other emerging economies, a large number of foreign banks have entered the Turkish banking system as either deposit or participation banks in the last two decades (see Table A.2 in the Appendix for detailed documentation of the foreign bank entries in Turkey during 2003-2017). In order to examine the coreness of foreign banks in the derivative markets, we estimate a simple regression model controlling for bank size and network statistics (see Table 2.5).

In this model, we introduce various classifications of foreign banks that may have different associations in the coreness structure. In addition to the *Foreign Banks* dummy variable that we use for all types of foreign banks (deposit and participation) in the total coreness model,¹⁹ we have four different dummy variables for foreign banks: *Foreign Deposit Banks* is a dummy variable to classify a subsidiary or a branch of a foreign bank but excludes foreign participation banks. *Major Foreign Deposit Banks* is a dummy variable that classifies large foreign

some of the foreign banks are small and operate as branches only, the six largest foreign banks are selected and their average total coreness measure is calculated (they are called major foreign deposit in Figure.)

¹⁹For a bank to be grouped as foreign bank, either the bank should have a foreign share of more than 50 percent, or have a foreign controlling shareholder.

deposit banks with an extensive branch network. In this subgroup, there are six banks and these banks held 84.7 percent of the asset share of all foreign banks as of December 2017. In the third group, we classify banks with at least 25 percent of foreign-owned shares as the *Major Foreign Deposit Banks*²⁵ dummy; this covers eight large foreign deposit banks. We include this classification to study how coreness in the derivative market is affected if there are more major banks with a considerable foreign share in Turkey. As a last group, *Major Foreign Banks+*, we add three relatively large foreign participation banks with an extensive branch network to the third subgroup. We perform the regressions for derivative exposures using data for the 2014-2017 period due to the availability of derivative reportings.

As seen in Table 2.5, not all foreign banks, but rather only major foreign banks tend to be in the core. As expected, foreign banks operating with a single branch or foreign banks that are not subsidiaries of large investment banks have very small or no role in the derivative market. Nevertheless, we observe an interesting association between large foreign banks and their coreness measure in the network. When we compare the coefficients of the major foreign bank dummy variables, *Major Foreign Deposit Banks* and *Major Foreign Deposit Banks*²⁵, we find that this association increases significantly when banks with a significant foreign share are also grouped as foreign banks. As seen in column (5), we find that with the inclusion of large foreign participation banks the association weakens, suggesting the importance of the business model of a bank in the derivative transactions.

Our last econometric exercise is related to interbank security contracts. Because banks other than investment and development banks have issued security contracts since after 2011, we run our regressions for the period between 2011 and 2017. In this network, we have different models for security outcoreness (which shows the strength of a bank for investing in bank bonds) and security incoreness (which

Table 2.5: Panel Estimations for the Determinants of Derivative Coreness Measure

	(1)	(2)	(3)	(4)	(5)
<i>Asset Size</i>	0.0356*** (0.008)	0.0356*** (0.008)	0.0360*** (0.008)	0.0321*** (0.008)	0.0318*** (0.008)
<i>Betweenness-D</i>	0.9748*** (0.254)	0.9736*** (0.254)	0.9346*** (0.254)	0.9533*** (0.250)	0.9579*** (0.246)
<i>Foreign Banks</i>	-0.0040 (0.018)				
<i>Foreign Deposit Banks</i>		-0.0019 (0.018)			
<i>Major Foreign Deposit Banks</i>			0.0535** (0.023)		
<i>Major Foreign Deposit Banks25</i>				0.2372*** (0.045)	
<i>Major Foreign Banks+</i>					0.1902*** (0.049)
<i>Intercept</i>	-0.6436*** (0.177) 2317	-0.6448*** (0.177) 2317	-0.6599*** (0.166) 2317	-0.6026*** (0.166) 2317	-0.6012*** (0.174) 2317
<i>R-squared</i>	0.6026	0.6030	0.6458	0.7022	0.6739

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard deviations are in parenthesis. Dependent variable is coreness measure calculated from derivative exposures. *Asset Size* is natural logarithm of a bank's total assets. *Betweenness-D* is the betweenness centrality calculated using derivative exposures. *Foreign Banks* is a dummy variable that has value 1 for the all types (deposit and participation) of foreign banks having 50 percent foreign ownership and 0 otherwise. *Foreign Deposit Banks* is a dummy variable that has value 1 for the all foreign deposit banks. *Major Foreign Deposit Banks* is a dummy variable that has value 1 for the six largest deposit banks having 50 percent foreign ownership and 0 otherwise. One of these six banks is grouped as foreign since 2015 July, so before that date five banks take value 1 in that group. *Major Foreign Deposit Banks25* is a dummy variable that has value 1 for the six largest foreign deposit banks and two largest private deposit banks having more than 25 percent foreign ownership and 0 otherwise. The bank that has been acquired in July 2015 had foreign share more than 25 percent before July 2015, so this bank has value 1 for all periods in that group. *Major Foreign Banks+* is a dummy variable which takes value 1 for *Major Foreign Deposit Banks25* and for three foreign participation banks.

shows the strength of banks in terms of their bonds to be held by the other banks). In the security outcoreness model, we control for bank characteristics such as asset size, liquidity, and capitalization of a bank. Moreover, we run separate regressions for the “largest” banks and the other banks in the banking industry.

As seen in Table 2.6, we find that there is no association between the liquidity of a bank and security outcoreness among non-large banks. On the other hand, highly liquid (low *Loan to Deposit* or high *Liquidity Coverage Ratio*) large banks seem to invest more in bank bonds suggesting more diversification of ample resources by these banks. While the existence of significant and negative association between capitalization of a large bank and security outcoreness suggest that an increase in the capital adequacy ratio decreases the willingness to invest in bank bonds for larger banks, this effect is inverse for non-large banks. The finding for non-large banks is compatible with the expectations; however, for the large banks the relationship is contrary. Large Turkish banks have capital adequacy ratios well above minimum standards, which may be mitigating the effect on bank bond investments. On the other hand, the effect of the capital adequacy ratio is insignificant in the third and fourth model, since the estimation period is shorter in these regressions. Moreover, in the second and fourth models, the capital adequacy ratio and asset size is highly negatively correlated. If asset size is removed from the second model, the significance of the capital adequacy ratio disappears. To sum up, the findings about the effect of the capital adequacy ratio should be interpreted more cautiously.

On the other hand, for a bank to invest in another bank’s bond, the bond-issuing bank must be sound. So, in order to control for the soundness of a bond-issuing bank, we use a large bank dummy, the capital adequacy ratio and the liquidity coverage ratio and present the results in column 5 and 6 of Table 2.6. We find that banks invest in the bonds of large banks significantly more often. Since these banks

are thought to be rescued in times of stress because they are state-owned or because they are too-big to fail, banks find it is safer to invest in the bonds of these banks. The liquidity coverage ratio, however, has no significant association with the coreness measure. The capital adequacy ratio of a bank is weakly associated with the coreness measure in column 5; in other words, as the capital adequacy ratio of a bank increases the extent to invest in bonds of that bank decreases. We further examine this association by excluding development and investment banks. These banks have much higher capital adequacy ratio compared to the other banks. The average CAR ratio for the Turkish banking sector was 16.3 percent in the 2011-2017 period, whereas this ratio for investment and development banks, on average, is 34.3 percent. As seen in column 6, the significance of the capital adequacy ratio disappears in the model without development and investment banks and, hence, we conclude that the largest banks are in the core in terms of their bonds to be held by the other banks.

2.4.2 Change in Banking Group Networks

In this section, we examine the similarity of the network structure of banking groups through time. There are a variety of ways used in the literature to assess network similarity (Aldasoro and Alves, 2018). While topological similarity implies similarity in terms of degree or density distributions, point-wise similarity indicates similarity in terms of the existence of links between two nodes. We analyze the time persistence in the network structures of banking groups using cosine similarity index which is a point-wise similarity measure. Cosine similarity index computes the angle between two vectors. If two vectors are the same or a multiple of each other, then cosine similarity between these two vectors (say, X and Y) are 1.²⁰

²⁰Cosine similarity is calculated with the following formula (the ratio of dot product of two vectors over the multiples of the lengths of these vectors):

Table 2.6: Panel Estimations for Determinants of Security Coreness Measure

	Security Outcoreness			Security Incoreness		
	Large (1)	Non-Large (2)	Large (3)	Non-large (4)	All Banks (5)	Excluding Dev & Inv Banks (6)
<i>Asset Size</i>	0.0755 (0.071)	0.0265 (0.023)	-0.0376 (0.035)	0.0416 (0.044)		
<i>Loan/Deposit</i>	-0.2964*** (0.081)	0.0082 (0.009)				
<i>Liquidity Coverage Ratio</i>			0.0553* (0.032)	0.0144 (0.014)	0.0040 (0.014)	-0.0156 (0.011)
<i>CAR</i>	-2.5047*** (0.971)	0.0796* (0.046)	-0.1031 (0.194)	-0.0240 (0.114)	-0.6573* (0.385)	-0.2931 (0.315)
<i>Large Bank Dummy</i>					0.2877*** (0.043)	0.3131*** (0.040)
<i>Intercept</i>	-1.1230 (1.865)	-0.5775 (0.526)	1.1381 (0.953)	-0.9026 (1.028)	0.1462** (0.069)	0.0873 (0.054)
<i>N</i>	588	2232	336	982	826	720
<i>R-squared</i>	0.049	0.025	0.060	0.006	0.726	0.812

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard deviations are in parenthesis. In columns 1-4, dependent variable is outcoreness measure calculated from security exposures. In columns 1 and 3, regression model is run for large banks and in columns 2 and 4, regression model is run for non-large banks. In columns 5-6, incoreness measure calculated from security exposures is used as dependent variable to understand which banks' bonds are held by other banks. These models are run for the banks issuing bonds. In column 5, all banks are considered, while in column 6 investment and development banks are excluded. *Asset Size* is natural logarithm of a bank's total asset. *Large Bank Dummy* is a dummy variable that has the value 1 for the largest seven banks according to their asset size. *Liquidity Coverage Ratio* is calculated according to Basel standards which is defined as the share of high quality liquid assets over net cash outflow in the 30-day period and available since 2014. *CAR* ratio is the regulatory capital over risk weighted assets. *Loan/Deposit* ratio is total loans over total deposits ratio of the banks. For *CAR*, *Loan/Deposit* and *Liquidity Coverage Ratio*, values smaller than the 5th percentile and larger than the 95th percentile are replaced by 5th percentile and 95th percentile values.

Recently, Aldasoro and Alves (2016) assessed the similarity between different instruments and maturities of large European banks using the cosine similarity index and Bargigli et al. (2015) analyzed time persistence in Italian interbank market using the same measure.

In this section, we partition the total interbank exposures network according to banking groups and analyze the similarity of the banking group networks through years. In the banking group network analysis, because we focus on the last four-year average networks, we select 2013 as the base year and analyze the similarity in the networks in the last four years. We compute the cosine similarity index via comparing the network in 2013 and 2014, then 2013 and 2015 and so on. If the cosine similarity index is found to be 0.9 in 2014, this means that the similarity of the networks in 2014 compared to 2013 is 90 percent, so the network changed 10 percent in one year. As seen in Figure 2.12a, we observe that networks of foreign participation banks, investment banks, and state-owned banks change more than the other banking groups in the four year period from 2013 to 2017. We find that the network of state-owned banks, foreign participation, investment banks change by 9, 66, and 15 percent respectively since cosine similarity index in 2017 is 91, 34, and 85 percent for these banking groups. Since there was no state-owned participation banks in 2013, we do not see this group in the figures.

We also report cosine similarity measures for each banking group, excluding derivative exposures, in Figure 2.12b. Since derivative instruments were started to be reported in 2014, their entry might have some impact on the similarity measure. As seen in Figure 2.12b, cosine similarity index for foreign participation banks decreases to 83 percent in 2017 from 100 percent level in 2013, so when derivative

$$\text{Cosine similarity index} = \frac{X \cdot Y}{\|X\| \|Y\|}$$

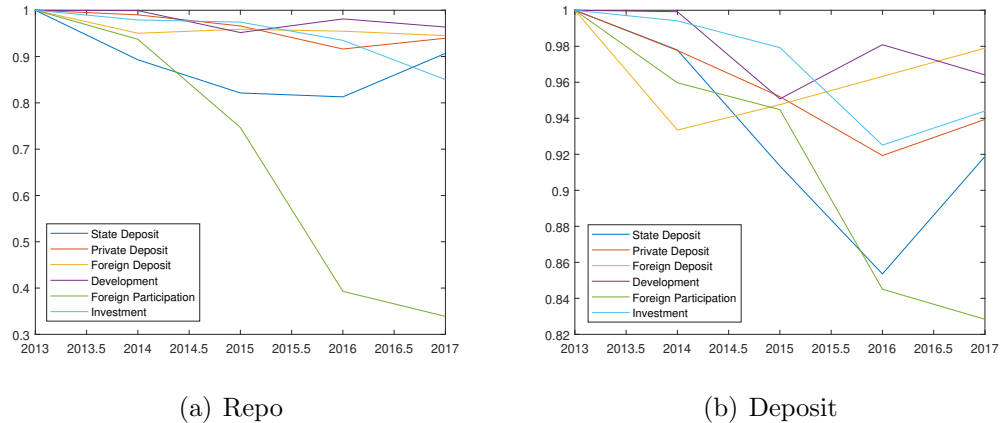


Figure 2.12: Cosine Similarity Index Between Banking Groups.

Notes: The original bank-level networks are collapsed to form 6x6 banking group-level networks. Then, monthly average of banking group-level networks are taken to form yearly networks. Cosine similarity index is calculated for each year compared to the base year, 2013, using banking group-level networks.

exposures are excluded, the change in the network in the four year becomes 17 percent. If we compare the change in the network of foreign participation banks in Figure 2.12a and 2.12b, we see that the change in the network of foreign participation banks decreases significantly, from 66 percent to 17 percent when derivative instruments are excluded. As presented in section 4.1, foreign participation banks have an important role in derivative transactions and exclusion of these transactions changes the network among banking groups significantly. Nevertheless, we find that the highest change in the network is still among foreign participation banks (17 percent) and state-owned banks (8 percent).

Since 2015, two new state participation banks have entered the Turkish banking system, one of which started to operate in May 2015 and the other in February 2016. Since these newly entered state-owned participation banks are subsidiaries of state deposit banks and they work according to the same principles as the other participation banks, the change in the network structure of state and participation banks after 2015 might be due to these new entries. Moreover, one private participation bank grouped under foreign participation banks exited in 2016. When

we examine the change in the network structure between 2013 and 2014 from Figure 2.12a, where the effect of new bank entries and bank exits are absent, we again see that the networks of state and foreign participation banks have changed more than other banks.²¹

2.4.3 Effect of Foreign Bank Purchases on Network Structure

In this section, we examine the change in network structure after foreign bank purchases in Turkey. During the sample period, there were 22 foreign purchase observations belonging to 17 banks in Turkey (see Table A.2 in the Appendix).²² Since after a foreign purchase, governance of the acquired domestic bank would change, we hypothesize that a foreign purchase may have an effect on the network structure of the purchased bank. As explained in the previous section, cosine similarity index is a good measure to analyze the similarity between different networks and assess whether network structure changed after the purchases. To calculate the cosine similarity index, if foreign purchase is in year t , we compare the network of the bank in year $t - 1$ and $t + 1$. In our analysis, we exclude security issuances and derivatives due to late existence of these transactions in the interbank relations. New bank entries, exits or mergers may also have an effect on the network change, so we examine network relations between 42 banks that are all active in the analysis period. We compare the change in the network of the purchased bank with the change in the network of the other banks. In this way, we

²¹As a robustness check, change in network structure is analyzed only considering the banks that have been active in the whole period between 2013 and 2017. So, 5 banks (3 exits and 2 entries) are excluded from the network and the analysis is repeated. When these banks are excluded the change in the network of state-owned banks decreased a little (from 8 percent to 7 percent) and foreign participation banks increased a little (from 17 percent to 18 percent) but the decrease is not so significant.

²²We only focus on significant foreign purchases here and share acquisitions in smaller percentages via investment funds are not included.

are able to infer whether foreign purchases have a significant effect on the network relations of the purchased bank.

Table 2.7 summarizes cosine similarity index values for the purchased banks and remaining other banks. For example, in 2005 two banks were purchased by foreigners. When we compare the networks of these banks in years 2004 and 2006, we find that cosine similarity index is 0.680 and 0.331 respectively suggesting that the networks of the banks changed by 32 percent and 66.9 percent.²³ On the other hand, cosine similarity index for the network composed of all remaining active banks is 0.781 suggesting the change in the network is 21.9 percent. Thus, in 2005, the networks of the two purchased banks changed more compared to the network of other banks. In Table 2.7, the numbers in italic report the cases that violate our hypothesis, i.e., a foreign bank purchase did not affect the network of the purchased bank. For example, in 2006, we find that one out of four purchases violates our hypothesis since cosine similarity index of that bank is higher than the cosine similarity index value of the banks other than the purchased banks.

Overall, cosine similarity index values suggest that foreign purchases seem to change the network in Turkey. In particular, while before 2010, of 13 foreign purchases, for ten of them change in the network of the bank whose shares are acquired is higher as compared to the change in the network of the other banks. After 2010, there are evidence that network structure has changed for some banks by the foreign bank purchases but not as common as before. A foreign purchase wave has swept through Turkish banking system during 2005-2010 with foreigners being controlling shareholders of the acquired banks. On the other hand, nearly half of the violating observations (of the hypothesis that foreign purchases change network structure) after 2010 belong to the second purchases of the banks that

²³The change in the network between two years is calculated as the difference of cosine similarity index from one.

Table 2.7: Cosine Similarity Index of the Networks Before and After Foreign Purchases.

Year of Foreign Purchase	Number of Purchases	Cosine Similarity Index of		
		Banks Purchased by Foreigners	Other Banks	Other Banks
2005	2	0.680 ; 0.331		0.781
2006	4	0.249 ; 0.171 ; 0.513 ; 1.000		0.657
2007	5	0.246 ; 0.846 ; 0.709 ; 0.662 ; 0.344		0.790
2008	1	<i>0.764</i>		0.748
2009	0	-		-
2010	1	0.191		0.468
2011	2	<i>0.674 ; 0.753</i>		0.432
2012	2	0.666 ; 0.601		0.670
2013	1	<i>0.846</i>		0.658
2014	0	-		-
2015	3	<i>0.776 ; 0.696 ; 0.346</i>		0.490
2016	1	<i>0.635</i>		0.610

Notes: The table shows the cosine similarity index of the networks calculated via comparing the networks before and after foreign purchases. The first column shows the year of foreign purchase and second column shows the number of bank purchases in that year. When calculating the cosine similarity index, if foreign purchase is in year t , we compare the network in year $t - 1$ and $t + 1$ and report the similarity index in third and fourth columns. Third column shows the cosine similarity index for the banks purchased by foreigners and calculated for the $1 \times n$ network of the purchased bank where n shows the total number of banks. Cosine similarity index of each bank purchased in the related year is separated with semi-colons in the third column. Fourth column shows the cosine similarity index for the other banks that are not purchased by a foreigner in that year and calculated for the $(n - a) \times (n - a)$ network of the other banks where a shows the number of purchased banks in that year. Numbers in italic indicate the violating observations of the hypothesis that foreign purchases change the network structure of the purchased bank more compared to the network structure of the other banks. If the cosine similarity index in the third column is higher than the number in the fourth column, this means that the network of the bank purchased by a foreign bank changed less after the foreign purchase compared to the network of other banks, so this observation violates the hypothesis.

were previously purchased by foreign banks (see Table A.2 in the Appendix). Thus, we argue that one should not expect to see the network structure to change as significant as before since another foreign bank takeover wouldn't have significant change on the network structure of the purchased foreign bank.

As we mentioned before, we exclude derivative contracts in the analysis of foreign purchases due to their short existence in the interbank transactions. However, we have also shown that foreign banks have an important role in the derivative contracts. We expect that if we have the chance to study the change in the network including derivative contracts, we could have observed stronger evidence of change in the networks of purchased banks. So, we suggest that this hypothesis is worthy of being tested in the networks of other countries.

2.5. Conclusion

In this paper, using monthly interbank exposures data, we examine the interbank network structure and association among different banking groups in a large emerging economy. Our findings show that the core-periphery (CP) structure gives a better fit to the Turkish interbank network compared to the random and scale-free structures. This finding suggests that banks in Turkey care counterparty relationships and link formations in the interbank market during the sample period of 2003-2017. In a banking system with no regional banks, we find all large banks, some medium-sized banks, and even small banks to be highly connected. The existence of small banks in the core bank set is very interesting, considering their role in funding SMEs in an emerging economy. Nevertheless, the asset size and network statistic of a bank, (i.e., betweenness or closeness centrality) are found to be the major determinants of the coreness of a bank.

Although the probability of an event large enough to distress a larger institution is

low, if a large enough shock were to occur, it may disrupt the whole payment system. Turkey had a similar experience almost two decades ago. In November 2000, banks started to close their interbank credit lines to vulnerable Turkish banks after concerns about the health of the banking sector. Consequently, the difficulties of large state-owned deposit banks and mid- and small-sized private deposit banks turned into a systemic banking crisis in February 2001. Since then, a new regulatory system and the financial liberalization of the market have deepened the financial system in Turkey. Hence, we argue that monitoring the coreness of a bank as well as its interactions with other banks provides valuable information on the stability of the whole banking system and the real economy.

In our analysis we study, for the first time, the interbank network structure using banking group and instrument breakdown and find that some banking groups, especially foreign and state deposit banks, play an important role in shaping the interbank network structure. Using the cosine similarity measure, we observe that foreign bank entries, especially before 2010, seem to change the Turkish interbank network structure. Among 22 events of foreign purchases during the sample period, we show how the entrance of a foreign bank or an increase in the shareholding of a foreign partner changes the network structure of the acquired/target bank. The tiered or CP structure of the interbank system arises partly for organic reasons and partly in response to regulatory constraints. In the paper, as a final contribution, we also show that some local factors, such as the limits in the repo market with the Central Bank and Basel regulations, play a role in shaping the network structure. In particular, highly liquid large banks and well-capitalized non-large banks are found to invest more in the interbank security market.

This study is important in terms of several policy implications. Foreign bank interest in domestic banks is important for the financial and economic development of the emerging countries. On the other hand, foreign banks have comparative

advantage in some type of instruments such as derivatives which generally have a shorter maturity and more complex structure compared to other instruments.

Considering the growing derivative transactions in a financially integrated emerging economy such as Turkey, the coreness of foreign banks has to be also monitored for the stability of the currency markets. Moreover, the acquisition of domestic banks via foreign banks changes the network structure of the acquired bank if the share purchases are in higher percentages.

Additionally, among banking groups, we present evidence that state banks tend to invest in other state institutions and hence increase the concentration of risks. The regulatory authorities should follow risk concentrations in the network for the stability of the interbank markets.

CHAPTER III

CROSS BORDER INTERBANK NETWORK OF TURKISH BANKS

3.1. Introduction

The 2007-2009 global financial crisis has drawn considerable attention and created greater concern about the complex interconnections between financial institutions. Glasserman and Young (2016) argue that relations between network topology and bank characteristics such as liquidity levels or bank size distribution make more complex to 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. While the interbank network studies in the literature focus on mostly relations between domestic banks (see e.g. Furfine, 2003; Degryse and Nguyen, 2007; Lelyveld and Liedorp, 2006; Upper and Worms, 2004 for network studies between domestic banks.), there are a few studies that investigate cross-border interbank relations. In this paper, we aim to contribute global interbank network literature by focusing on how network structure of a financially integrated emerging economy is shaped by cross-border linkages. While the studies in the literature that examine global interbank relations on bank level is dependent on syndication loan details, we have interbank relation

details of repo, deposit and derivative transactions besides loan. To our knowledge, this is the first study that analyzes the direct connections between foreign lenders and local banks (either by foreign-owned or domestically owned banks) through different type of contracts.

BIS locational and consolidated banking statistics is one of the key data sources to study global interbank networks. BIS publishes this dataset by aggregating interbank relations at the country level, hence the granularity of the data limits to explore only international banking flows between countries. Using BIS statistics, von Peter (2007) documents several network statistics for core reporting countries and emphasizes the presence of foreign banks as one of the most cited features of financial centers. He finds that United Kingdom is an important global reach because of broad representation of banks from emerging markets in London. Similarly, Minoiu and Reyes (2013) analyze interbank relations between countries for an extensive period of time, 1978-2010. They 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 direct cross-border lending is more sensitive to supply factors during crises times compared to lending by foreign affiliates of the same bank. Finally, Cerutti and Zhou (2017) highlight that although the size of cross-border claims decreased after the global financial crises, the change in cross-border claims is due to decreasing interbank relations between core banks. They also show that some parts of the network became even more interlinked compared to before global crisis period.

Besides the global network studies that investigate aggregated interbank relations between countries using BIS statistics, there are papers that construct global interbank networks using syndication loan details.¹ Hale (2012) is the first study

¹Different from the network studies that work with actual interbank exposures data, Demirer et

that form global interbank network on bank-level using syndication loans for 7938 banks from 141 countries. She shows that recessions and banking crises had an important effect in the formation of new interbank relations and the distribution of connections. Using global interbank networks constructed from syndication loans, Hale et al. (2019) present evidence that exposures to countries facing crisis tighten credit conditions and reduce firm growth and investment even in countries not experiencing banking crises themselves.

There are also a few studies that combine different cross-border network relation data. Cerutti et al. (2015) combine syndicated loan and BIS data and study the drivers of cross border lending of syndicated and non-syndicated loans. Cabellero et al. (2018) study interbank and trade relations of two countries and shows 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.

After a deterioration in global interbank market due to a financial crisis, there are evidence that interbank relations may act as transmission mechanisms and may have negative effects in the credit supply to the real economy.²For example, Cetorelli and Goldberg (2012) show that foreign banks play important role in transmitting shocks to host countries. During the global financial crisis, foreign banks are found to withdraw 12 percent internal fund from an averaged-sized US branch and one dollar fund withdrawal. The effect of one dollar fund withdrawal is shown to lower loan supply of US branches 40 to 50 cents. Cingano et al. (2016) study bank-firm relations of Italy after global financial crises and show that banks which heavily relied on interbank borrowing before the crises tightened lending to firms more due to contraction in interbank markets. Due to the tightening credit

al. (2018) study global network connectedness using correlations in asset returns.

²In the case of Continental Illinois crisis, after foreign banks withdrew funds from the bank, the bank needed to stop lending to smaller domestic banks which deepened the crisis (Sheldon and Maurer, 1998).

conditions, investment of firms are found to decrease by 20 percent and the effect is stronger for small and young firms which are dependent on bank credit. Similarly, Iyer et al. (2013) investigate the effect of freeze in interbank markets after GFC using Portuguese bank data and show that banks that are more dependent on interbank borrowing decrease credit supply more. Schnabl (2012) studies the effect of 1998 Russian crisis on bank lending to an emerging economy, Peru. He shows that after the crisis, lending by domestic banks which use international bank borrowing channel, decreased more compared to foreign banks that continue to have access to international funds.

Thus, 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 have been substantially connected in the recent years. Among these emerging economies, Turkey is a good example which is financially well-integrated into the global financial system. The borrowings of Turkish banks from foreign countries in repo, deposit and loan type constitute approximately 20 percent of their total liabilities. Moreover, domestically operating banks in Turkey have a growing share of derivative transactions to hedge currency risk with foreign counterparties.

In this chapter, we examine the network relations between Turkish domestic banks and foreign banks abroad for 2014-2018 period for different types of instruments. In 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 Özyıldırım, 2019 for Turkey;

Aldasoro and Alves, 2018 and Montagna and Kok, 2016 for EU banks). Therefore, we aim to cover different type of interbank contracts in the analysis. First, we analyze the evolvement of several network 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 and strength are highly correlated. Second, we investigate the similarities between different instrument-level networks and through time similarities in each network. We show that in through 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 requires 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 through 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.

Turkey is an interesting country to study the effect of a crisis on interbank relations. After financial liberalization, since the beginning of 1980s, Turkey experienced persistent macroeconomic and financial instability or at least a threat of a financial crisis(Öniş, 2010). On 13th of August 2018, Turkey faced with a currency shock and in one day currency depreciated about 20 percent. After that currency shock, interest rates rose dramatically and caused loan demand and supply to depress. In this chapter, we document the impact of the shock on the network relations. First, 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 banks abroad. Second, we see a sharp 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. Among the foreign banks that act as counterparty for Turkish banks, some of them have shares in domestic Turkish banks and some banks work according to islamic principles. Islamic banks are interest sensitive banks and can only make transactions that their Sharia board is allowing. By grouping foreign banks as islamic foreign and conventional foreign banks, we observe that islamic Turkish banks seem to invest their excess funds more in islamic banks and borrow from foreign islamic banks most of the time during the analysis period. On the other hand, since derivative transactions requires specialized pricing, conventional banks form the most important counterparty for islamic Turkish banks. Compatible with the findings of Cerutti and Claessens (2016), we see 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 chapter is organized as follows: In Section 3.2, we introduce our data set, define banking groups and give descriptive statistics. In Section 3.3, we analyze the relations between different banking groups. In Section 3.4, we document several network statistics and in Section 3.5, we investigate through time and between instrument similarities.

3.2. Data Description

In this study, we use two unique datasets that are collected by Banking Regulation and Supervision Agency of Turkey. In the first one, repo, deposit and loan type instruments are reported in a monthly frequency in the 2003-2018 period. In the second dataset, derivative contracts in a daily frequency between 2014-2018 period is available. In the first dataset, transactions having a positive outstanding balance at the end of the month is reported, so any short-term transaction that is entered into and closed within the month is not reported in that dataset. However, most of the transactions in the dataset is in loan type which has a longer maturity structure, so we expect the share of missed transactions due to short-term structure to be small. Although the reporting frequency of the second dataset is daily, to make compatible with the first dataset, we used the outstanding derivative balances at the end of each month.

Resident banks in Turkey are required to report detailed information of transactions such as currency, amount, opening and closing dates of the transactions as well as details of the counterparty. In the first dataset, counterparties were reported only with their names during January 2003 and February 2012 period, however swiftcodes of counterparties were added to the reporting template after March 2012. The identification of counterparty banks from their names correctly is almost impossible since there are different foreign banks having same names. Thus, in this chapter, we analyze cross-border network structure after 2014, since identification from swiftcodes in the first dataset is possible and derivative reportings in the second dataset are also available after that date. For the transactions that swiftcodes of the counterparties is not available, we used the names of the counterparties to identify the counterparty. In the second dataset, swiftcodes, names, and tax identification number of the counterparties are

used to determine the other party in the transaction. After identifying counterparties, the misreportings in the dataset are controlled. According to the reporting standards, there must be two records for a single derivative transaction. Assume that two parties enter into a currency swap agreement to buy USD and sell TRY in the forward date. This transaction should be reported as shown in Table 3.1 as a double entry. Banks should report both entries with the same transaction number which would be unique for each transaction of the bank. However, there are misreportings and not all derivative transactions are reported as a double entry in our dataset. In particular, there are transactions without a transaction number or different transaction numbers are given to the records of the same transaction. Before starting the analysis, we checked whether each transaction has its couple in order to work with only matched data. We followed a three step matching algorithm. In the first step, if there is only one record having same counterparty, opening date, maturity date, transaction number and transaction type (e.g. currency swap, forward, interest rate swap) with the record that we search for its couple, we take these transactions as matched transactions. In the second step, among the unmatched transactions, we search for the entries without a transaction number or with an incorrect transaction number. In that step, we matched the entries having only one couple with the same counterparty, opening date, maturity date, and transaction type. 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.³ By following

³While going over the unmatched transactions, we noticed some reporting errors and corrected these errors in the dataset. For example, some banks are reporting gold swap (buy) and currency swap (sell) transactions as a couple with the same transaction number if derivative transaction is for buying/selling gold against a currency. We changed the transaction types of these entries and

Table 3.1: An Example for Double Entry Reporting of a Derivative Transaction

Transaction Type	Bank	Counterparty Bank	Currency		Opening	Maturity	Transaction Number
			#1	#2	Date	Date	
Currency Swap (Buy)	Garanti	HSBC	USD	TRY	15.12.2018	23.03.2019	DT112
Currency Swap (Sell)	Garanti	HSBC	TRY	USD	15.12.2018	23.03.2019	DT112

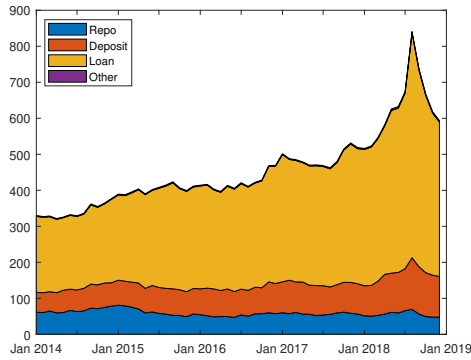
Notes: Table shows how an example derivative transaction should be reported as a double entry correctly. The example derivative transaction is opened on 15th of December, 2018 with a maturity date of 23th of March, 2019. Garanti Bank has entered in a currency swap transaction with HSBC to buy TRY and 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.

these steps, we are able to match almost 99 percent of the transactions both in number of observations and size.

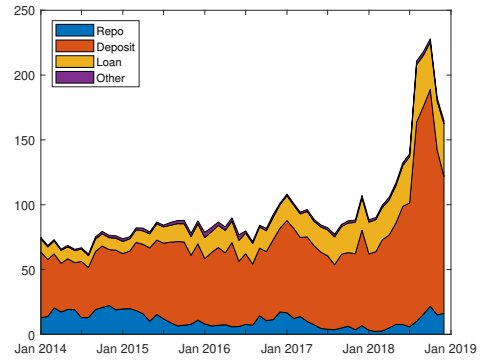
We exclude the non-bank financial institutions operating in Turkey as the counterparty from the analysis, since these institutions have borrowing and lending relationships mostly with their parent banks in Turkey. There are also domestic banks that have established special purpose vehicles (SPVs) for 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.

Figure 3.1 shows the breakdown of exposures in both datasets. As of December 2018, total payables of Turkish banks to the banks (both domestic and foreign) amount to 593.6 billion TL (112.4 billion USD) and share in the total assets is 15.3 percent. Share of total payables to total assets range between 15.3 and 19.2 percent between January 2014 and December 2018. The breakdown of total payable exposures is as eight percent repo, 19 percent deposit and 72 percent loan as of December 2018. The share of repo was 19 percent in the beginning of 2014 suggesting a shift in the debt composition of the banks from repo type to loan type. As of December 2018, total receivables from banks (both domestic and

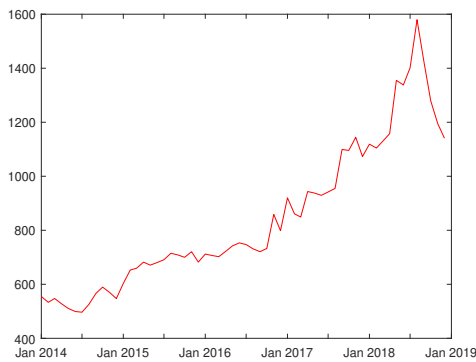
tried to match again.



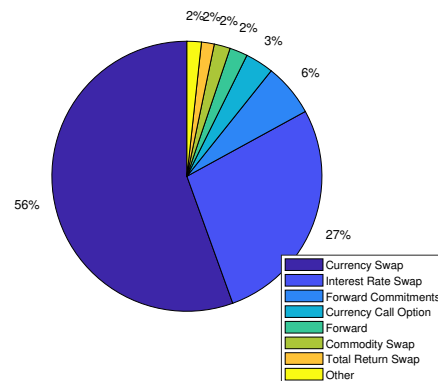
(a) Payables in on-balance sheet items



(b) Receivables in on-balance sheet items



(c) Traded volume in derivatives



(d) Breakdown of derivative types in December 2018

Figure 3.1: Breakdown of Transactions in the First and Second Dataset

Notes: The amounts in the Figure 3.1a, Figure 3.1b and Figure 3.1c show the outstanding balances at the end of each month in Billion TL. Other in Figure 3.1a and Figure 3.1b represent the transactions that the instrument type is not reported.

foreign) amount to 164.8 billion TL (31.2 billion USD), which shows that Turkish banks have payables more than receivables which is mostly due to the payables to the foreign banks. The share of total receivables in the total assets is 4.3 percent as of the last observation and this share ranges between 2.6 and 5.7 percent in the analysis period. The composition of the receivables is slightly different from the payables, where deposit type instruments form 64 percent and the share of repo and loan type instruments are ten and 25 percent respectively as of December 2018.

Figure 3.1c shows the volume of traded derivatives. As of December 2018, the volume is 1141 billion TL (216 billion USD). Due to exchange rate spike in August

2018, the volume seems to boom in August 2018 and then decreased sharply, however the volume is stable in terms of USD until June 2018, after which a decreasing trend started. Turkish banks started to decrease borrowing in FX from abroad which caused a decrease in on-balance sheet FX position and derivative volume which will be explained in detail in the next paragraphs. As of December 2018, 56 percent of the derivative transactions is in currency swap type (Figure 3.1d). Turkish banks are mainly using derivative transactions to hedge currency risk via making similar the currency of liabilities and the currency of the assets. Table 3.2 shows the TL and FX composition of assets and liabilities of Turkish banking sector as of December 2018. While FX share in the total liabilities is 49.8 percent, FX share in total assets is 43.7 percent. Turkish banks are receiving FX funds from foreign banks, however FX loan demand of Turkish corporates is limited. Households are not allowed to use FX loans since 2009 due to macroprudential measure. So banks make currency swaps with foreign banks to be able to extend TL loans to corporates and households. Deposits constitute an important share of total liabilities for Turkish 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 3.1d, 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.

In this chapter, in order to examine the changes in the network structure, we formed flow exposure matrices using opening dates of transactions in the reportings. For example, a transaction entered on 6th of January 2014 with a maturity date of 6th of March 2014 is accounted both in January 2014 and February 2014 reportings. By keeping transactions whose opening month and year is equal to reporting month and year, we form flow exposure matrices and count

Table 3.2: 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.

this transaction only in January 2014 period.⁴ In this way, we form 20 quarterly networks using monthly flow relations during the sample period of January 2014 and December 2018.

In our analysis period, we count 1047 swiftcodes belonging to different counterparties (including domestic Turkish banks) from 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 and include only 778 swiftcodes in the analysis. 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.

⁴We exclude all of the transactions not having an opening date.

We aggregate swiftcodes of banks in the same bank group. For example, there are 23 swiftcodes belonging to HSBC group. For example, HSBC Bank Egypt has swiftcode of *EBBK* and HSBC Bank Malaysia has *HBMB*. Then, we classify banks in 6 groups according to ownership structure and type of business model (Table 3.3). Foreign banks are grouped according to whether they hold shares of Turkish banks or not. We make another group banks according to conventional or islamic banking model. The banks identified as the ones having shares in Turkish banks have considerable shares, specifically more than 40 percent. ⁵

In our bank set, there are in total 33 foreign banks that have shares in Turkish banks of which only seven of them are islamic banks. In our analysis, we noticed identifying banks as islamic is not an easy task. We use several sources to make a list of islamic banks. First, we checked websites and papers documenting the lists of islamic banks.⁶Second, we checked the websites of the banks to see whether there is any menu regarding islamic banking or Sharia board.⁷ In this way, we identify islamic banks in our sample. There are 53 resident banks in Turkey in our dataset. Subsidiaries of these banks in foreign countries such as Garanti-Moscow has also been grouped together with Turkish shareholders, Garanti Bank, and assigned the same bank identifier number. ⁸ 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 foreign banks type not having any shares in Turkish banks.

⁵There are only two banks in the shareholder banks set that have 8-9 percent share in Turkish banks, which are Islamic development bank and Public institution for social security.

⁶Some of the websites used are: 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

⁷Several 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, HSBC bank in UK and HSBC Amanah bank in Malaysia are grouped together under HSBC bank.

⁸Since, subsidiaries of Turkish banks are generally connected with their shareholders, diagonal entries of interbank matrices is not zero.

Table 3.3: Banking Groups in the Analysis

Group	Number of swiftcodes in the group	Number of banks 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 such as HSBC, Royal Bank of Scotland. “Islamic foreign banks having shares in domestic banks” are the banks that work according to islamic principles and have shares in domestic banks such as Kuwait Finance House. “Resident banks in Turkey and subsidiaries” cover both Turkish banks operating in Turkey and their subsidiaries abroad such as subsidiary of Garanti Bank in Moscow. “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.

Figure 3.2 shows the breakdown of exposures in the first dataset which is formed according to opening dates of the transactions. While Figure 3.1 shows the breakdown according to the outstanding balances at the end of each month, Figure 3.2 shows the breakdown according to the flow exposures in each quarter. In Figure 3.1a, majority of the exposures were in loan type, on the other hand the breakdown is slightly different in Figure 3.2a. Since loan type instruments have a longer maturity compared to deposit and repo type instruments, an opened transaction is seen in many periods in Figure 3.1a and increases the share of longer maturity instruments. This different outlook in Figure 3.1 and 3.2 in terms of breakdown of exposures shows the importance of working with flow exposures when maturities of the instruments are different. For the opened transactions in the last quarter of 2018, the share of repo, deposit and loan type instruments are 18, 43 and 37 percent respectively for the payables of Turkish banks (Figure 3.2a). Compared to the first quarter of 2014, while the share of repo payables has decreased, the share

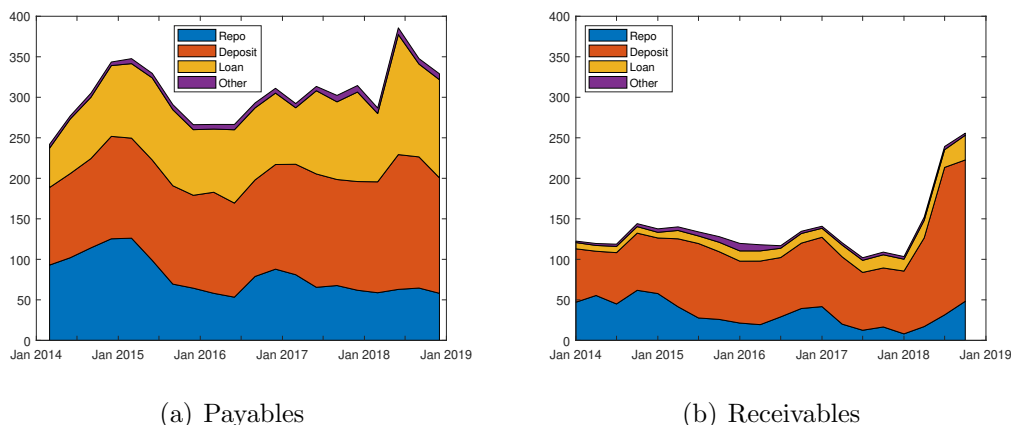


Figure 3.2: Receivables and Payables in Type of Repo, Deposit and Loan
Notes: The amounts in the figures show the sum of exposures that are entered into in the related quarters (Billion TL).

of loan payables increased. For the receivables of Turkish banks, for the transactions opened in the last quarter of 2018, the share of repo instruments is 19 percent, deposit is 68 percent and loan is 12 percent (Figure 3.2b). Similar to the payables, there is a shift from repo share to deposit and loan shares.

We document country breakdown of the exposures in the first dataset for the first quarter of 2014 and last quarter of 2018 in which countries are sorted according to the size of payables (Table 3.4). While the set of leading countries in terms of providing funds to Turkish banks did not change significantly in the five years period, the rankings of the countries are slightly different. For example, we observe that Turkish banks started to receive funds from United Arab Emirates, Russia and Qatar more, while the relative funding from Netherlands and Switzerland decreased.

Figure 3.3 illustrates the development of quarterly volume of traded derivatives according to the opening dates. Since derivative transactions have shorter maturities, flow exposures are quite close to the outstanding balances in derivative transactions. While outstanding derivative balance is 1141 billion TL in December 2018 (Figure 3.1a), the volume of derivatives that are opened in 2018Q4 is 1133

Table 3.4: Country Breakdown in the First Dataset

2014Q1			2018Q4		
Country	Receivable	Payable	Country	Receivable	Payable
Turkey	90.6	93.4	Turkey	100.5	108.5
United Kingdom	5.7	52.4	United Kingdom	55.4	53.9
Switzerland	0.0	19.0	North Cyprus	5.0	26.2
France	0.3	10.3	Russia	0.8	16.8
Libya	0.0	7.8	Qatar	0.7	14.9
USA	8.7	7.4	Switzerland	1.5	12.4
North Cyprus	0.0	6.7	France	5.5	11.8
Netherlands	0.6	6.4	United Arab Emirates	0.0	10.0
Germany	8.4	4.2	USA	15.8	9.8
Iran	0.0	3.7	Netherlands	0.8	6.4
Other	8.0	30.5	Other	69.7	58.4

Notes: The numbers in the table shows the size of exposures (denoted in billion TL) to the related countries in the beginning and end of the analysis period. The countries are sorted according to the payable amounts.

billion TL (Figure 3.3). Flow exposures also show that Turkish banks have been using derivative transactions more since 2017 due to the low appetite of FX loan demand of Turkish corporates and increasing on-balance sheet FX position.⁹

When we analyze the counterparty countries of Turkish banks in the derivative transactions, United Kingdom is found as an important derivative partner respectively providing about 70 percent of the traded volume (Table 3.5). Similar to the figures in Table 3.4, ranking of the countries in derivative transactions has slightly changed in 2018Q4 compared to 2014Q1. For example, Thailand and Spain are listed in top ten counterparty countries in derivative transactions in 2018Q4, although they were not in the list in 2014Q1. An interesting observation is that Turkish banks started to trade less with each other.

As the final step, we construct networks between banks from the transaction-level data. For the first dataset, although foreign banks abroad are not required to

⁹Turkish corporates preferred to use FX loan instead of TL loan before 2016 since FX loan rates are lower than TL loan rates and exchange rate has a more stable pattern.

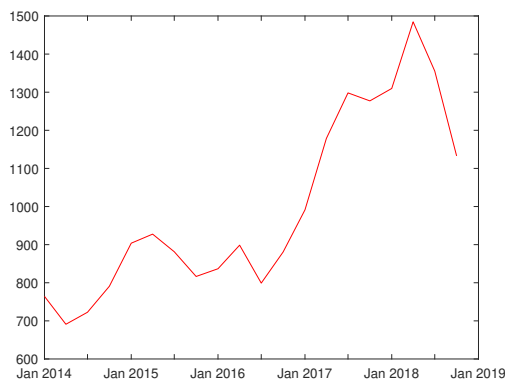


Figure 3.3: Traded Volume in Derivatives

Notes: The amounts in the figure show the sum of exposures that are entered into in the related quarters (Billion TL).

report to domestic banking authority (BRSA), resident banks in Turkey (domestic banks) are reporting both their receivables and payables and we use these reporting to form networks. For example, if domestic bank A reports that it has 10 TL receivable from foreign bank B and 5 TL payable to the same bank, then the payable amount is registered as the receivable of the foreign bank B from domestic bank A. This procedure is summarized in Table 3.6. Using this procedure, we construct networks between domestic banks and between domestic banks and foreign banks. Since the relations between foreign banks abroad is missing, we assign 0 to the associated entries. In the second dataset, derivative volume reported with domestic bank A and foreign bank B is also registered as the derivative volume between foreign bank B and domestic bank A. Thus, domestic bank to foreign bank and foreign bank to domestic bank regions in derivative network are mirror of each other.

Table 3.5: Country Breakdown in the Second Dataset

2014 Q1		2018 Q4	
Country	Exposure	Country	Exposure
UK	497.8	UK	764.6
France	81.7	France	114.3
Turkey	61.1	Switzerland	72.0
Switzerland	39.2	Bahrein	65.9
Bahrein	20.7	Turkey	49.4
Germany	18.2	Germany	23.1
Austria	16.3	Spain	9.8
Netherlands	8.1	Malta	6.3
Spain	5.9	Thailand	6.1
Malta	3.6	Netherlands	5.6
Other	11.7	Other	15.5

Notes: The numbers in the table shows the size of exposures (denoted in billion TL) to the related countries in the beginning and end of the analysis period.

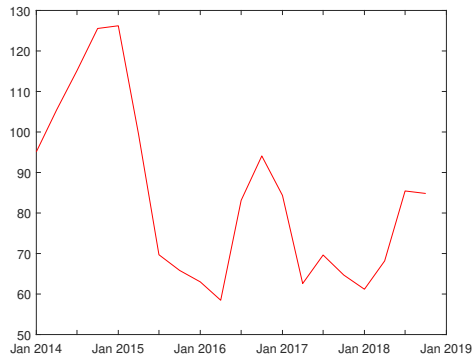
Figure 3.4 shows the development of exposures in the networks formed. Since payables of domestic banks to foreign banks are receivables of foreign banks, all of the receivables in Figure 3.2a and payables of Turkish banks to foreign banks in Figure 3.2b are summed to form Figure 3.4. For the derivatives, except the volume of derivatives between domestic Turkish banks, the volume is multiplied. So, the traded derivative volume in Figure 3.4d is nearly double of the volume in Figure 3.3.

Figure 3.5a shows link breakdown in each instrument. Similar to the share in total size (Figure 3.3), repo type instruments has minimum share in the link breakdown. Number of links in repo type instruments decreased nearly to the half compared to the beginning of the analysis period and the number of links opened in the last quarter of 2018 amount to 97. Deposit and loan type instruments have similar number of links. The number of links entered into in 2018:Q4 are 606 and 589

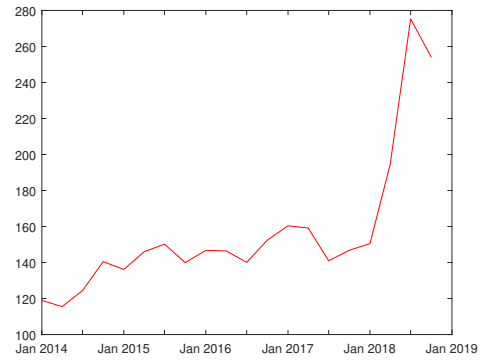
Table 3.6: Network Construction

First Dataset		Second Dataset					
DB ₁	DB ₂ ... DB _n	FB ₁	FB ₂ .. FB _m	DB ₁	DB ₂ ... DB _n	FB ₁	FB ₂ .. FB _m
DB ₂	Receivable of DB	Receivable of DB		DB ₂	Volume-DB-DB	Volume-DB-FB	
...				...			
DB _n				DB _n			
FB ₁				FB ₁			
FB ₂	Payable of DB=Receivable of FB	0	0	FB ₂	Volume DB-FB	0	0
...				...			
FB _m				FB _m			

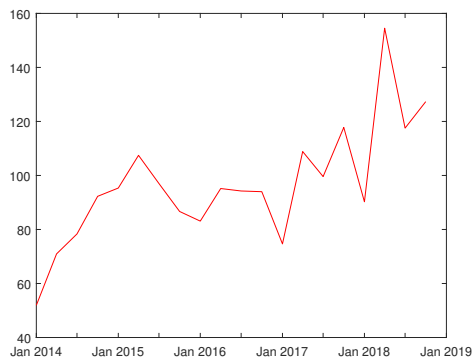
Notes: DB refers to domestic bank and FB refers to foreign bank in the table. There are n domestic banks and m foreign banks in the set. DB₁ shows first domestic bank and DB_n shows the last domestic bank.



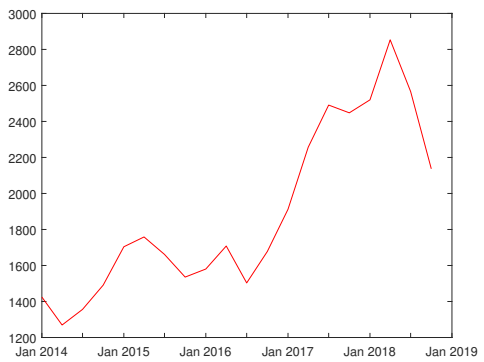
(a) Repo



(b) Deposit



(c) Loan



(d) Derivative

Figure 3.4: Exposures in the Related Quarters
Notes: Exposures are denoted in Billion TL.

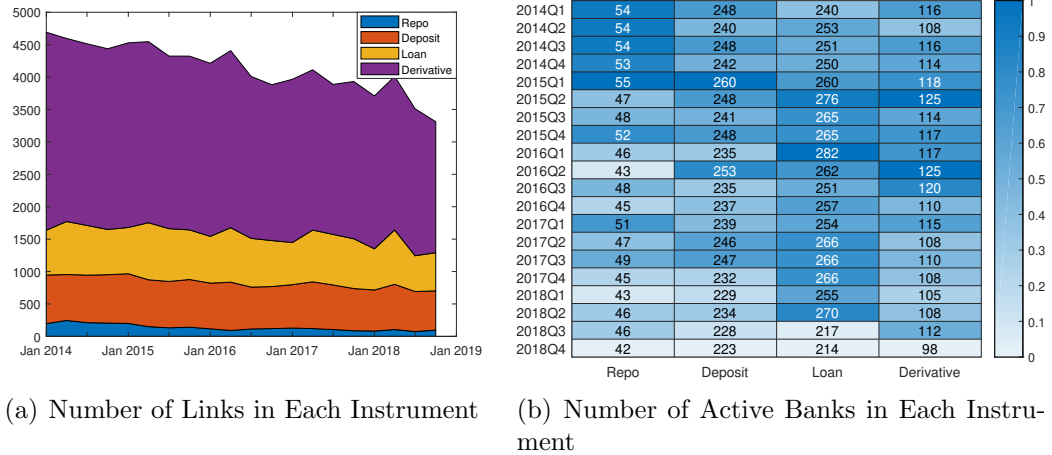


Figure 3.5: Number of Links and Active Banks

Notes: 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

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 2014:Q1 is 2980, the size of these links decreased to 2020 in 2018:Q4.

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. Moreover, all banks may not enter into transaction with resident banks in Turkey in each quarter. Hence, we document the number of active banks in different type of instruments in Figure 3.5b. 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 3.5b shows that number of active banks in repo transactions range between 42 and 55, which is smaller compared to other instruments. Figure 3.5b also shows that number of active banks in all type of instruments decreased in the last quarter compared to the first period of the analysis.

3.3. Banking Group Relations

In this section, we examine the concentration of exposures between six bank groups that are summarized in Table 3.3. First, we illustrate the relations between bank groups under different instruments (Figure 3.6). In the first quarter of 2014, resident banks in Turkey are found to have repo transactions mainly with each other. In the first quarter of 2014, the share of repo transactions that are within domestic banks in the total transactions was 49 percent and this share almost decreased to half, i.e. 22 percent, in the last quarter of 2018. On the other hand, domestic banks increased the share of repo transactions with foreign banks having shares in them in the last quarter of 2018. In repo transactions, islamic banks are found to be inactive. These banks are not allowed to make repo transactions due to Sharia rules.¹⁰

Similar to repo transactions, majority of transactions in deposit exposures in the first quarter of 2014 was between banks resident in Turkey, i.e., 36 percent. Over time, this share decreased by 30 percent but still constitutes 24 percent of the deposit exposures in the last quarter of 2018. Domestic banks increased deposit receivables from other conventional foreign banks in 2018Q4. As seen in Figure 3.2b, this change, increase in deposit receivables, started in 2018Q3 after the currency shock experienced by Turkey. Banks resident in Turkey needed to show that they have enough liquidity to pay their syndication loans back and increased their deposits in the other conventional foreign banks group.

In loan type instruments, share of exposures between banks resident in Turkey is smaller compared to repo and deposit exposures, i.e. 11 percent in 2014Q1 and

¹⁰Other islamic foreign banks group is seen in the repo graph in 2018Q4 because one of the banks in that group has an islamic subsidiary and due to that grouped together under other islamic foreign banks group, however parent company which is a conventional bank is making the repo transaction with domestic banks.

increased to 22 percent in 2018Q4. In loan exposures most of the exposures are between banks resident in Turkey and foreign banks having shares in these banks. In derivative exposures, the share between banks resident in Turkey was 7 percent in 2014Q1 and 6 percent in 2018Q4. Domestic banks conduct most of their derivative transactions with foreign banks having shares in these banks and other foreign banks. The banks in these groups are generally larger banks specialized in derivative transactions, so these banks act as leading derivative partners for domestic banks.

When we group banks according to their business model as conventional or islamic banks, we find interesting relations between banks. As of December 2018, there were 52 banks operating in Turkey of five works according to islamic principles. Islamic domestic banks constitute about five percent of total Turkish banking sector assets. In this analysis, we aim to investigate whether there is a preference by islamic Turkish banks or foreign islamic banks to lend or borrow from islamic counterparties. Islamic domestic banks are not active in repo transactions as mentioned above. Thus, we could analyze repo receivables and payables of conventional domestic banks only. Conventional domestic banks increased repo receivables from foreign conventional banks in the last two quarter of 2018 after the currency shock in August 2018 (Figure 3.7a). Due to increasing loan interest rates and asset quality concerns, banks preferred to be liquid and shifted to short-term investments in that period. Islamic domestic banks prefer to invest their deposits in islamic banks most of the time, while in the beginning of 2014, majority was deposited in islamic foreign banks, in the last years, they switched to deposit in islamic domestic banks (Figure 3.7b). On the other hand, from Figure 3.8b, conventional banks seem to prefer to invest in islamic domestic banks, so conventional domestic and conventional foreign banks are also seen in the composition of deposit payables of domestic islamic banks. However, detailed

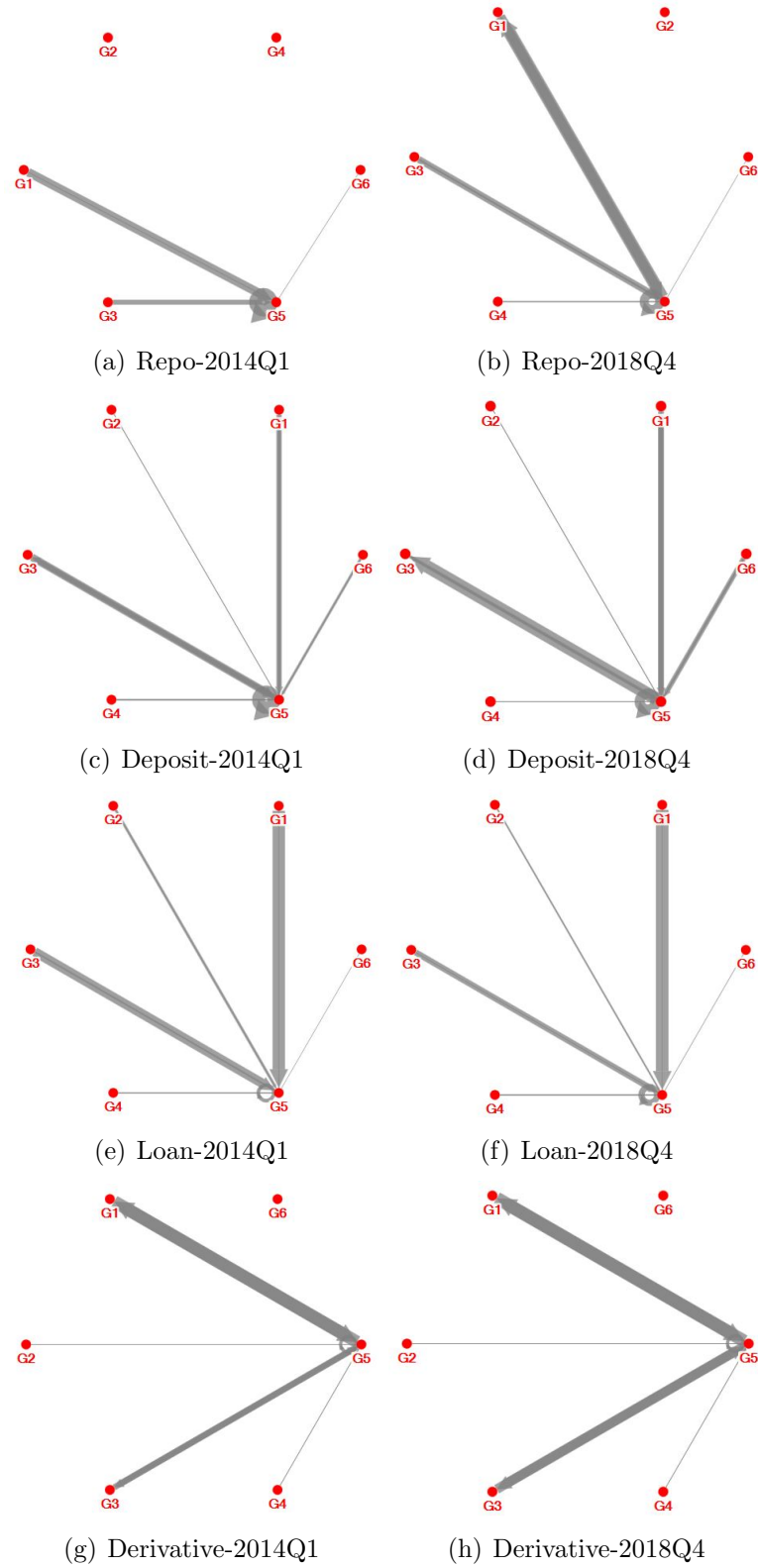
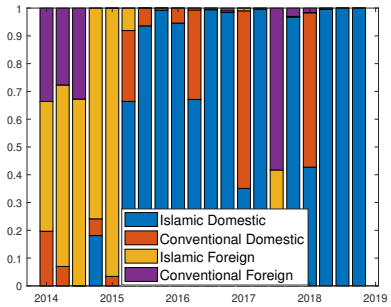
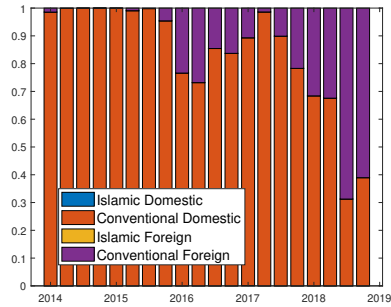


Figure 3.6: Relations between Banking Groups

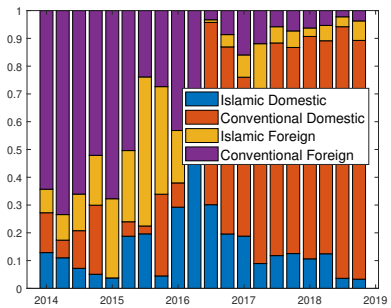
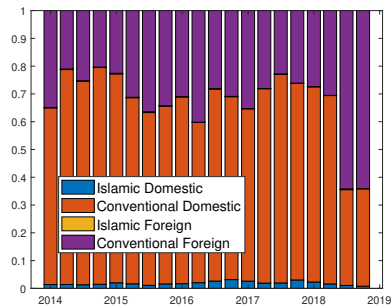
Notes: Edge thickness is proportional to the exposures between related entities. G1, G2, G3, G4, G5 and G6 represent conventional foreign banks having shares in domestic banks, islamic foreign banks having shares in domestic banks, other conventional foreign banks, other islamic foreign banks, banks resident in Turkey and their subsidiaries and central banks respectively

analysis of the deposit payables of domestic islamic banks to conventional domestic banks shows that most of the relations are coming from one domestic bank which has a foreign shareholder that has signed memorandum of understanding with one of the participation banks and other relations are coming from three state-owned banks in Turkey. Domestic conventional banks invest their deposits mostly in conventional banks and attract deposits of other conventional banks (Figure 3.7c and 3.8c). The difference between domestic islamic banks and domestic conventional banks is seen best in loan payables. While foreign islamic banks is the major counterparty for domestic islamic banks, foreign conventional banks is major for Turkish conventional banks (Figure 3.8d and Figure 3.8e). For derivative transactions, due to need of specialization in these products to be able to make pricing, conventional foreign and conventional domestic banks become the essential partner for both domestic conventional and domestic islamic banks.

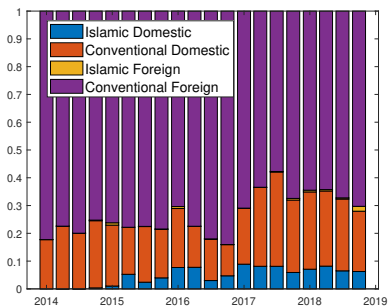
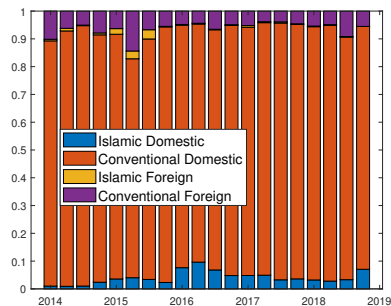
As the final analysis in this section, we investigate whether the foreign banks abroad prefer to lend their subsidiaries in Turkey more compared to other banks. For this analysis, we group domestic banks as the ones having foreign shares and ones not having. Similarly, we differentiate between foreign banks that have shares in Turkish banks and foreign banks not having shares. Receivable and payable exposures based on shareholder information is presented in Figure 3.9 and Figure 3.10 respectively. A general observation is that in receivables of domestic banks, we find no significant difference for counterparties of domestic banks, however there are differences in deposit and loan payables. We document no difference in terms of counterparty concentration of domestic banks with foreign shares and others in repo receivables and payables (see Figure 3.9a, 3.9b, 3.10a, 3.10b). In deposit receivables, breakdown of the counterparty exposures are similar, only difference being higher concentration between same type of Turkish banks, for example in Figure 3.9c, concentration of exposures between domestic banks having foreign



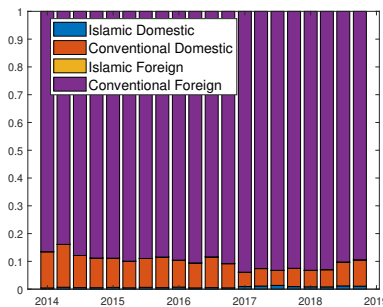
(a) Repo - Domestic conventional banks (b) Deposit - Domestic islamic banks



(c) Deposit - Domestic conventional banks (d) Loan - Domestic islamic banks

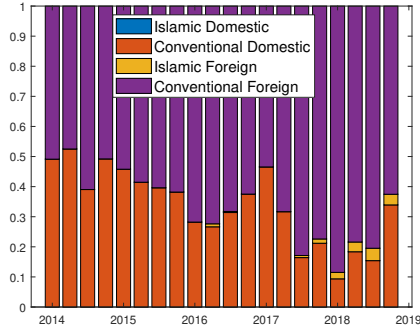


(e) Loan - Domestic conventional banks (f) Derivative - Domestic islamic banks

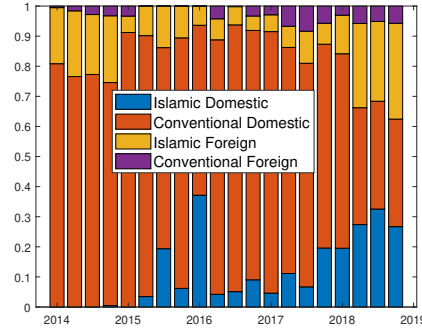


(g) Derivative - Domestic conventional banks

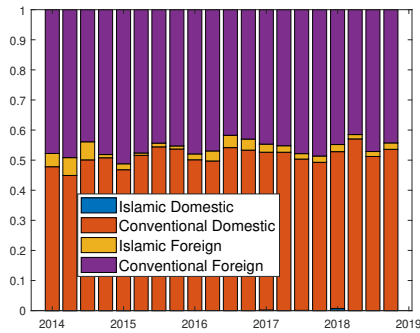
Figure 3.7: Percentage Share of Receivable Exposures between Banking Groups when Banks are Grouped as Islamic or Conventional Banks



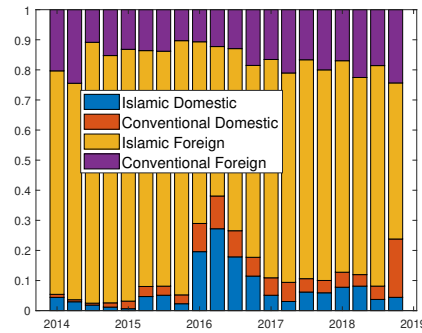
(a) Repo - Domestic conventional banks



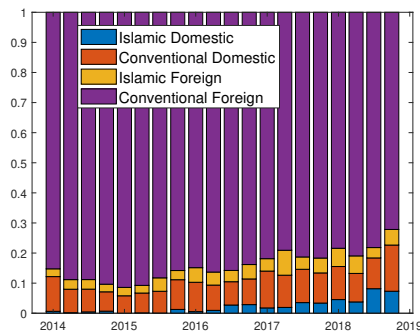
(b) Deposit - Domestic islamic banks



(c) Deposit - Domestic conventional banks



(d) Loan - Domestic islamic banks



(e) Loan - Domestic conventional banks

Figure 3.8: Percentage Share of Payable Exposures between Banking Groups when Banks are Grouped as Islamic or Conventional Banks

shares is higher compared to the concentration of exposures between domestic banks not having foreign shares in Figure 3.9d. In terms of loan receivables, major counterparty is domestic banks for both domestic banks having foreign shares and the others (Figure 3.9e and 3.9f). For loan and deposit payables, foreign banks having shares in Turkish banks has a higher importance in terms of granting funds for the domestic banks that have foreign shares compared to the ones not having any foreign share (Figure 3.10c, 3.10d, 3.10e, 3.10f).

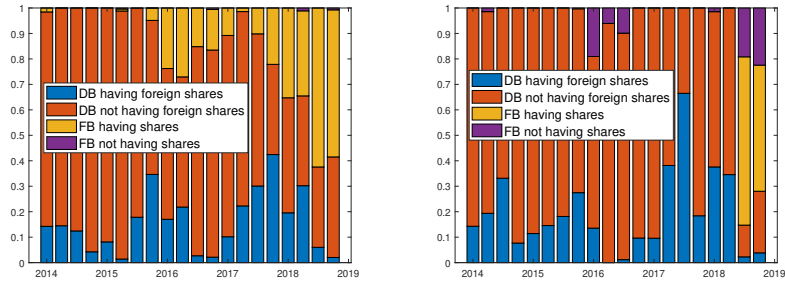
3.4. Network Statistics

In this section, we present several network statistics for each instrument to understand the characteristics of interbank relations. Network statistics are employed in the literature to identify systemically important institutions. These statistics show the importance of banks in terms of having higher number of connections, having connections in larger volume or being on the intermediation flow of other banks.

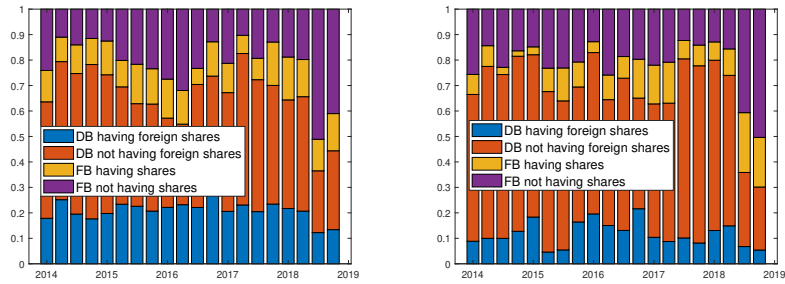
3.4.1 Degree and Strength

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 node i is lending to node j and 0 otherwise.

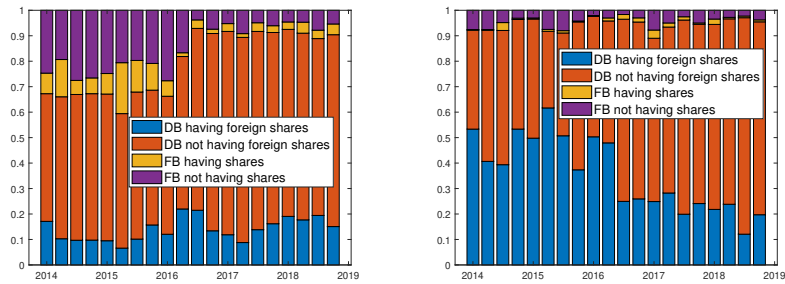
$$\begin{aligned} \text{In-degree} &= k_i^{\text{in}} = \sum_j a_{ji} \\ \text{Out-degree} &= k_i^{\text{out}} = \sum_j a_{ij} \end{aligned}$$



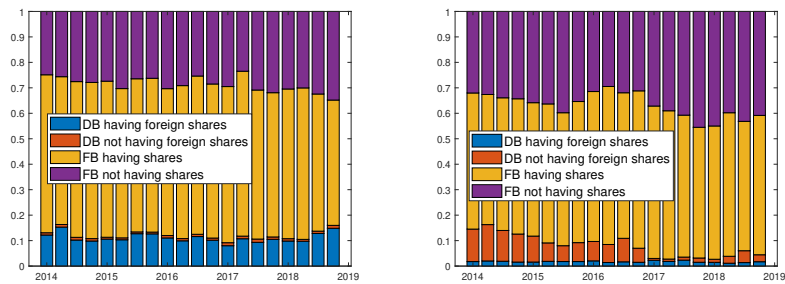
(a) Repo - DB having foreign shares (b) Repo - DB not having foreign shares



(c) Deposit - DB having foreign shares (d) Deposit - DB not having foreign shares



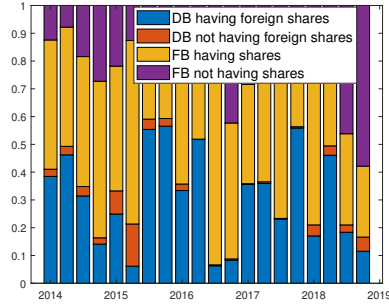
(e) Loan - DB having foreign shares (f) Loan - DB not having foreign shares



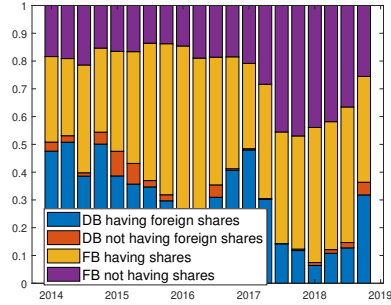
(g) Derivative - DB having foreign shares (h) Derivative - DB not having foreign shares

Figure 3.9: Percentage Share of Receivable Exposures between Banking Groups when Banks are Grouped according to Shareholder Structure

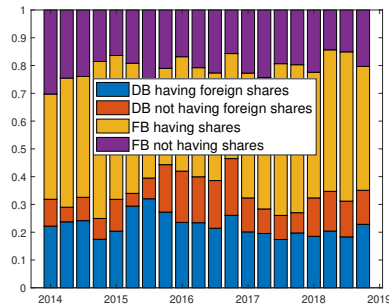
Notes: Domestic banks (DB) are grouped as DB having foreign shares and not, and foreign banks (FB) are grouped as FB having shares in Turkish banks and not.



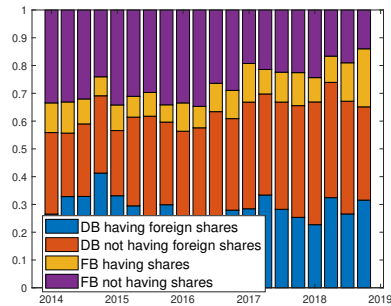
(a) Repo - DB having foreign shares



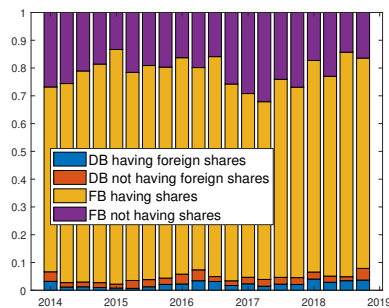
(b) Repo - DB not having foreign shares



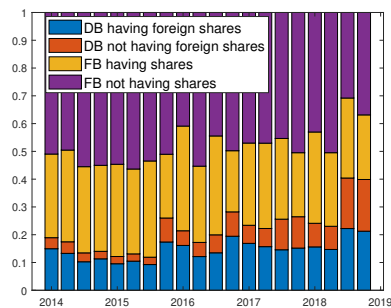
(c) Deposit - DB having foreign shares



(d) Deposit - DB not having foreign shares



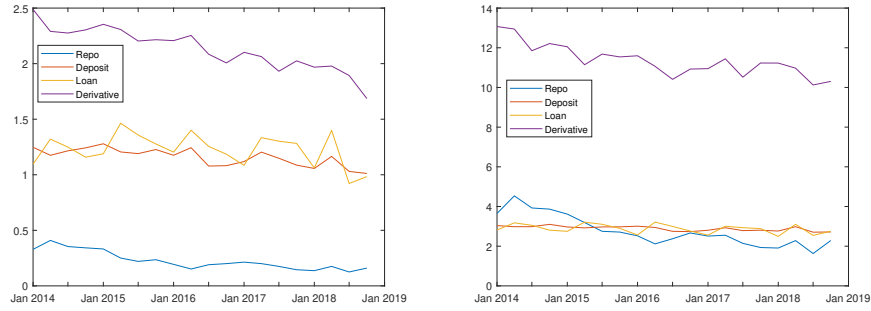
(e) Loan - DB having foreign shares



(f) Loan - DB not having foreign shares

Figure 3.10: Percentage Share of Payable Exposures between Banking Groups when Banks are Grouped according to Shareholder Structure

Notes: Domestic banks (DB) are grouped as DB having foreign shares and not, and foreign banks (FB) are grouped as FB having shares in Turkish banks and not.



(a) Average in-degree over All Banks (b) Average in-degree over Active Banks

Figure 3.11: Average in-degree for All Banks

Notes: The figure on the left shows average in-degree calculated over all banks, figure on the right shows average in-degree calculated over only active banks. Active bank refers to banks having total degree different than zero. Since an incoming link for a bank will be an outgoing link for the other bank, average out-degree and in-degree is equal for each quarter.

Figure 3.11a shows the average degree for each instrument, in which case averages are calculated over all banks.¹¹ As mentioned before, we are unable to obtain the interaction between foreign banks abroad. Since there are 549 foreign banks in the study, relations for 301401 (549×549) entries of the network is missing and zero degree will be added for the relations between these banks. Also, not all banks are active in each quarter, since there may not be a transaction between banks in our set in the related quarter. Hence, we calculate averages over only active banks and observe that when active banks are considered, average degree for repo becomes closer to deposit and loan type instruments (Figure 3.11b). For derivative transactions, number of active banks range between 98 and 124, which is smaller compared to the number of active banks in deposit and loan networks, and so average degree calculated over active banks in derivative network ranges between 10.1 and 13.1.

We also calculate average degrees for resident banks in Turkey, i.e., total number of degrees of resident banks are divided to the number of resident banks (Figure 3.9).

¹¹There are 602 banks in the bank set, however two domestic banks operate under Savings Deposit Insurance Fund of Turkey, so they are nearly inactive in terms of interbank relations. We exclude these banks from the analysis in network statistics.

For repo transactions, in-degree and out-degree move quite similar. 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, comovement is 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 so similar compared to repo transactions. For loan transactions, in-degree shows a seasonal pattern increasing in the second quarter of the years. Domestic banks are making syndication loan agreements with foreign banks abroad and renewing some percent of these loan each year at the current market rates. Depending on the FX fund need, Turkish banks either renew the contracts above/below or at 100%. 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.

Network statistics can be used to identify systemically important banks. By calculating the rankings of banks in each instrument for each quarter, we analyze



Figure 3.12: Average in-degree and out-degree for Domestic Banks

the change in the rankings of banks based on both degree and strength of the bank.¹² 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 3.7 and 3.8 for degree-based and strength-based rankings respectively. Since correlation coefficient is calculated for banks opening transaction in both periods, we observe quite 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 for repo transactions due to shorter

¹²in-strength of the bank is the total amount of credit it receives and out-strength is the total amount of credit it lends.

Table 3.7: 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.

maturity structure of these transactions. The importance of counterparties seems to be not important in the short-term transactions for banks in liquidity need. Minimum value of correlation coefficient in repo transactions is found to be 0.28 and realized when comparing the rankings of 2018Q2 and 2018Q3, which is the currency shock period (Table 3.7). 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 2018Q3 is compared with 2018Q2. However, an interesting observation is that standard deviation in time series correlation of rankings in repo transactions is higher compared to other instruments. Since repo is a source of short-term financing, relative importance of the banks that are entered into relation in these transactions changes easier.

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 are found to be high in each instrument,

Table 3.8: 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.

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 3.13).

Similar to the analysis in the banking groups section, we group foreign banks according to whether they have shares in domestic banks or not and investigate how average strength for incoming and outgoing relations evolve. We make a separate group for domestic banks. So, we form three groups in the analysis which are foreign banks having shares in domestic banks, foreign banks not having shares and domestic banks. We divide total receivables (out-strength) or payables (in-strength) to the number of active banks (the banks that entered into relation) in the related quarter to obtain average values. In other words, if three banks in the foreign banks having shares in domestic banks group has a receivable of 12

billion TL in total in period t , then as the average out-strength of this group 4 billion TL is reported for period t . The relations are shown in Figure 3.14. As seen in Figure 3.14a, there is a notable increase in repo payables of foreign banks having shares in domestic banks. This is due to the relation between a domestic bank and its shareholder bank abroad. After the currency shock in August 2018, this domestic bank started to increase its funds that are utilized in its headquarter bank abroad. Domestic banks have on average 4.7 billion TL repo payables from a bank between 2014-2018. Figure 3.14b shows that in general, an average foreign bank having shares in domestic banks lends in repo instruments more compared to the average other foreign banks. All three lines co-moved similarly until 2018, where the bank mentioned while explaining repo in-strength started to increase repo transactions with the shareholder. The co-movement shows that depending on the liquidity need in the market, domestic banks seem to be searching for funds from all countries in the repo market. Figure 3.14c and 3.14d show that in deposit type relations, again the exposure size of an average domestic bank is higher compared to foreign banks. Figure 3.14e indicates that loan payables of foreign banks to domestic banks is close to zero on average, however domestic banks have loan payables from other domestic banks. Loan receivables of foreign banks having shares in domestic banks are much higher compared to other foreign banks (Figure 3.14f). For derivatives, since in-strength and out-strength of each bank is equal, we report average strength in Figure 3.14g which shows that again average foreign bank having shares transacts more in derivative compared to other banks.

Number of banks that are used in the calculation of averages are shown in Figure 3.15. The cyclical behaviour in degree distributions of loan transactions as observed in Figure 3.9c is also seen in Figure 3.15f. Since foreign banks not having shares is larger in terms of number, the cyclical behaviour due to syndication loan renewals is seen better in that serie. An interesting finding is that in 2018Q3

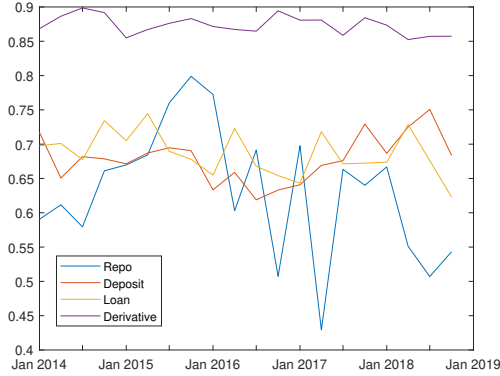


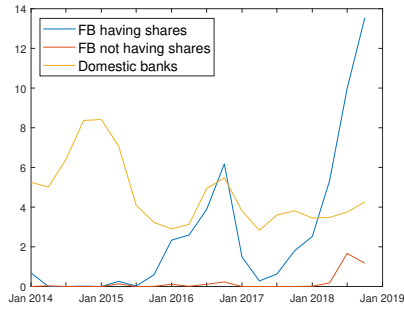
Figure 3.13: Correlation between Rankings based on Total Degree and Total Strength
Notes: Total degree shows the sum of in-degree and out-degree and total strength shows the sum of in-strength and out-strength.

compared to the previous quarter, number of banks that lend in loan type decreased by 53 in number. Another interesting observation is that except repo transactions, number of foreign banks that have shares in domestic banks that are active are much more stable compared to other foreign banks. These findings are compatible with the literature which documents that direct cross-border lending is more volatile compared to the lending to the foreign affiliates of the same bank during crises times (Cerutti and Claessens, 2016).

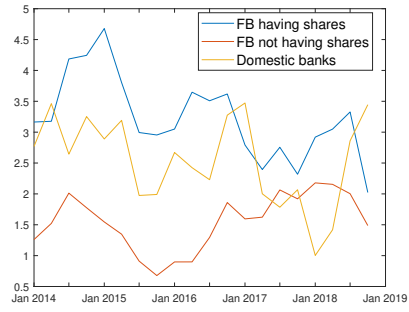
3.4.2 Herfindahl-Hirschman Index (HHI)

We also used HHI to measure the concentration of exposures between counterparties. In this section, we calculated HHI-in and HHI-out, to represent concentration in borrowing and lending respectively. HHI-in is the sum of squared shares of lenders in the total inflow of the borrower and HHI-out is the sum of squared shares of borrowers in the total outflow of the lender. HHI is formulated mathematically as follows, where ω_{ij} shows the amount of loan extended by bank i to bank j .

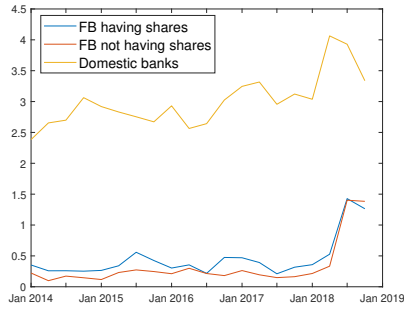
$$HHI - out(i) = \sum_j \left(\frac{\omega_{ij}}{\sum_j \omega_{ij}} \right)^2$$



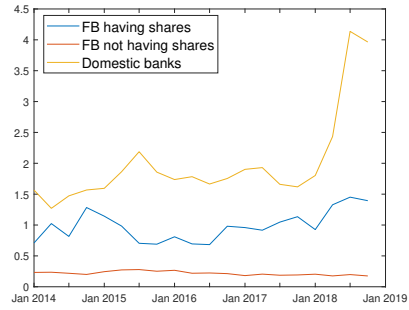
(a) Repo in-strength



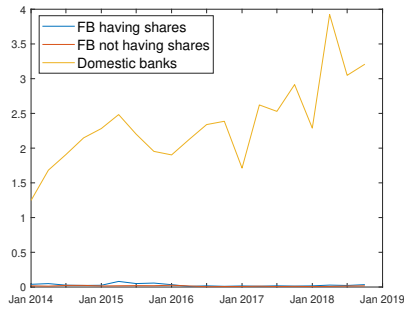
(b) Repo out-strength



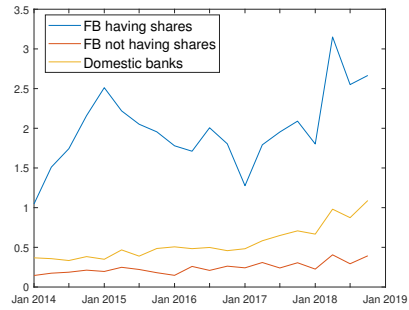
(c) Deposit in-strength



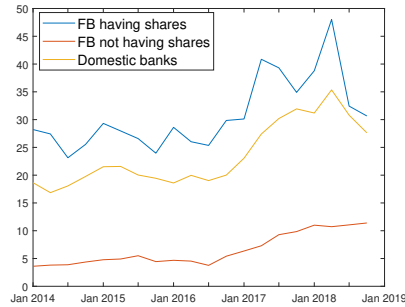
(d) Deposit out-strength



(e) Loan in-strength

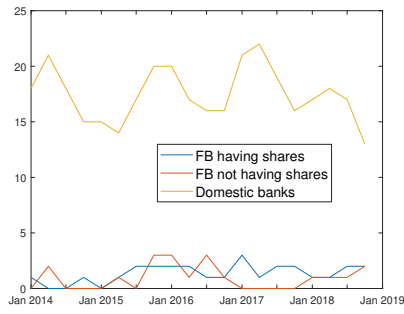


(f) Loan out-strength

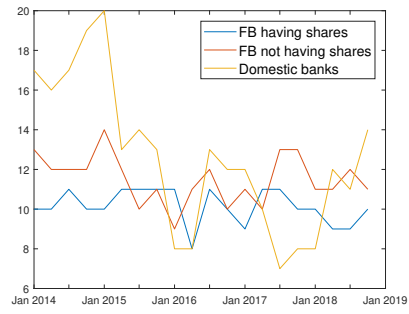


(g) Derivative in-strength/out-strength

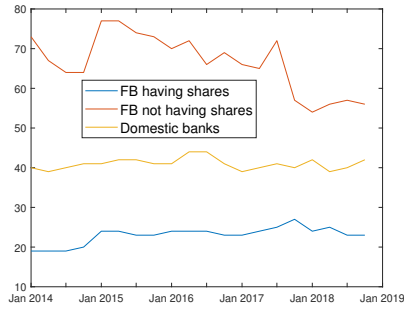
Figure 3.14: Average in-strength and out-strength according to Bank Groups
Notes: Exposures are denoted in Billion TL.



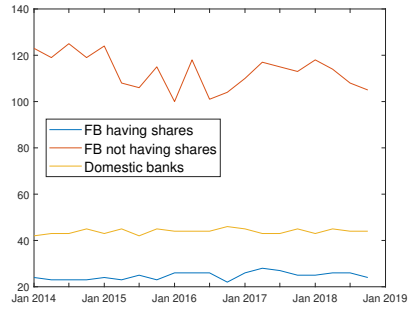
(a) Repo in-strength



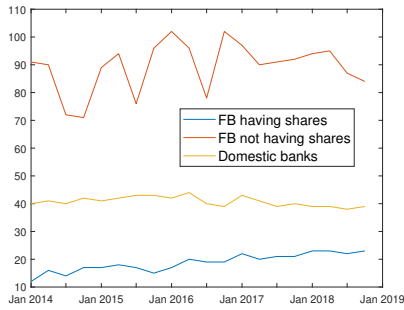
(b) Repo out-strength



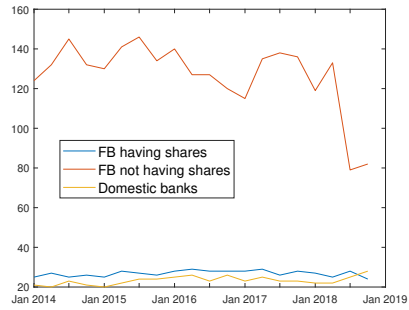
(c) Deposit in-strength



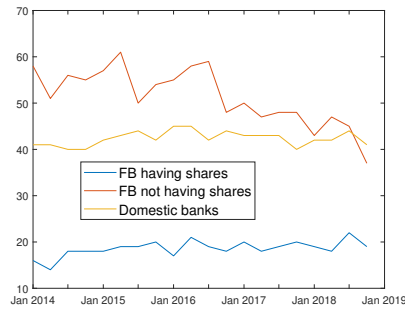
(d) Deposit out-strength



(e) Loan in-strength



(f) Loan out-strength



(g) Derivative in-strength/out-strength

Figure 3.15: Number of Active Banks in the Related Instrument

Notes: These numbers are used for calculating the averages in Figure 3.14.

$$HHI - in(i) = \sum_j \left(\frac{\omega_{ji}}{\sum_j \omega_{ji}} \right)^2$$

HHI takes values between 0 and 1 and increase in HHI indicates more concentrated market. After calculating HHI for each bank, by taking averages over banks we calculated average HHI for each quarter. We have taken averages over banks resident in Turkey since, we do not know exact information for all relations of the foreign banks. Descriptive statistics calculated over 20 quarters for HHI-in and HHI-out is summarized in the upper part of Table 3.9. Average HHI indicates that concentration in the market is above 0.39 and concentration in derivative market is lower. On the other hand, standard deviation of concentration in the repo market is higher compared to other instruments. The reason for high volatility in repo market is the characteristic of market which is to be a source for short-term liquidity needs. To analyze the effect of relations of domestic banks with each other in the concentration, we also calculated HHI excluding receivable/payable relations between domestic banks. For that, for each domestic bank, over lending relations with foreign banks we calculated HHI-out and for borrowing relations from foreign banks we calculated HHI-in. HHI values of domestic banks are averaged and descriptive statistics are given in the lower part of Table 3.9. There are several interesting findings derived from HHI using all and foreign banks. Since domestic banks make most of their repo transactions with domestic banks, when only foreign banks are considered in the lending/borrowing relations, concentration becomes close to 1 in HHI-out for repo. For loan payables and derivative receivables/payables of domestic banks difference in the concentration for all banks and foreign banks is smaller since these transactions are conducted mostly with foreign partners. Except the HHI-out in loan transactions, HHI values calculated with foreign banks is higher compared to all banks. So, indeed the concentration from foreign banks is more compared to the concentration between domestic banks.

Table 3.9: Descriptive Statistics of HHI

All Banks								
	HHI-In				HHI-Out			
	Repo	Deposit	Loan	Derivative	Repo	Deposit	Loan	Derivative
Mean	0.42	0.50	0.46	0.39	0.47	0.39	0.53	0.39
Min	0.23	0.46	0.40	0.36	0.25	0.32	0.45	0.35
Max	0.59	0.58	0.53	0.46	0.70	0.44	0.64	0.44
Std	0.10	0.03	0.03	0.02	0.12	0.03	0.05	0.02
Foreign Banks								
Mean	0.46	0.60	0.46	0.42	0.95	0.67	0.48	0.42
Min	0.34	0.55	0.41	0.38	0.73	0.50	0.36	0.38
Max	0.55	0.65	0.54	0.47	1.00	0.78	0.61	0.47
Std	0.05	0.02	0.03	0.03	0.09	0.07	0.05	0.03
Difference								
in mean	-0.04	-0.09	-0.01	-0.03	-0.48	-0.27	0.05	-0.03

Notes: The table shows descriptive statistics of HHI which is a measure of concentration. HHI is calculated for all banks network and the subnetwork between domestic banks and foreign banks to exclude the concentration of exposures between domestic banks. After calculating HHI for each bank, averages are taken for domestic banks for each quarter and descriptive statistics are calculated over 20 quarters. Difference in mean row shows the difference between the mean of all banks and the mean of the foreign banks.

We don't calculate standard network statistics as betweenness centrality or closeness centrality, since foreign bank-foreign bank region of the networks are missing. Due 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.¹³

3.5. Similarity Analysis

In this section, we analyze similarities in the networks using Cosine and Jaccard indexes. Aldasoro and Alves (2018) investigate the similarity between different type of instruments and maturities of large European banks. Bargigli et al. (2015)

¹³Same 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.

analyze time persistence in Italian interbank market using these 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 1. 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 as the intersection of two vectors over the union of these networks.

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

In our analysis, first we calculate through time similarity in each instrument level network. By taking the network in 2014Q1 quarter as the base year network, we compare the similarity with the networks in the following quarters. Thus, similarity index in 2014Q1 takes value 1. As seen in Figure 3.16, 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 through time similarity in derivative networks higher. Higher correlation in derivative transactions found in Table 3.7 and Table 3.8 in

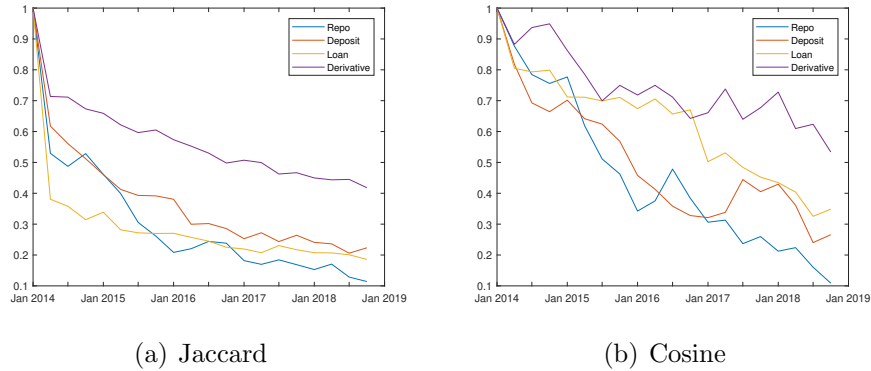


Figure 3.16: Through Time Similarity of Instrument-level Networks

Notes: 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.

terms of ranks of banks confirm also higher similarity found for these transactions. On the other hand, we find that the smallest through 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 through time smaller.

Secondly, we investigate the similarity between different instrument-level networks. We find 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. On the other hand, 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. However, 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.

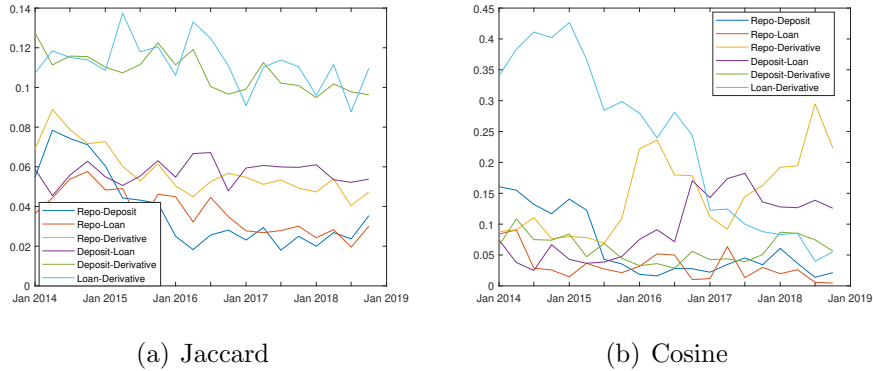


Figure 3.17: Between Similarity of Instrument-level Networks

Notes: The figure on the left shows calculated similarity index via Jaccard index and on the right with Cosine index.

3.6. 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 chapter 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 banks abroad 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, first we document several network statistics. We see cyclical movements in loan and derivative degree distributions due to syndication loan

renewals. We show that systemically important banks for Turkey is highly correlated if these banks are determined using degree or strength statistics. We also analyze through time and between instrument similarities for instrument-level networks using both Jaccard and Cosine similarity indices and find that through 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. Some of the foreign banks in our bank set have shares in domestic banks. Moreover, some domestic and foreign banks work 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, 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 a currency shock in the third quarter of 2018, in which currency depreciated about 20 percent. We also investigate the effects of this shock in interbank relations. We document that banks used their excess FX liquidity as repo or deposit in foreign banks due to slow-down in economic growth. Second, we see a sharp 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.

CHAPTER IV

CONCLUSION

A proper functioning of interbank market is important for financial intermediation. Therefore, policies that prevent its freeze must be ensured by regulatory authorities and central banks. The importance of understanding interbank relations and risks stemming from too connected banks has been underscored until the recent global financial crisis (GFC) in 2008. Failure of several large financial institutions during the GFC motivated researchers to investigate the relations between network structure and resilience of the system. However, since interbank transaction details are generally stored in the regulatory authorities, literature on network studies is still open to new researches. In this study, we contribute to the literature by investigating interbank relations of resident banks in Turkey using private network data. We try to identify the effect of factors such as bank ownership structure, business model of the bank, type of interbank contract and financial regulations in shaping the network structure.

In the first chapter, we focus on the network relations between domestic banks for 2003-2017 period. First, we show that core-periphery network structure explains interbank relations of Turkey better. Second, we study the interaction between bank ownership structure, financial regulations and network relations which is not explored in the literature before. Thirdly, we believe we contribute to the literature by analyzing the effect of foreign acquisitions in the network relations of the

acquired bank. We show that globalization of the banking sector in Turkey change the network structure.

In the second chapter, we focus on the network relations between resident banks in Turkey and foreign banks abroad for 2014-2018 period. Turkey is an interesting emerging economy to study cross-border interbank relations due to several factors. First, Turkey is a typical bank-based country well connected to foreign counterparties via both on-balance and off-balance sheet contracts. Second, in the analysis period, Turkey experienced a currency shock in which domestic currency depreciated about 20 percent against dollar. Third, Turkey is a country in which different type of banks as state-owned, foreign, private and islamic banks operate. Thus, we are able to investigate interconnections between different banking groups under normal and crisis period. We group foreign banks as the ones having shares in domestic banks and the others and the foreign banks that are islamic and others. We find that islamic domestic banks prefer in general islamic counterparties except derivative transactions which require specialized pricing. We also show that foreign banks having shares in domestic banks prefer to lend to their subsidiaries in Turkey underlining the importance of shareholder structure in shaping network relations. Moreover, we observe that relations between foreign banks that have shares in domestic banks is more stable compared to the relations with other foreign banks especially in crisis period.

In this study, we believe that we contributed to the literature via investigating interbank network structure of banks in Turkey in several dimensions by disaggregating the interbank relations according to type of interbank contract, currency of the relation and type of counterparty. We hope that our study broadens horizons of other researchers interested in network studies.

REFERENCES

- Acemoglu, D., Ozdaglar, A., and Tahbaz-Salehi, A. (2015). Systemic risk and stability in financial networks. *American Economic Review*, 105(2):564–608.
- Akyüz, Y. and Boratav, K. (2003). The making of the turkish financial crisis. *World Development*, 31(9):1549–1566.
- Aldasoro, I. and Alves, I. (2018). Multiplex interbank networks and systemic importance: an application to european data. *Journal of Financial Stability*, 35:17–37.
- Allen, F. and Babus, A. (2009). Networks in finance. *The network challenge: strategy, profit, and risk in an interlinked world*, 367.
- Allen, F., Carletti, E., and Gale, D. (2009). Interbank market liquidity and central bank intervention. *Journal of Monetary Economics*, 56(5):639–652.
- Allen, F. and Gale, D. (2000). Financial contagion. *Journal of political economy*, 108(1):1–33.
- Barabási, A.-L. and Albert, R. (1999). Emergence of scaling in random networks. *science*, 286(5439):509–512.
- Bargigli, L., Di Iasio, G., Infante, L., Lillo, F., and Pierobon, F. (2015). The multiplex structure of interbank networks. *Quantitative Finance*, 15(4):673–691.
- Bech, M. and Keister, T. (2017). Liquidity regulation and the implementation of monetary policy. *Journal of Monetary Economics*, 92:64–77.
- Bonner, C. (2016). Preferential regulatory treatment and banks’ demand for government bonds. *Journal of Money, Credit and Banking*, 48(6):1195–1221.

- Bonner, C. and Eijffinger, S. C. (2016). The impact of liquidity regulation on bank intermediation. *Review of Finance*, 20(5):1945–1979.
- Borgatti, S. P. and Everett, M. G. (2000). Models of core/periphery structures. *Social networks*, 21(4):375–395.
- Boyd, J. P., Fitzgerald, W. J., Mahutga, M. C., and Smith, D. A. (2010). Computing continuous core/periphery structures for social relations data with minres/svd. *Social Networks*, 32(2):125–137.
- Caballero, J., Candelaria, C., and Hale, G. (2018). Bank linkages and international trade. *Journal of International Economics*, 115:30–47.
- Calomiris, C. (2011). The AAF Virtual Debates: Charles Calomiris on State-Owned Banks. <http://blogs.worldbank.org/allaboutfinance/the-aaf-virtual-debates-charles-calomiriss-response-on-state-owned-banks/>.
- Cerutti, E. and Claessens, S. (2016). The great cross-border bank deleveraging: supply constraints and intra-group frictions. *Review of Finance*, 21(1):201–236.
- Cerutti, E., Hale, G., and Minoiu, C. (2015). Financial crises and the composition of cross-border lending. *Journal of International Money and Finance*, 52:60–81.
- Cerutti, M. E. M. and Zhou, H. (2017). *The global banking network in the aftermath of the crisis: is there evidence of de-globalization?* International Monetary Fund.
- Cetorelli, N. and Goldberg, L. S. (2012). Follow the money: Quantifying domestic effects of foreign bank shocks in the great recession. *American Economic Review*, 102(3):213–18.
- Cingano, F., Manaresi, F., and Sette, E. (2016). Does credit crunch investment down? new evidence on the real effects of the bank-lending channel. *The Review of Financial Studies*, 29(10):2737–2773.
- Cocco, J. F., Gomes, F. J., and Martins, N. C. (2009). Lending relationships in the

- interbank market. *Journal of Financial Intermediation*, 18(1):24–48.
- Cont, R., Moussa, A., et al. (2010). Network structure and systemic risk in banking systems. *Edson Bastos e, Network Structure and Systemic Risk in Banking Systems (December 1, 2010)*.
- Craig, B. and Von Peter, G. (2014). Interbank tiering and money center banks. *Journal of Financial Intermediation*, 23(3):322–347.
- Degryse, H., Nguyen, G., et al. (2007). Interbank exposures: An empirical examination of contagion risk in the belgian banking system. *International Journal of Central Banking*, 3(2):123–171.
- Demirer, M., Diebold, F. X., Liu, L., and Yilmaz, K. (2018). Estimating global bank network connectedness. *Journal of Applied Econometrics*, 33(1):1–15.
- Dornbusch, R. (2001). A primer on emerging market crises. Technical report, National Bureau of Economic Research.
- Eichengreen, B., El-Erian, M., Fraga, A., Ito, T., Pisani-Ferry, J., Prasad, E., Rajan, R., Ramos, M., Reinhart, C. M., Rey, H., et al. (2011). *Rethinking central banking: committee on international economic policy and reform*. Brookings Institution.
- Erdős, P. and Rényi, A. (1959). On random graphs publ. *Math. debrecen*, 6:290–297.
- Freixas, X., Parigi, B. M., and Rochet, J.-C. (2000). Systemic risk, interbank relations, and liquidity provision by the central bank. *Journal of money, credit and banking*, pages 611–638.
- Fricke, D. and Lux, T. (2015). Core–periphery structure in the overnight money market: evidence from the e-mid trading platform. *Computational Economics*, 45(3):359–395.
- Furfine, C. H. (2003). Interbank exposures: Quantifying the risk of contagion. *Journal of money, credit and banking*, pages 111–128.
- Gabbi, G., Iori, G., Jafarey, S., and Porter, J. (2015). Financial regulations and

- bank credit to the real economy. *Journal of Economic Dynamics and Control*, 50:117–143.
- Gençay, R. and Selçuk, F. (2006). Overnight borrowing, interest rates and extreme value theory. *European Economic Review*, 50(3):547–563.
- Glasserman, P. and Young, H. P. (2016). Contagion in financial networks. *Journal of Economic Literature*, 54(3):779–831.
- Hale, G. (2012). Bank relationships, business cycles, and financial crises. *Journal of International Economics*, 88(2):312–325.
- Hale, G., Kapan, T., and Minoiu, C. (2019). Shock Transmission Through Cross-Border Bank Lending: Credit and Real Effects. *The Review of Financial Studies*.
- Iyer, R., Peydró, J.-L., da Rocha-Lopes, S., and Schoar, A. (2013). Interbank liquidity crunch and the firm credit crunch: Evidence from the 2007–2009 crisis. *The Review of Financial Studies*, 27(1):347–372.
- König, M. D., Tessone, C. J., and Zenou, Y. (2014). Nestedness in networks: A theoretical model and some applications. *Theoretical Economics*, 9(3):695–752.
- Langfield, S., Liu, Z., and Ota, T. (2014). Mapping the uk interbank system. *Journal of Banking & Finance*, 45:288–303.
- Lelyveld, I. and Liedorp, F. (2006). Interbank contagion in the dutch banking sector: A sensitivity analysis. *International Journal of Central Banking*, 2(2).
- Martinez-Jaramillo, S., Alexandrova-Kabadjova, B., Bravo-Benitez, B., and Solórzano-Margain, J. P. (2014). An empirical study of the mexican banking system’s network and its implications for systemic risk. *Journal of Economic Dynamics and Control*, 40:242–265.
- Minoiu, C. and Reyes, J. A. (2013). A network analysis of global banking: 1978–2010. *Journal of Financial Stability*, 9(2):168–184.
- Montagna, M. and Kok, C. (2016). Multi-layered interbank model for assessing

systemic risk.

- Öniş, Z. (2010). Crises and transformations in turkish political economy. *Turkish Policy Quarterly*, 9(3):45–61.
- Schnabl, P. (2012). The international transmission of bank liquidity shocks: Evidence from an emerging market. *The Journal of Finance*, 67(3):897–932.
- Sheldon, G., Maurer, M., et al. (1998). Interbank lending and systemic risk: An empirical analysis for switzerland. *REVUE SUISSE D ECONOMIE POLITIQUE ET DE STATISTIQUE*, 134:685–704.
- Silva, T. C., de Souza, S. R. S., and Tabak, B. M. (2016). Network structure analysis of the brazilian interbank market. *Emerging Markets Review*, 26:130–152.
- Sümer, T. P. and Özyıldırım, S. (2019). Do banking groups shape the network structure? evidence from turkish interbank market. *International Review of Financial Analysis*, 66:101387.
- Sun, A. J. and Chan-Lau, J. A. (2017). Financial networks and interconnectedness in an advanced emerging market economy. *Quantitative Finance*, 17(12):1833–1858.
- Upper, C. (2011). Simulation methods to assess the danger of contagion in interbank markets. *Journal of Financial Stability*, 7(3):111–125.
- Upper, C. and Worms, A. (2004). Estimating bilateral exposures in the german interbank market: Is there a danger of contagion? *European economic review*, 48(4):827–849.
- van Lelyveld, I. et al. (2014). Finding the core: Network structure in interbank markets. *Journal of Banking & Finance*, 49:27–40.
- Von Peter, G. (2007). International banking centres: a network perspective. *BIS Quarterly Review Working Paper*.

APPENDICES

Core-Periphery Model and Estimation Approach

Discrete core-periphery (CP) models aim to classify nodes as either core or periphery via working with adjacency matrices, alternatively in continuous models, a coreness measure is assigned to each node. If the values of coreness measures are restricted to take binary values, then continuous model reduces to the discrete model. Borgatti and Everett (2000) which is the first study that defines CP structure formally, impose two conditions for a perfect discrete CP model. The first condition is that core banks should be bilaterally linked to each other and the second condition is that periphery banks should not have any link with each other. On the other hand, they do not impose any restriction for core to periphery and periphery to core relations. Craig and von Peter (2014) modify this model to be used for interbank relations via adding the third condition which imposes that core banks should both lend to and borrow from at least one periphery bank.

To be able to compare the fitness of different core-periphery partitions, alternative fitness measures are used in the literature. While Borgatti and Everett (2000) use the unnormalized Pearson correlation coefficient, Craig and von Peter (2014) use error score as the fitness measure. In Craig and von Peter (2014) approach, any missing or extra link in the network that does not satisfy the above-mentioned three conditions are both counted as an error. For example, in the ideal CP structure there should not be any link between periphery banks, if there were any link between the identified periphery set then they would all be counted as an error. Similarly, since all banks in the core set should be connected to each other, any missing link between these banks is counted as an error. The aim of the problem is to find the core-periphery partition which minimizes the total number of error scores.

The use of exhaustive search algorithms for fitting deterministic models and grouping banks as core and periphery becomes inefficient as the size of nodes increase. Therefore, generally heuristic approaches are preferred to solve the problem in the literature. As the heuristic approach, we use Craig and von Peter (2014) sequential optimization algorithm. In that algorithm, first square root of the number of banks in the system are selected randomly and assigned as core banks. Then, the error score of this random assignment is calculated. Over all the nodes, we search for the node that will give highest decrease in error score if core-periphery assignment of this node is reversed. The assignment of this node is reversed and this step is repeated until there is no need for a change. To avoid running in local optimum, the steps starting with the random core assignment is repeated for 1000 times. At the end of the algorithm, the nodes that have been found as core banks in at least 80 percent of the steps are selected as core banks and the remaining banks are assigned as periphery banks. In the estimation approach for continuous CP model, the aim is to minimize the sum of squared differences between pattern matrix implied by coreness measures of the nodes and weighted actual matrix where ω and p denote weighted actual matrix and pattern matrix respectively. This problem is formulated mathematically as follows:

$$\arg \min_c \sum_i \sum_{j \neq i} (\omega_{ij} - p_{ij})^2$$

There are two versions of continuous CP model depending on the definition of the pattern matrix. In the symmetric version of CP model, there is only one coreness vector, c , where $0 \leq c_i \leq 1$ and $p=cc'$ (Borgatti and Everett, 2000). If the amount borrowed by a bank differs significantly from the amount lent by this bank, then the use of two coreness measures, u and v to represent outcoreness and incoreness vectors is suggested in the asymmetric version of CP model and $p= uv'$ (Boyd et

al., 2010). Outcoreness vector shows the importance of the bank in terms of lending to the other banks and incoreness vector shows the importance of the banks in terms of borrowing from the other banks.

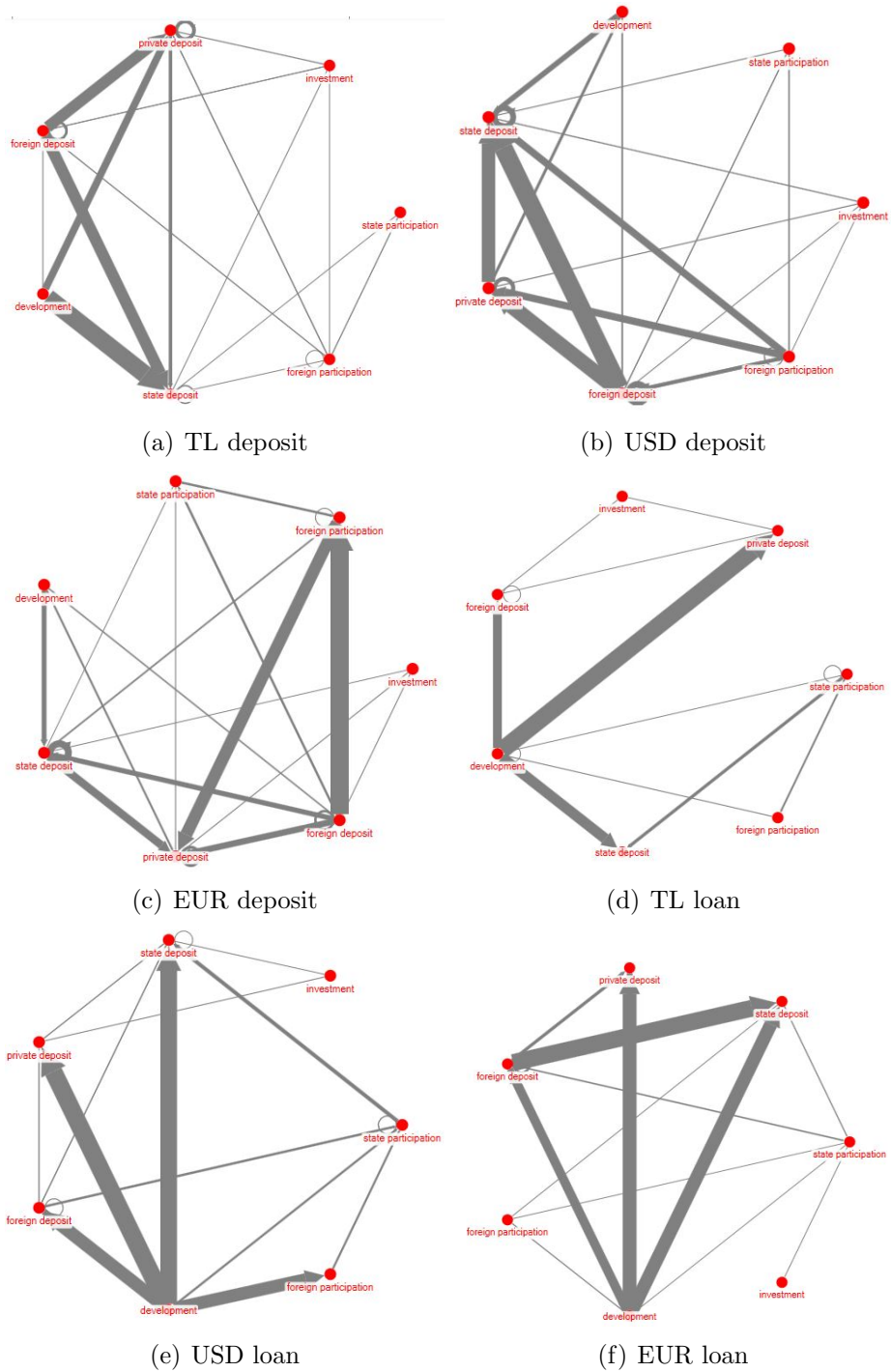


Figure A1: Network Relations Between Banking Groups for Deposit and Loan Type Exposures in Currency Breakdown

Notes: Arrow size shows the comparative weight of the relation compared to other relations. A circle type relation shows intra-group relations.

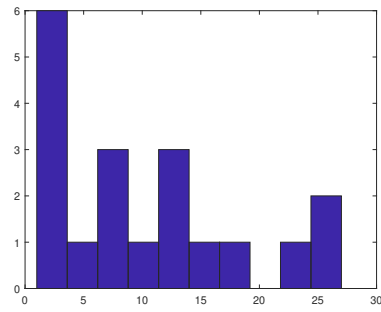
Table A1: Descriptive Statistics and Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Descriptive statistics:								
Mean	21.857	0.149	0.041	0.475	0.019	1.209	1.290	0.340
Standard Deviation	2.411	0.356	0.077	0.162	0.066	1.253	0.660	0.291
N	8481	8481	8480	8480	2317	4832	1318	8348
Pairwise correlation:								
(1) <i>Asset Size (in logarithm)</i>	1							
(2) <i>Large Bank Dummy</i>	0.582	1						
(3) <i>Betweenness-T</i>	0.437	0.500	1					
(4) <i>Closeness-T</i>	0.578	0.206	0.408	1				
(5) <i>Betweenness-D</i>	0.331	0.420	0.887	0.417	1			
(6) <i>Loan/Deposit</i>	-0.247	-0.154	-0.132	-0.125	-0.125	1		
(7) <i>Liquidity Coverage Ratio</i>	-0.315	-0.194	-0.130	-0.205	-0.029	-0.070	1	
(8) <i>CAR</i>	-0.545	-0.187	-0.278	-0.411	-0.136	0.087	0.442	1

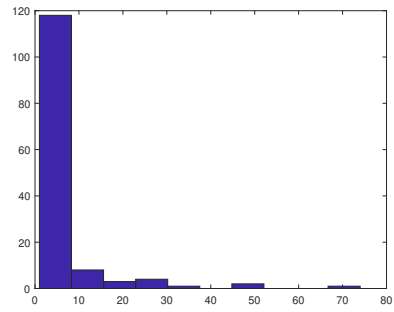
Table A2: Foreign Purchases of Turkish Banks

	Purchase Date	Target Bank	Purchaser	Percent	
				Share	New Name
1*	February 2005	TEB Holding	BNP Paribas	41.25	
2†	September 2005	YKB	Koç Holding (50% Unicredit Bank)	57.43	
3	August 2006	Finansbank	National Bank of Greece	46.00	
4	October 2006	Denizbank	Dexia	75.00	
5	November 2006	C Bank	Bank Hapoalim	57.55	Bank Pozitif
6	December 2006	Tatbank	Merrill Lynch	100.00	Merrill Lynch
7	January 2007	Akbank	Citibank	20.00	
8	January 2007	MNG Bank	Arab Bank PLC (50%)+Bank Med(41%)	91.00	Turkland Bank
9	March 2007	Şekerbank	Bank Turanalem JSC	33.89	
10	March 2007	Tekfenbank	EFG Eurobank	70.00	Eurobank Tekfen
11	February 2008	Turkishbank	National Bank of Kuwait	40.00	
12	February 2008	Oyakbank	ING Bank	100	ING Bank
13	December 2010	Millenium Bank	Credit Europe Bank NV	95.00	Fibabanka
14‡	February 2011	Fortisbank	Türk Ekonomi Bankası	100.00	Türk Ekonomi Bankası
15	March 2011	Garanti Bankası	BBVA	24.89	
16	September 2012	Denizbank	Sberbank of Russia	99.8	
17	December 2012	Eurobank Tekfen	Burgan Bank	99.26	Burgan Bank
18	July 2013	Alternatifbank	Commercial Bank of Qatar	74.30	
19	February 2015	Taibbank	Pasha Bank OJSC	79.90	Pasha Bank
20	May 2015	Tekstil Bankası	Industrial and Commercial Bank of China (ICBC)	75.50	ICBC Turkey
21	June 2016	Finansbank	Qatar National Bank	99.80	
22	July 2015	Garanti Bankası	BBVA	14.89	

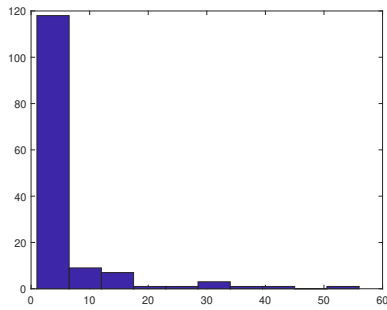
Notes: Purchase dates show the effective change in shareholder structure. *BNP Paribas has bought 50 percent of TEB Holding, so indirect shareholding of BNP Paribas in Türk Ekonomi Bankası became 41.25 percent. †57.43 percent of YKB was purchased by Koç Holding in which Unicredit has 50 percent shares, so indirect shares of Unicredit in YKB became 28.7 percent ‡After that purchase, foreign share in Türk Ekonomi Bankası became 68 percent.



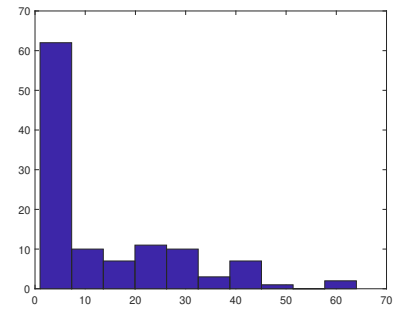
(a) Repo-2014Q1



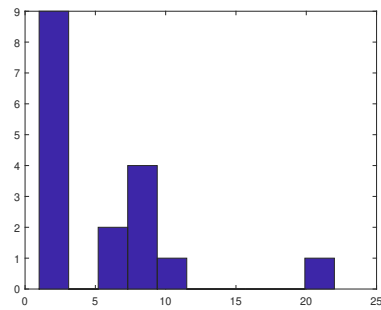
(b) Deposit-2014Q1



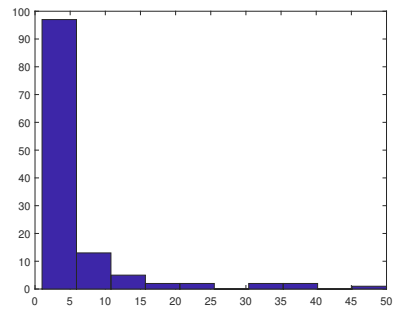
(c) Loan-2014Q1



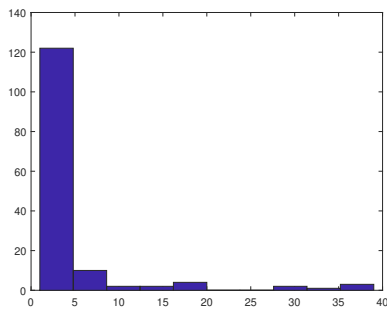
(d) Derivative-2014Q1



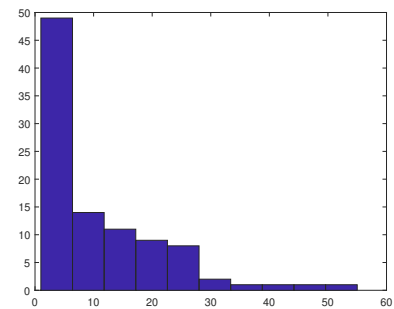
(e) Repo-2018Q4



(f) Deposit-2018Q4



(g) Loan-2018Q4



(h) Derivative-2018Q4

Figure A2: Histograms for in-degree Distributions

Notes: Banks having zero in-degree are excluded while plotting histograms.