AN EMPIRICAL STUDY FOR THE SYSTEMIC RISK IN THE TURKISH BANKING SYSTEM

A Thesis

by

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AN EMPIRICAL STUDY FOR THE SYSTEMIC RISK IN THE TURKISH BANKING SYSTEM

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To my family and all my beloved ones,

with respect, thanks and honor…

ABSTRACT

In this thesis, the relationship between the interbank connections and the systemic risk have been analyzed in the Turkish Banking System. The data is gathered from the financial statements of banks on a yearly basis between the years 2007 and 2018. In an attempt to find the triggering levels of systemic risk, a study is implemented by only using the number of banks, independent of data of banks. With different values of default probability P of a single bank, the likelihood to giving a start to a contagion effect is measured. It is found that, in Turkish banking system, it is enough for a single bank to have a default likelihood of 1 percent to trigger the contagion effect. The default probabilities have been evaluated based on the strength of banks' Capital Adequacy Ratio(CAR) level. It is concluded that high level of average CAR of a bank reduces the possibility of default. Large Banks are identified as the pioneers among the lenders, while State Banks are the main borrowers of the system. In a primary scenario analysis where one bank in the lender bank group gives the entire loan that would be given to a bank in the borrower bank group, in the insolvency situation of borrower bank, reaction of the lender bank based on its Return On Assets(ROA) level have been analyzed. If the entire loan that would be given to borrower bank distributed evenly among a lender group, contagion effect is deduced to be tolerated.

ÖZET

Bu çalışmada Türk bankacılık sistemindeki bankalar arası bağlantılar ile sistemik risk ilişkisi detaylıca incelenmiştir. Çalışmalarda yararlanılan data bankaların 2007 ile 2018 yılları arasında yıllık olarak yayınladıkları finansal raporlardan derlenmiştir. Çalışmada kullanılan banka sayısı ile sistemik riski tetikleyen bireysel banka batma oranları bulunmuştur. Farklı *P* bireysel batma oranları ile sistemik riskin yayılma etkisinin başlangıç olasılığı hesaplanmıştır. Buna göre Türk bankacılık sisteminde, bir bankanın yüzde 1 batma ihtimaline sahip olmasının, sistemik riskin yayılmaya başlaması için yeterli bir oran olduğu görülmüştür. Bunun yanı sıra, banka dataları ile yapılan çalışmalarda bankaların Sermaye Yeterlilik Oranı(CAR) seviyelerine göre batma ihtimalleri irdelenmiştir. Yüksek CAR seviyelerine sahip bankaların batma ihtimallerinin düşük olduğu gözlenmiştir. Bulunan değerlere göre Büyük Ölçekli banka grubunun en çok borcu sisteme sağlayan olduğu, ve en çok borçlananın da Kamu Bankaları grubu olduğu sonucuna varılmıştır. Senaryo analizinde, borcu, borç veren grupta sadece bir bankanın üstlendiği kabul edilmiş ve borç alan banka grubunda bir banka battığında, borçlu olunan banka ve grubuna olan etkisi Aktif Karlılık(ROA) bazında ölçülmüştür. Verilen tüm borcun, borcu veren grup içerisinde eşit miktarda dağıtıldığı varsayıldığında, oluşan sistemik riskin etkilerinin grup içerisinde tolere edilmesi beklenmiştir.

ACKNOWLEDGMENTS

I would like to thank my thesis advisor Muzaffer Akat for his support and expertise during my thesis. I also thank my family for their devotion, patience and unrequited love. They always believe me in my entire academic life, so that I would be able to accomplish all of my aims.

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CHAPTER I

INTRODUCTION

Systemic risk is a deep investigation area in the financial society. This extensive structure of the topic obstructs the researchers to reach a consensus on the definition of the financial stability and the systemic risk. The studies on systemic risk started to appear in the literature in the mid-‘90s, but the depth of the researches increased after the burst of the global financial crisis. Even though it is learned the hard way, the evaluation of market risk via specific risks showed that systemic risk was underestimated by financial institutions and caused financial devastations in global crisis. Negligence of the relationship between credit risk, liquidity risk and operational risk lead up to aggregation of these risks like a snowflake aggregates to avalanche. Thus, it affected financial environment deeply.

1.1 Background on Systemic Risk

From the view of academics and economists, it is hard to unite under a certain systemic risk definition; the financial stability and the systemic risk complete each other conceptually. In Smaga (2013)[1], while financial stability definitions indicates that the stress is on appropriate diversification of sources, the impact of lack of financial stability to real economy is addressed. In addition to that, the risks ensue from mispricing of assets and interrelationships between instruments of the financial system are ignored, however it may start a contagion effect. On the other hand, Sheldon and Maurer (1998)[2] defines

systemic risk for finance sector what Nessie, the monster of Loch Ness, is for the Scots. Everyone is aware and can depict the hazard. Nessie, like systemic risk, is ubiquitous, but nobody knows when and where it might strike. There is no proof that any one has really encountered it. Nevertheless, there is no doubt that it exists.

As well as definition of risk differs from person to person, systemic risk definitions vary in aspects like imbalances, collapse of confidence, correlated exposures of financial institutions, negative impacts on the real economy, information asymmetry, feedback effects, asset bubbles, contagion and negative externalities, according to Bisias et al. (2012)[3] and Oosterloo and de Haan (2003)[4].

In the literature, Allen and Carletti (2011)[5] divide systemic risk into six groups. These are; common exposure to asset price bubbles-particularly real estate bubbles, liquidity provision and mispricing of assets, multiple equilibria and panics, contagion, sovereign default, currency mismatches in the banking system. Since the contagion effect of systemic risk is the main interest of this thesis, some relevant information have been provided below.

Constâncio (2012)[6] states that some kind of domino effect is the main reason for financial instability to become widespread. Lublóy (2005)[7] defines the procedure of contagion as in the graph below. Domino effect starts with a failure of a financial institution. This impact affects the entire financial system and triggers a chain reaction of other defaults. The most sensitive sector to contagion is banking system due to its risky nature. Kaufmann (1992)[8] explains the reaction of banking sector to contagion as a thing that happens all of a sudden, spreads widely in the sector, triggers multiple failures

and larger losses to investors of defaulting banks, surpasses the banking sector by its negative effects and infects the financial system entirely.

According to Allen and Carletti (2010)[9]and Fouque and Sun (2012)[10], even though the greater number of interlinkages between financial institutions improves the financial stability, it leaves the banks and other financial institutions vulnerable to potential shocks which may cause multiple default and as a result it may trigger a contagion.

1.2 Background on Capital Adequacy Ratio

As mentioned above, due to the risky nature of financial activities, it was important to develop a buffer mechanism for banks to prevent from the effects of probable financial crisis. Thus, to see the position of banks in the financial sector, to maintain the financial stability of the system and to assess and render continuous the safety and soundness, some capital ratios were created. One of them is Capital Adequacy Ratio. It scales the amount of bank's capital to bank's risk weighted assets.

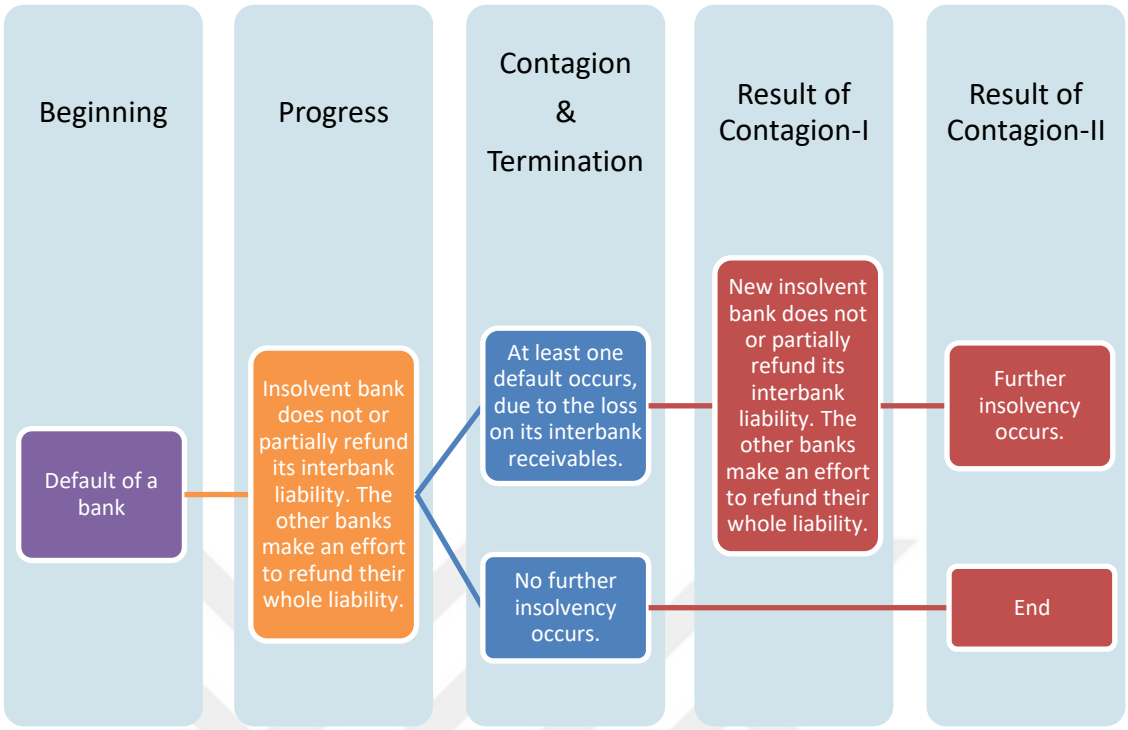


Figure 1 – The scheme of contagion effect. Domino effect starts with a failure of a financial institution. This impact affects the whole financial system and triggers a chain reaction of another defaults.

CAR can be thought as an early warning system for bank because it clearly demonstrates the capacity of bank to cover the possible insolvency circumstance. Due to the importance of capital adequacy, Basel Committee on Banking Supervision published the "Capital Accord" with the name Basel I in 1988. Since then, Basel Accord has practiced capital adequacy requirements to banks internationally. It stressed the minimum capital held by banks to reduce the costs to depositors if a bank defaults. Basel I settled CAR as a minimum limit of 8%. Although there were some updates about market risk in 1996 and calculations about market risk in 1998, as the derivate financial instruments that used by banks has improved, the capital adequacy ratio became insufficient with its calculation technique to measure the increased risk. It would not show the capacity of banks' to counterbalance the predictable or unpredictable losses according to its own risk

criteria. Therefore, the Basel Committee announced the new report of "New Basel Capital Accord" namely Basel II in 2004. The committee improved the accords in calculation of CAR by strengthening risk management, increasing the activity of auditing mechanism applied by supervisory authorities and sustaining financial stability by controlling the market.

$$CAR = \frac{Core\ Capital(Tier\ 1) + Supplementary\ Capital(Tier\ 2)}{Risk\ Weighted\ Assets} \times 100$$

In Turkey, adaptation of Basel regulations into legislations started in 1989. Until then also CAR started to be calculated by the banks. Additional improvements announced by the Basel Committee about the market risk and its measurement in 1996 and 1998, started to implement in 2001 and 2002, respectively. The compliance with Basel II standards has ensured by the Banking Regulations and Supervision Agency and it is under their supervisory since 2009.

In the literature, there are many studies on the relationship between the level of CAR's and the monetary behaviors of countries. For instance, Peek and Rosengren (1995)[11] claimed that capital-constrained and unconstrained banks react differently to monetary policy changes. Specifically, at times of monetary tightening, unconstrained banks reacts more than constrained banks and gives a lot fewer loans, and vice versa. Aktaş and Taş (2007)[12] implemented an empirical analysis of the theory of Peek and Rosengren for Turkey, with measuring the capital-constrained and unconstrained situations of banks due to their CAR level. Aktaş and Taş evaluated a bank being in a

constrained condition in two different ways. One is according to the average of CAR's for all banks in yearly basis. They considered a bank as constrained when a bank's capital adequacy fall below the yearly average CAR and as unconstrained when a bank's capital adequacy is above the average level of CAR in a year. The other evaluation criteria comes after an announcement of Bank Regulation and Supervisory Agency that banned to open new branches to banks whose CAR are below 12%. So as a second criterion, to look whether a bank's CAR is below or above a level of 12% is considered.

In conclusion, even if two different classification methods has adopted, the results that are obtained by Aktaş and Taş, held with each other just differing with their significance levels and had a qualification that corroborate the theoretical claims of Peek and Rosengren. They provided empirical results that, when there is a monetary tightening in the economy, the loans that unconstrained banks loaned out decrease significantly more than capital-constrained banks. On the other hand, when there is an ease in the monetary policy, the loans that unconstrained banks loaned out increase more than the loans by capital-constrained banks.

CHAPTER II

LITERATURE REVIEW

We talk about the existence of a systemic risk, if the bankruptcy or a default of more than one bank causes some panic in the banking system, subsequently a panic in the financial system, and eventually in the entire economy of a country. It is not hard to imagine that the damage in case of such an event is gross. Hoggarth et al. (2002)[13] analyzed the cost of more than 30 systemic financial crisis from year 1977 to 2002. It is estimated in this study that, although the number varies from crisis to crisis and from economy to economy, the cost is somewhere around 18% of the yearly GDP of the specific economy. The reason behind this kind of an overall panic could be due to several different explanations; Banks defaulting could be directly connected to each other via financial operations; Banks could be linked directly to the same financial institution in danger of defaulting; financial or non-financial institutions in danger could be selling their assets at a high rate, which yields a decline in all the assets in the economy, etc. For an extensive survey study in this area, one can see De Bandt and Hartmann (2000)[14].

Demirguc-Kunt and Detragiache (2002)[15] tries to understand the impact of the regulation imposed by the governments on the systemic risk in the banking system. Unfortunately, this study and many other studies along those lines do not consider the networking structure of the banks within the system. In other words, how many banks are connected to how many other banks; how many banks are connected to common sources of risk; how many banks have similar assets in their portfolios; this type of information are overlooked in these studies. Allen and Gale (2000)[16] specifically tackles this issue,

and presents several basic examples where the structure of the interbank relationship plays a vital role in the contagion of the default risk in the entire banking system. When all the banks are linked to the entire system, i.e. all the banks can borrow from or lend to all other banks, we say that the system is complete. Note that, if the system is complete then the default of one particular bank can be absorbed within the system because each bank takes on a rather smaller part of the risk due to this sudden event. On the other hand, if the system is not complete, the exact opposite would happen and the default of a one specific bank could have a devastating effect on the entire system. Allen and Gale (2000)[16] is one of the important papers that motivates this thesis, but in their system there are only four banks which is highly unrealistic for any kind of financial system of interest.

In the recent years the significance of the interbank borrowing or lending system have been recognized by the academic researchers as well as the central banks of big economies. After all, the central banks are the institutions that are responsible for maintaining the financial stability of an economy. This recognition leads to several important empirical studies for particular economies. For instance, Sheldon and Maurer (1998)[2] analyzes the systemic risk in the banking sector in Switzerland; Furfine (1999)[17] does a similar work for US economy; Upper and Worms (2004)[18] analyzes the banking system of Germany. In this study, we will carry out an empirical analysis of the financial systemic risk in the banking sector of Turkish economy based on the data of the recent twelve years.

Nier et al. (2007)[19] analyzes the relationship between the systemic risk and the density of linkages in the financial system. While analyzing, they take into consideration that the effect of the size of the monetary reserves and their interbank borrowing and

lending structures. As an empirical research, they have enlightened by the results of some country-based studies, which are all focus on the construction of banking sector with interbank exposures. However, since every country has its own systemic risk-driven events, it is hard to generalize the findings. Consequently, they ended up with ideas that banks with larger monetary reserves tend to survive more easily from swarming defaults. In addition, they claim that even though increasing linkages trail contagion effect right after, the more connectivity increases; the better banks can absorb systemic shocks. We use this inspirational article as our starting point and detailed our literature review more country-base.

CHAPTER III

DATA AND METHODOLOGY

3.1. Data

Most of the data used in this research have been obtained from the annual financial reports of banks, which are published in the PDP website. PDP (Public Disclosure Platform) is an electronic database system from which the electronically signed notifications can be accessible. Regarding to the Capital Markets Board of Turkey's (CMB) 'Communiqué Regarding Principles of Submitting Electronically Signed Information, Documents and Notifications to the Public Disclosure Platform', the documents has to be publicly disclosed via PDP. All the companies that appear in Borsa Istanbul has to quarterly report their financial statements to the relevant government office. Those financial statements are published on PDP. Also these financial statements have to be in accordance with the CMB's 'Communiqué on Accounting Standards in Capital Markets'. Material events that would be disclosed have to be in accordance with the CMB's 'Communiqué on Principles Regarding the Disclosure of Material Events'. Other events required to be publicly disclosed in accordance with the CMB and Borsa Istanbul regulations by means of PDP.

This database system serves the opportunity to reach correct, timely, fair and complete information on its website. Besides, using PDP to attain the historical data is easy and low-cost. So, due to these advantages, this website is used to obtain the historical data the years between 2009 and 2018.

In this report, the data is constituted of 16 banks' financial information in between the years 2007 and 2018. With respect to the Turkish Financial Reporting Standards, every bank has to publish their financial statements in quarterly periods. Here, fourth quarter's report is taken in to consideration while evaluating the data. The banks are State Banks which are Türkiye Halk Bankası A.Ş., T.C. Ziraat Bankası A.Ş., Türkiye Vakıflar Bankası T.A.O.. Established Large Banks are Akbank T.A.Ş., Türkiye İş Bankası A.Ş., Yapı ve Kredi Bankası A.Ş.. Banks that includes Foreign Partners are Türkiye Garanti Bankası A.Ş., Denizbank A.Ş., ING Bank A.Ş., ICBC Turkey Bank A.Ş., QNB Finansbank A.Ş., Şekerbank T.A.Ş.. Development Banks Türkiye Sınai Kalkınma Bankası A.Ş., Türkiye Kalkınma ve Yatırım Bankası A.Ş.. Private Bank is Fibabanka A.Ş., and a Participation Bank, Albaraka Türk Katılım Bankası A.Ş.. Except Fibabanka A.Ş. and T.C. Ziraat Bankası A.Ş., the other banks are traded in the stock exchange. Since the years before 2009 cannot available in PDP, the websites of banks also have been used as a source to get annual financial reports.

An annual report is examined in two ways while the data is being collected. To quantify the interbank transactions, a vector, which comprises of the ratios of interbank lending and borrowing of banks, is constructed. A bank's interbank lending and borrowing is obtained from its balance sheet's "Banks", "Interbank Receivables/Liabilities" and "Deposits" items and their relevant footnotes. To measure the default threshold, due to the equations used to define probability of default, return on assets ratio (ROA), capital to assets ratio (CAR) and alpha (overhead to assets ratio) is needed. Thus, to calculate the ROA, the net income and the total asset amount is taken from the balance sheet. The CAR is obtained from the information about equity.

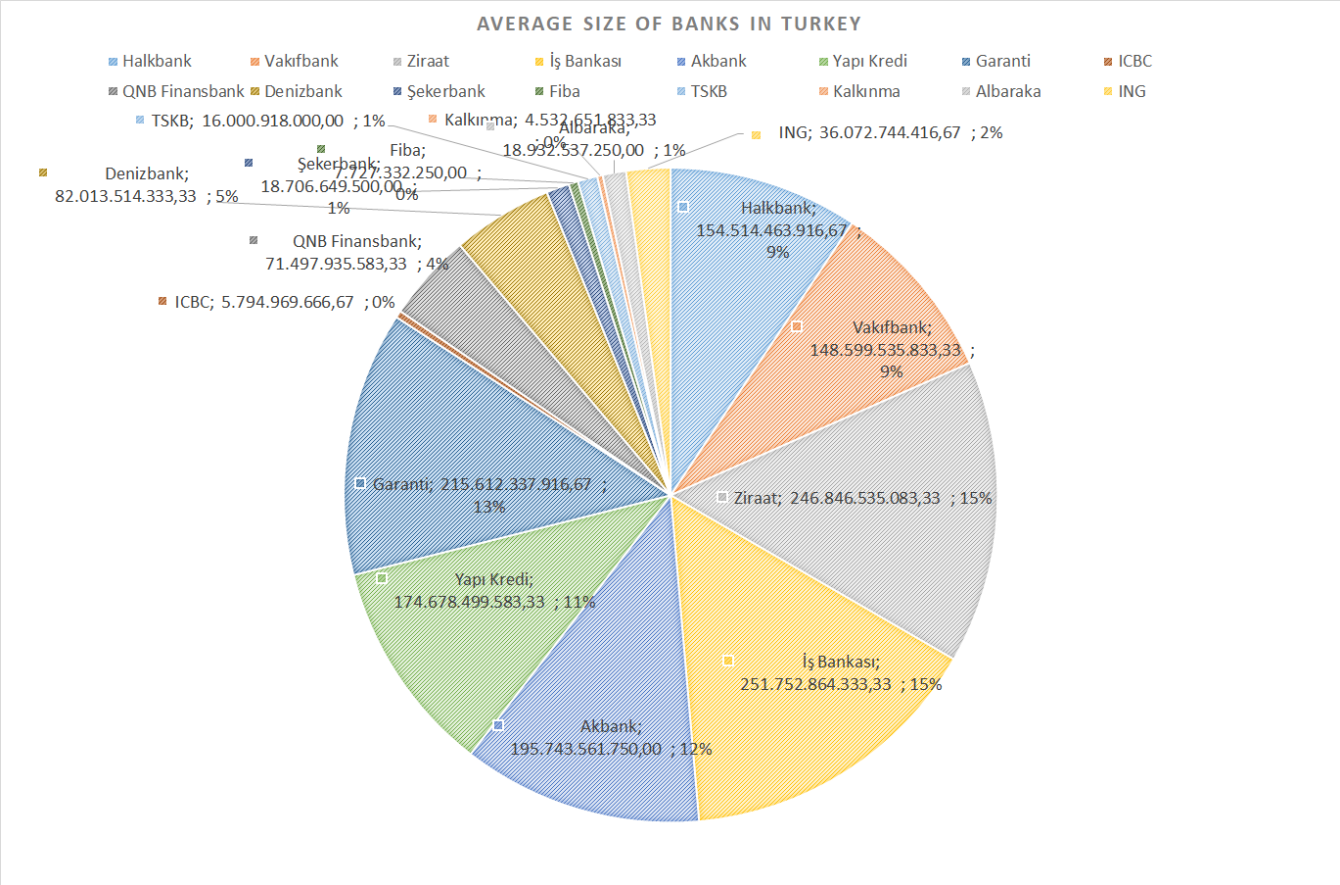
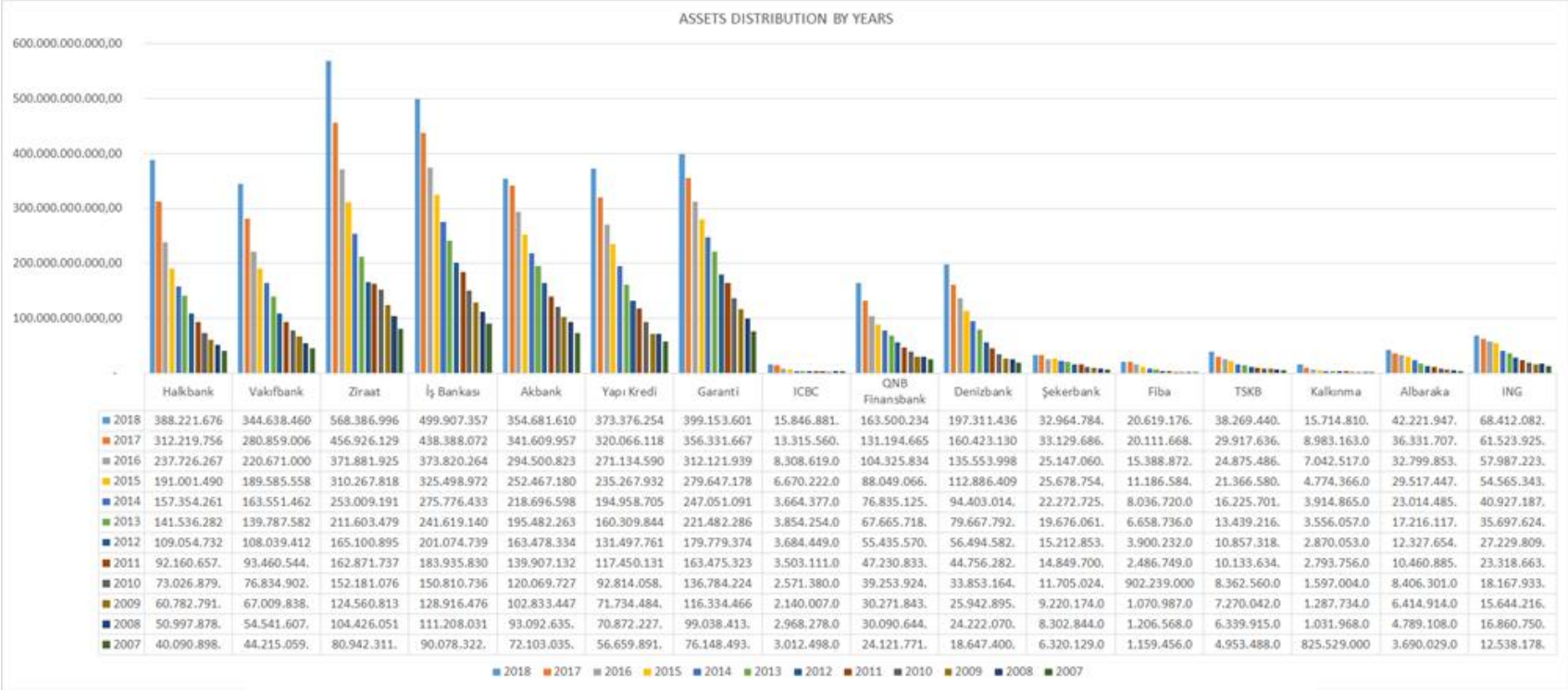


Figure 2 – Pie chart shows the average of banks' annual sizes in between the years 2007 and 2018. Data gathered from the financial statements of banks. It is frankly seen that, Large Banks has the largest shares of all.

In addition, for alpha, overhead is found by adding the staff expenses to other operating charges and overhead to assets ratio gives the alpha. Staff expenses and other operating charges items is taken from the income statement footnotes.

All of these data collecting procedures are implemented to the years from 2007 to 2018 and acquired data is gathered to get the meaningful results.



	Halkbank	Vakıfbank	Ziraat	İş Bankası	Akbank	Yapı Kredi	Garanti	ICBC	QNB Finansbank	Denizbank	Şekerbank	Fiba	TSKB	Kalkınma	Albaraka	ING
2018	388.221.676	344.638.460	568.386.996	499.907.357	354.681.610	373.376.254	399.153.601	15.846.881.	163.500.234	197.311.436	32.964.784.	20.619.176.	38.269.440.	15.714.810.	42.221.947.	68.412.082.
2017	312.219.756	280.859.006	456.926.129	438.388.072	341.609.957	320.066.118	356.331.667	13.315.560.	131.194.665	160.423.130	33.129.686.	20.111.668.	29.917.636.	8.983.163.0	36.331.707.	61.523.925.
2016	237.726.267	220.671.000	371.881.925	373.820.264	294.500.823	271.134.590	312.121.939	8.308.619.0	104.325.834	135.553.998	25.147.060.	15.388.872.	24.875.486.	7.042.517.0	32.799.853.	57.987.223.
2015	191.001.490	189.585.558	310.267.818	325.498.972	252.467.180	235.267.932	279.647.178	6.670.222.0	88.049.066.	112.886.409	25.678.754.	11.186.584.	21.366.580.	4.774.366.0	29.517.447.	54.565.343.
2014	157.354.261	163.551.462	253.009.191	275.776.433	218.696.598	194.958.705	247.051.091	3.664.377.0	76.835.125.	94.403.014.	22.272.725.	8.036.720.0	16.225.701.	3.914.865.0	23.014.485.	40.927.187.
2013	141.536.282	139.787.582	211.603.479	241.619.140	195.482.263	160.309.844	221.482.286	3.854.254.0	67.665.718.	79.667.792.	19.676.061.	6.658.736.0	13.439.216.	3.556.057.0	17.216.117.	35.697.624.
2012	109.054.732	108.039.412	165.100.895	201.074.739	163.478.334	131.497.761	179.779.374	3.684.449.0	55.435.570.	56.494.582.	15.212.853.	3.900.232.0	10.857.318.	2.870.053.0	12.327.654.	27.229.809.
2011	92.160.657.	93.460.544.	162.871.737	183.935.830	139.907.132	117.450.131	163.475.323	3.503.111.0	47.230.833.	44.756.282.	14.849.700.	2.486.749.0	10.133.634.	2.793.756.0	10.460.885.	23.318.663.
2010	73.026.879.	76.834.902.	152.181.076	150.810.736	120.069.727	92.814.058.	136.784.224	2.571.380.0	39.253.924.	33.853.164.	11.705.024.	902.239.000	8.362.560.0	1.597.004.0	8.406.301.0	18.167.933.
2009	60.782.791.	67.009.838.	124.560.813	128.916.476	102.833.447	71.734.484.	116.334.466	2.140.007.0	30.271.843.	25.942.895.	9.220.174.0	1.070.987.0	7.270.042.0	1.287.734.0	6.414.914.0	15.644.216.
2008	50.997.878.	54.541.607.	104.426.051	111.208.031	93.092.635.	70.872.227.	99.038.413.	2.968.278.0	30.090.644.	24.222.070.	8.302.844.0	1.206.568.0	6.339.915.0	1.031.968.0	4.789.108.0	16.860.750.
2007	40.090.898.	44.215.059.	80.942.311.	90.078.322.	72.103.035.	56.659.891.	76.148.493.	3.012.498.0	24.121.771.	18.647.400.	6.320.129.0	1.159.456.0	4.953.488.0	825.529.000	3.690.029.0	12.538.178.

2018 2017 2016 2015 2014 2013 2012 2011 2010 2009 2008 2007

Figure 3 –Year based distribution of total assets of banks. It shows that as years passed banks assets under management increased. It is inferred that State Banks and Large Banks are domşnated the Turkish Banking System.

3.2. Methodology

In the implementation of this project, the aim is to measure and characterize the domino effect in between the banks. By the phrase "domino effect", the potential spread of default circumstance of a bank in the whole banking system is meant. The default of one bank can affect all the other banks via the interbank loan structure.

First, the default has to be explained so that the importance for the banking system can be monitored. In this project, default, aka insolvency, is examined as the quality and the sufficiency of a bank's monetary background. The adequacy of a bank's revenue is an assurance for the repayment of its loans to the other banks. Hence, the strong capital adequacy prevents the bank to fall in an insolvency situation.

Simply, the default can be defined as the exceeding of a bank's losses of its capital amount. It should not be forgotten that loss is a negative net income. So this is where CAR, ROA, alpha and overhead originated. To cover it briefly, when the overhead added to the net income, revenue is obtained. Dividing it by the total assets amount gives the ROA. Besides, since when the default occur, net income is less than $-Capital$, adding overhead also to capital and dividing it by the total assets amount gives the $\alpha - CAR$, which is also called as default threshold. It is assumed that, if ROA becomes smaller than this level, the bank regarded as in default circumstance.

$$revenues < -(capital - overhead) \quad (1)$$

$$\frac{revenues}{total\ assets} < \frac{-(capital - overhead)}{total\ assets} \quad (2)$$

$$ROA < \alpha - CAR \quad (3)$$

Therefore, since net income is not predictable until the end of the reporting period, to model the uncertainty, ROA is assumed as a dummy variable with mean $E(ROA)$ and standard deviation $\sigma(ROA)$. So that, the default probability can be measured by,

$$P(Bank\ i\ fails) = P(ROA\ <\ \alpha - CAR) \tag{4}$$

$$P = \left[\frac{ROA - E(ROA)}{\sigma(ROA)} < \frac{\alpha - CAR - E(ROA)}{\sigma(ROA)}\right] \tag{5}$$

In Turkey's financial reporting system, it is not feasible to find the interbank relationships specialized by name, i.e. from which bank the money goes to the other bank. Instead, it is given under the "Interbank Receivables/Liabilities" item in the balance sheet as a bank's entire interbank lending or borrowing. In order to see the effect of a possible default of a bank to the banking system, it is essential to get interbank loan structure's bank-by-bank distribution. Hence, due to the lack of specialized data, to converge to the accurate interbank relationships, an approximation method is adopted from Sheldon and Maurer, 1998[2].

In order to visualize the interbank transactions better, an interbank lending matrix is constituted that have M rows and N columns. Here, M rows stands for M lending banks and N columns for N borrowing banks. Since a bank need not be both lender and borrower, M may not be equal to N. Each row corresponds to one of lending banks that have undischarged debts with one or multiple of N borrower banks.

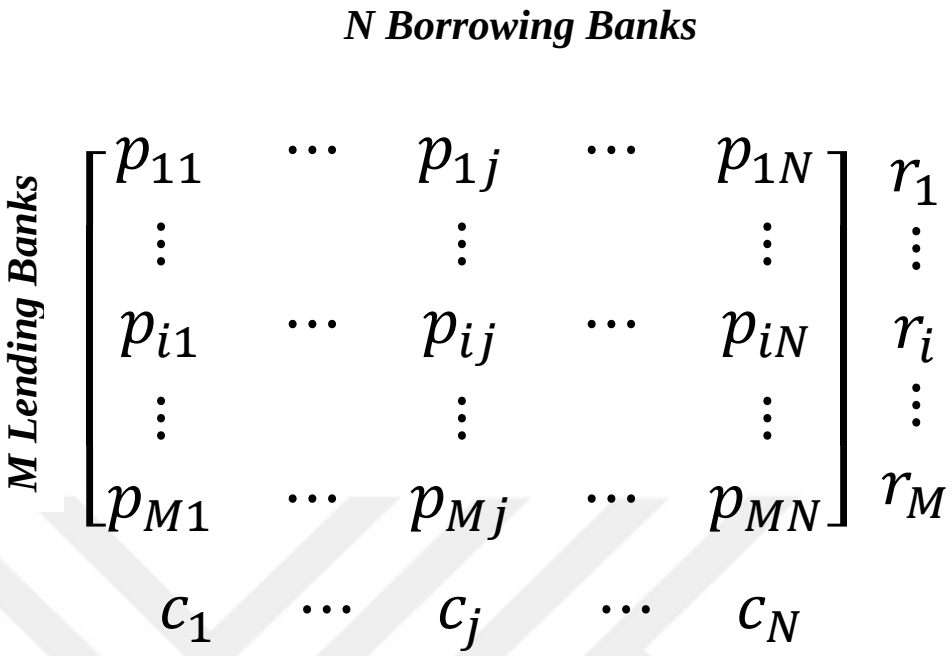


Figure 4 – Matrix includes M rows that shows lending banks and N columns that shows borrowing banks. M may not be equal to N, since a bank need not be both lender and borrower. p_{ij}'s defined as the portion of total interbank loans within the banking system which comprises the loans of bank i as a lender to bank j as borrower. Summing throughout the row i gives r_i that can be described as the portion of total interbank loans given by bank i and likewise, summing the column j turns c_j that can be described as the portion of total interbank loans received by bank j.

Also, marginal distributions can be expressed as,

$$\sum_{j=1}^{N} p_{ij} = r_i \qquad and \qquad \sum_{i=1}^{M} p_{ij} = c_j \qquad (6)$$

As stated above, due to the uncertain data of bank basis interbank transactions, the matrix's components p_{ij}'s defined as the portion of total interbank loans within the banking system which comprises the loans of bank i as a lender to bank j as borrower. Summing throughout the row i gives r_i that can be described as the portion of total interbank loans given by bank i and likewise, summing the column j turns c_j that can be described as the portion of total interbank loans received by bank j. However the

interbank relationship can be visualized by interbank lending matrix, since the transaction amounts are unknown, in practice p_{ij}'s are unattainable for researchers from published financial statements. The outer column and row of the lending matrix that contain total share of lendings and borrowings become marginal distributions.

Thus,

$$\sum_i r_i = \sum_j c_j = 1 \tag{7}$$

In this research, since interbank relationships and its effects on systemic risk are observed, the p_{ij}'s are needed to be found. On the other hand, although the inner side of the lending matrix is uncertain, the outer column r_i and row c_j can be calculated directly from the balance sheet of banks. They can easily derived from the division of a banks interbank lending or borrowings to all banks' total interbank lending or borrowing. In order to find these unknown p_{ij}'s, linear algebra would assist to find the way. Hence, our problem reduces to a basic algebraic equation below.

$$\mathbf{Ap} = \mathbf{B} \tag{8}$$

where,

$$p' = [p_{11}, \ \dots, \ p_{1N}, \ \dots, \ p_{ij}, \ \dots, \ p_{M1}, \ \dots, \ p_{MN}],$$
$$B' = [r_1, \ \dots, \ r_M, \ c_1, \ \dots, \ c_N],$$

Here A is matrix by $(M + N) \times (M.N)$. It comprises from 1's and 0's to help to yield vector B by pre-multiplying it with the $(M.N) \times 1$ vector p.

Summarizing the problem at hand briefly, matrix $\boldsymbol{A}$ is constituted with the help of given previous restrictions,

$$\sum_i \boldsymbol{r_i} = \sum_j \boldsymbol{c_j} = \mathbf{1} \quad \text{and} \quad \mathbf{0} \leq \boldsymbol{p_{ij}} \leq \mathbf{1} \tag{9}$$

By positioning 0's and 1's in the matrix to obtain the vector $\boldsymbol{B}$ as a result of pre-multiplying matrix $\boldsymbol{A}$ with vector $\boldsymbol{p}$. Vector $\boldsymbol{B}$ is found by dividing a banks interbank lending or borrowing to the total interbank lending or borrowing of all the banks.

After this point, a problem gets involved. Caused by the number of equation and unknown mismatch of (3), how can vector $\boldsymbol{p}$ be calculated? This kind of problem often arises in economics, comminucation, statistics and urban planning. In other words, it can be stated as adapting the entries of a matrix to meet the consistency requirements. These problems are called Matrix Balancing Problems. A matrix became balanced when it fulfilled the given restrictions for the problem. In general, due to the nature of equation (3), many solutions can be found. The main issue is to find a solution that satisfies the restrictions meanwhile related to the matrix $\boldsymbol{A}$ in an appropriately defined way. The mathematical representation of the problem defined by Schneider and Zenios (1990)[20]'s paper that faced is following,

Given an $m \times n$ nonnegative matrix $\boldsymbol{A}$ and positive vectors $\boldsymbol{u}$ and $\boldsymbol{v}$ of dimensions m and n, respectively, determine a nearby $m \times n$ nonnegative matrix $\boldsymbol{X}$ such that

$\sum_{j=1}^{n} x_{ij} = u_i$ *for* $i = 1, 2, \dots, m$

$\sum_{i=1}^{m} x_{ij} = v_j$ *for* $j = 1, 2, \dots, n$

and $x_{ij} > 0$ *only if* $a_{ij} > 0$.

Matrix balancing can be utilized in many fields such as mathematical programming, economics, numerical analysis and transportation, so there are many written works in the literature and they adopt different algorithms to balance their matrices. Balancing methods can be grouped in two, one is scaling algorithm and the other is optimization algorithm. In this project, an optimization model of entropy maximization theory is adopted. According to the theory, if there is a lack of knowledge about the distribution, then the distribution that has the largest entropy should be chosen as the least-informative default. In other words, maximizing entropy lowers the effect of outer information that affects the solution.

In a mathematical way entropy is defined as,

$$-\sum_{i=1}^{n} p_i \log p_i \tag{10}$$

Therefore, maximum entropy is harmonious with maximum unpredictability by given the lack of information about the distribution. It can be inferred that, when the entropy is zero then the probability vanished and the precision of the event to occur is 100%. On the other hand, when the entropy is at its maximum, the probability distribution became the least informative i.e. uniform distribution $p_i = \frac{1}{n}$, which gives equal possibility to every event to occur. It leads to entropy of $\log n$.

Returning to the problem discussed in this paper, equation **(10)** become,

$$-\boldsymbol{p}' \log \boldsymbol{p} \tag{11}$$

where $\boldsymbol{p}$ stands for the vector defined before in equation **(8)**.

Thus, maximizing **(11)** depending on the linear restrictions of **(8)** and given the marginal distributions placed in $\boldsymbol{B}$, gives the most uncertain distribution of the loans in the interbank lending matrix. In this approach, if these linear restrictions are ignored, equation **(11)** would become uniform distribution and all elements of interbank lending matrix would be equal. But, the marginal distribution is a prohibiting factor for vector $\boldsymbol{p}$ to construct in a uniform distribution form. Since, maximizing entropy maximizes the variation of loans for marginal distribution; the idiosyncratic risk in the banking system is minimized. In addition, in the progress, it is stochastically independent that a bank's choice of from which banks to lend to or vice versa. By doing so, it become intuitive that the solution of entropy maximization refers to the minima of the systemic risk placed in the banking system. Nonetheless, it should be taken in mind that the possible conflictions between the realism and the results of this paper is due to the lack of the information that can gathered rather than the method adopted. For instance, it is known that a bank cannot borrow or lend with itself, i.e. $p_{ij} = 0$ for $i = j$.

Maximizing **(11)** depending on **(8)**, gives the solution of,

$$p_{ij} = r_i \cdot c_j \tag{12}$$

referring independency in the preference of lending or borrowing among banks.

CHAPTER IV

RESULTS

In this study, financial statements of 16 different Turkish banks have been utilized for the selected time span, 2007-2018. To measure the probability of a bank insolvency in a given period, P is assumed as a default likelihood of a bank, where $0 < P < 1$. Also, P is assumed to be uniform across all I banks in the sector. Thus, the equation $(1 - P)^I$ is used for measuring the likelihood of no bank defaulting. Hence, the probability that at least one bank will default can be found via the equation

$$\mathbf{1} - (\mathbf{1} - \boldsymbol{P})^{\boldsymbol{I}} \qquad (13)$$

Here I is taken to be 16, the equation above is implemented. Therefore, Figure 4 is generated. This figure shows the upper limit of systemic risk related with different values of P, the likelihood of one bank will fail in a given period by supposing that at least one bank fails to start a contagion effect.

On the contrary to the results of Sheldon and Maurer, due to the difference in the number of banks used, the results that are generated in Figure 4 show that an individual default likelihood of 1 percent is sufficient to trigger the contagion effect. Whereas in the results of Sheldon and Maurer, as can be seen in Figure 5, this probability is at quite low levels like 0,05 percent. The likelihood that at least one bank will fail in the banking system in a given time period is approximately inevitable when the default probability of a single bank comes to 30 percent. On the other hand, this level is 1 percent in Sheldon and Maurer. Due to their research, there are 567 banks in average between the years 1987-

1995 in Swiss banking system. As a result of number of banks being too large, there is a density in interbank connections and even a single bank's default likelihood is reach to 1 percent, it directly affects whole banking system as a Mexican wave. However in Turkey, the banking system is shallow in contrast to Swiss banking system, hence a single bank's insolvency probability of 1 percent entails the probability of default of entire Turkish banking system to the level of 14 percent.

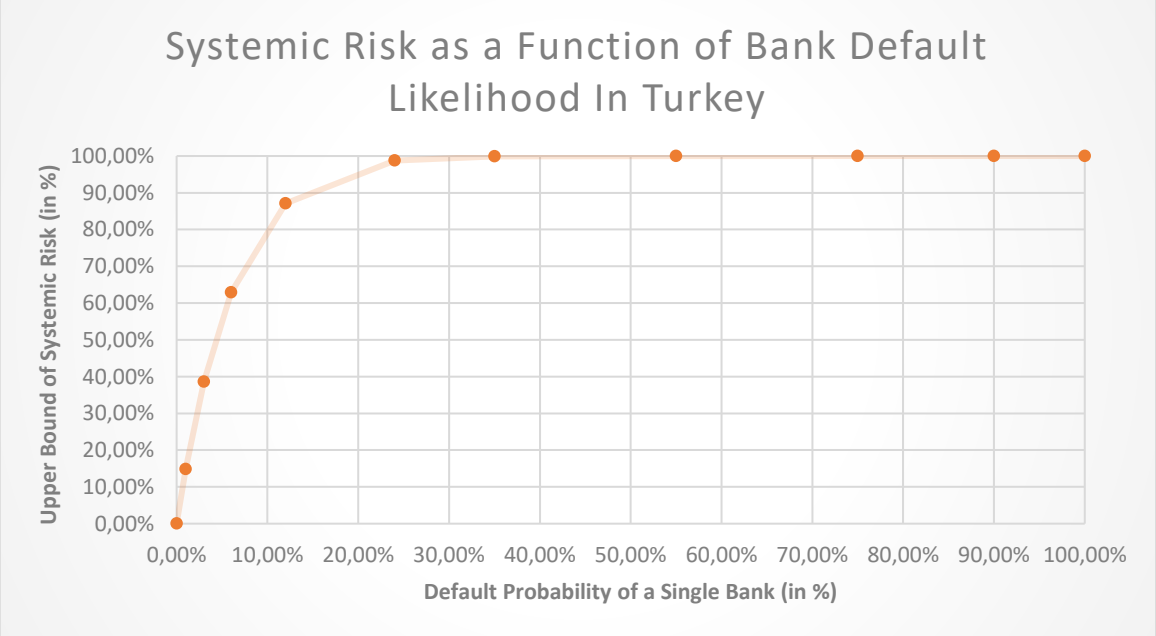


Figure 5 - An individual default likelihood of 1 percent is sufficient to trigger the contagion effect in Turkish banking system.

Even though, Figure 4 stands for general inference for the upper limit of systemic risk occurrence according to the individual bank default probabilities; also, singular default probabilities can be found in Table 1 and Table 2 below. Data in Table 1 is the average of annual values in between the year 2007-2018. As can be inferred from the paper of Sheldon and Maurer, when a bank's average CAR or a bank group's average

CAR is larger than the others, then the probability of default of the related bank or bank group is smaller than the others. Accordingly, results in the Table 1 and Table 2 show the consistency of this situation for Turkey. In both tables, it can be said that as CAR level is increasing, the probability of default is decreasing. It is mathematically explainable by the equation **(5)**. Since the CAR levels are larger when Turkey banks compared to Swiss banks, it clarifies the reason that all of the default probabilities obtained zero percent as regard to Swiss banks in Turkey. To provide easy tracking and to show how small differences occur between the banks –because all banks default probabilities equal to zero- , percentage and scientific forms of the probabilities are included in the Table 1 and Table 2. According to Table 1, Is Bank and TSKB have the least probability of default, which is exact percentage of zero. However, there is no chance for any bank to default in Turkey due to the likelihoods seen in the Table 1, in other words, all of the small digits are negligible, Fibabank and Sekerbank have some digits other than zero. In Table 2, banks are grouped into six. Halkbank, Vakıfbank and Ziraat bank united under the group of State Banks. Is Bank, Yapı Kredi Bank and Akbank grouped under Large Banks. Garanti, Sekerbank, ING, ICBC, QNB Finansbank, Denizbank constituted Foreign Associated Banks. TSKB and Kalkınma Bank grouped as Development Banks and lastly FIBAbank belongs to Private Banks group while Albaraka Turk forms Participation Bank group. The average CAR of development banks is the largest of all banking categories in Table 2, so they have the exact probability of zero for defaulting. On the other hand, the smallest average CAR level belongs to state and participation bank groups, which have the relative maximum two default probabilities. To emphasize that, all small digits are negligible and there is no chance for any Turkish bank to become insolvent due to their records that obtained from banks' financial statements.

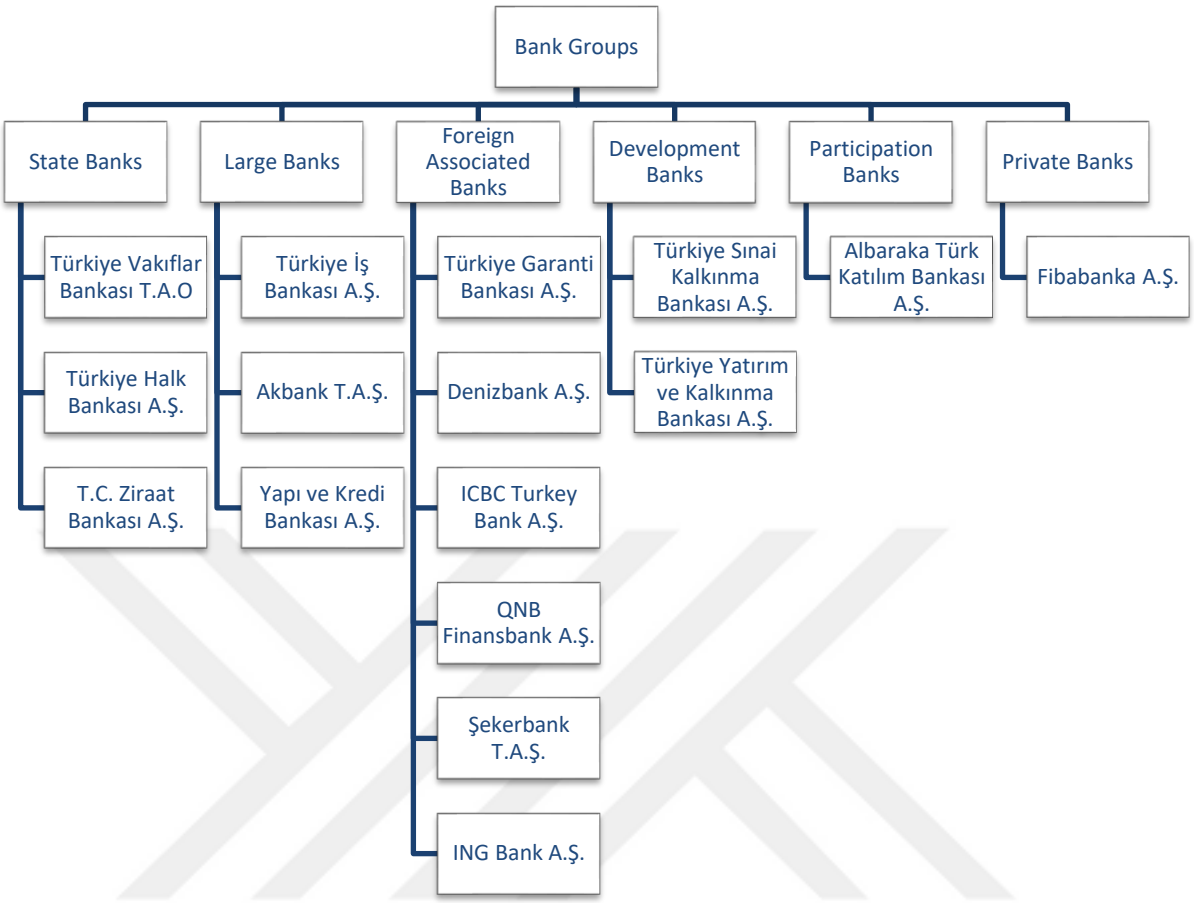


Figure 6 – In this study, bank classification is defined as showed in the scheme.

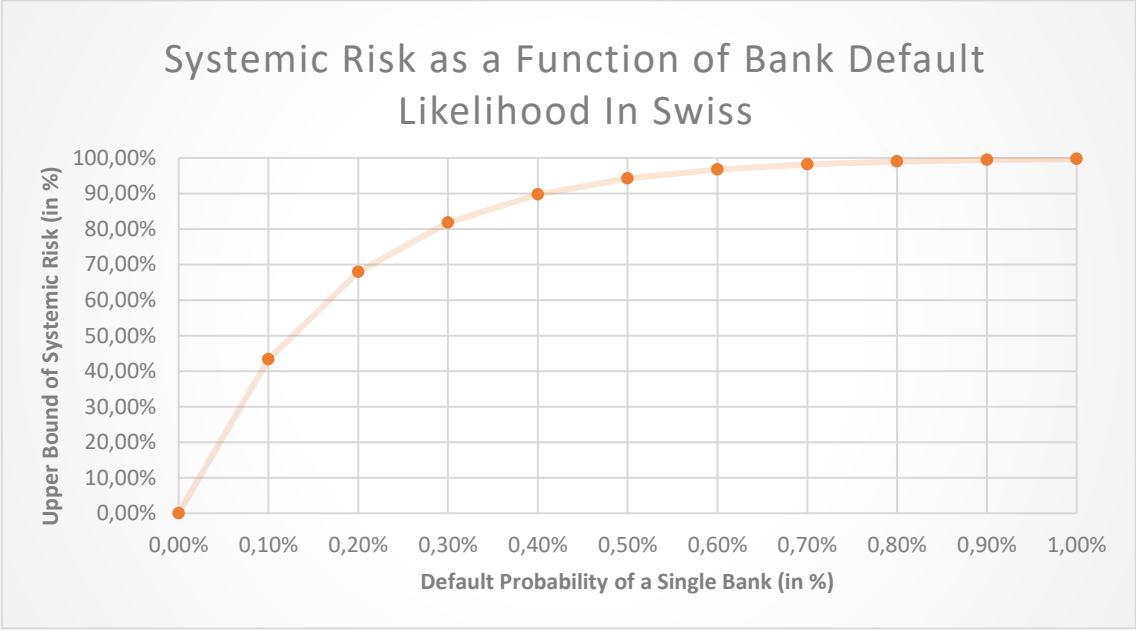


Figure 7 - An individual default likelihood of quite low levels like 0,05 percent is enouugh for Swiss banking system to start domino effects as regards to Turkish banking system.

	α	CAR	E(ROA)	σ(ROA)	P (in %)	P (in Scientific)
Halkbank	0,021	0,144	0,019	0,007	0,00%	9,85E-89
Vakıfbank	0,027	0,144	0,014	0,004	0,00%	6,51E-289
Ziraat	0,019	0,175	0,020	0,005	0,00%	7,46E-265
İş Bankası	0,036	0,161	0,015	0,003	0,00%	0,00E+00
Akbank	0,019	0,168	0,019	0,005	0,00%	6,70E-264
Yapı Kredi	0,027	0,144	0,016	0,005	0,00%	1,11E-136
Garanti	0,024	0,156	0,020	0,006	0,00%	9,51E-168
ICBC	0,032	0,180	0,006	0,004	0,00%	1,41E-267
QNB Finansbank	0,033	0,163	0,016	0,005	0,00%	1,86E-166
Denizbank	0,027	0,143	0,014	0,005	0,00%	4,52E-136
Şekerbank	0,042	0,140	0,011	0,006	0,00%	1,43E-67
Fiba	0,030	0,162	0,002	0,010	0,00%	4,53E-44
TSKB	0,009	0,188	0,023	0,005	0,00%	0,00E+00
Kalkınma	0,027	0,420	0,018	0,013	0,00%	1,38E-214
Albaraka	0,025	0,154	0,014	0,007	0,00%	3,83E-93
ING	0,034	0,152	0,009	0,004	0,00%	4,97E-180
Avg.	**0,027**	**0,175**	**0,015**	**0,006**	**0,00%**	**2,83E-45**

Table 1 - Average of annual values of banks in between the year 2007-2018. Is Bank and TSKB have the least probability of default, which is exact percentage of zero. However, there is no chance for any bank to default in Turkey due to the likelihoods seen above, Fibabank and Sekerbank have some digits other than zero.

	Cases	α	CAR	E(ROA)	σ(ROA)	P (in %)	P (in Scientific)
State	3	0,0222	0,1543	0,0176	0,0047	0,00%	4,75E-223
Large	3	0,0275	0,1576	0,0166	0,0040	0,00%	6,89E-297
Foreign Associated	6	0,0320	0,1556	0,0126	0,0040	0,00%	2,82E-257
Development	2	0,0179	0,3040	0,0206	0,0071	0,00%	0,00E+00
Participation	1	0,0253	0,1543	0,0139	0,0070	0,00%	3,83E-93
Private	1	0,0300	0,1617	0,0024	0,0097	0,00%	4,53E-44
All	**16**	**0,0258**	**0,1813**	**0,0139**	**0,0061**	**0,00%**	**2,83E-45**

Table 2 – Banks are grouped into 6. Halkbank, Vakıfbank and Ziraat bank united under the group of State Banks. Is Bank, Yapı Kredi and Akbank grouped under Large Banks. Garanti, Şekerbank, ING, ICBC, QNB Finansbank, Denizbank constituted Foreign Associated Banks. TSKB and Kalkınma Bank grouped as Development Banks and lastly FIBAbank belongs to Private Banks group while Albaraka Türk formes Participation Bank group. Development banks have the exact probability of zero for defaulting. On the other hand, state and participation bank groups have the relative maximum two default probabilities.

While the inferences about the relation between the CAR and the default probability are taking a shape, in order to observe the interbank connections, the entropy maximization is applied to the financial data of banks. Table 3 includes interbank lending, borrowing amounts that deduced from an approximation called as the principle of maximum entropy, and marginal distributions' data (Total Lending and Total Borrowing) obtained from the annual reports of banks. This approximation model maximizes the equation **(12)** and the results are embedded to the matrix. Similar to previous tables, Table 1 and Table 2, data used in Table 3 stand for the annual averages between 2007 and 2018. Since the sum of the borrowings of banks are larger than the sum of the lendings in amount, the row of Other-banks are constructed. In order to implement the entropy maximization smoothly, Other-banks row had to be created. Table 3 was divided into two parts for better visualization below. The colorization of the table refers to the grouping criteria mentioned for Table 2. The total largest amount of borrowing belongs to Halkbank and Ziraat Bank, while the smallest amount of borrowing done by Fibabank and ICBC. On the other hand, total lending amount of Is Bank is the largest, whereas Fibabank's is the smallest. Since the density of interbank connections improves the financial stability in the banking system, if the results of Table 1 and Table 3 are compared, it can be said that it is consistent for Fibabank to have relatively bigger likelihood of default -even if it is equal to zero possibility- with the smaller amount of total borrowing and lending. Total borrowings exceeds total lendings about 39 billion Turkish liras and it constructed the Other-Banks row.

	Halkbank	Vakıfbank	Ziraat	İş Bankası	Akbank	Yapı Kredi	Garanti	ICBC
Halkbank	211.016.512,16	146.136.193,50	248.974.969,18	95.077.888,40	68.093.609,88	77.536.068,36	81.561.314,04	4.731.130,13
Vakıfbank	383.101.848,44	265.311.208,51	452.015.673,72	172.614.523,96	123.624.391,03	140.767.235,72	148.075.095,40	8.589.397,48
Ziraat	308.944.971,52	213.955.020,29	364.519.174,25	139.201.597,19	99.694.465,38	113.518.976,24	119.412.256,35	6.926.751,12
İş Bankası	773.086.956,02	535.389.310,75	912.152.793,56	348.330.443,81	249.469.963,52	284.063.661,44	298.810.682,42	17.333.122,19
Akbank	224.005.608,42	155.131.589,49	264.300.593,75	100.930.396,50	72.285.103,93	82.308.791,81	86.581.811,01	5.022.354,28
Yapı Kredi	363.974.863,77	252.065.113,67	429.448.053,92	163.996.462,29	117.452.241,66	133.739.201,87	140.682.204,74	8.160.557,80
Garanti	351.683.384,21	243.552.841,25	414.945.536,02	158.458.279,95	113.485.863,84	129.222.811,24	135.931.347,97	7.884.974,68
ICBC	66.959.681,76	46.371.882,99	79.004.645,33	30.170.080,46	21.607.439,16	24.603.716,59	25.881.006,07	1.501.280,47
QNB Finansbank	60.446.864,73	41.861.533,16	71.320.277,88	27.235.594,98	19.505.796,89	22.210.642,13	23.363.696,36	1.355.258,79
Denizbank	173.062.084,64	119.851.446,84	204.193.154,13	77.976.729,89	55.845.971,28	63.590.064,53	66.891.310,49	3.880.166,70
Şekerbank	64.681.814,51	44.794.381,56	76.317.026,61	29.143.739,88	20.872.386,71	23.766.735,31	25.000.573,33	1.450.209,17
ING	158.156.386,31	109.528.738,00	186.606.161,79	71.260.656,78	51.036.002,63	58.113.103,35	61.130.015,65	3.545.971,06
Fiba	31.438.891,40	21.772.513,77	37.094.239,39	14.165.447,90	10.145.118,90	11.551.930,26	12.151.642,87	704.880,79
TSKB	101.589.867,94	70.354.478,18	119.864.241,82	45.773.432,74	32.782.367,43	37.328.258,65	39.266.136,27	2.277.712,20
Kalkınma	106.321.663,56	73.631.409,42	125.447.210,93	47.905.441,90	34.309.286,07	39.066.913,25	41.095.052,24	2.383.802,20
Albaraka	257.635.509,12	178.421.452,57	303.979.969,57	116.083.049,31	83.137.246,80	94.665.788,20	99.580.314,60	5.776.358,95
Other-banks	8.036.247.091,49	5.565.377.552,72	9.481.837.944,83	3.620.898.650,73	2.593.242.911,56	2.952.844.767,70	3.106.140.206,86	180.177.988,66
Total Borrowing	11.672.354.000,00	8.083.506.666,67	13.772.021.666,67	5.259.222.416,67	3.766.590.166,67	4.288.898.666,67	4.511.554.666,67	261.701.916,67

Table 3.a – Halkbank and Ziraat bank's total borrowing amounts are the largest whereas Fibabank and ICBC's total borrowings are the smallest amounts.

QNB Finansbank	Denizbank	Şekerbank	ING	Fiba	TSKB	Kalkınma	Albaraka	Total Lending
25.514.348,67	29.406.452,07	10.872.794,40	9.885.428,45	2.922.543,69	9.060.767,96	8.112.838,96	5.837.723,48	1.034.740.583,33
46.321.465,73	53.387.604,73	19.739.628,85	17.947.059,57	5.305.897,05	16.449.883,09	14.728.911,82	10.598.424,89	1.878.578.250,00
37.355.037,49	43.053.386,69	15.918.636,52	14.473.054,18	4.278.836,61	13.265.685,57	11.877.842,05	8.546.891,88	1.514.942.583,33
93.475.197,49	107.734.434,07	39.833.923,13	36.216.577,15	10.707.126,10	33.195.324,15	29.722.460,63	21.387.273,57	3.790.909.250,00
27.084.881,36	31.216.562,72	11.542.067,96	10.493.924,83	3.102.440,52	9.618.502,45	8.612.223,79	6.197.063,85	1.098.433.916,67
44.008.791,00	50.722.141,48	18.754.095,69	17.051.023,35	5.040.991,49	15.628.595,84	13.993.546,88	10.069.281,24	1.784.787.166,67
42.522.608,27	49.009.248,02	18.120.767,38	16.475.208,02	4.870.756,53	15.100.816,08	13.520.982,94	9.729.240,28	1.724.514.666,67
8.096.203,70	9.331.244,52	3.450.151,11	3.136.840,51	927.380,48	2.875.159,55	2.574.363,06	1.852.424,26	328.343.500,00
7.308.728,44	8.423.643,31	3.114.573,00	2.831.736,49	837.179,05	2.595.507,86	2.323.968,27	1.672.248,67	296.407.250,00
20.925.217,29	24.117.268,57	8.917.162,19	8.107.388,56	2.396.881,16	7.431.055,40	6.653.625,39	4.787.722,93	848.627.250,00
7.820.783,08	9.013.809,67	3.332.782,18	3.030.129,93	895.832,40	2.777.350,96	2.486.787,12	1.789.407,58	317.173.750,00
19.122.945,14	22.040.067,60	8.149.134,18	7.409.105,69	2.190.439,72	6.791.024,57	6.080.553,98	4.375.360,20	775.535.666,67
3.801.327,34	4.381.203,36	1.619.914,00	1.472.808,49	435.423,43	1.349.944,12	1.208.714,24	869.749,73	154.163.750,00
12.283.395,67	14.157.174,49	5.234.499,12	4.759.150,65	1.407.002,82	4.362.133,61	3.905.771,31	2.810.460,43	498.156.083,33
12.855.524,75	14.816.579,38	5.478.308,67	4.980.819,69	1.472.537,40	4.565.310,61	4.087.692,12	2.941.364,47	521.358.916,67
31.151.127,19	35.903.096,74	13.274.875,47	12.069.374,89	3.568.209,06	11.062.525,59	9.905.174,59	7.127.427,35	1.263.341.500,00
971.675.667,39	1.119.900.582,57	414.074.052,65	376.471.702,89	111.300.689,15	345.065.745,93	308.965.292,86	222.320.935,18	39.406.541.783,17
1.411.323.250,00	1.626.614.500,00	601.427.366,50	546.811.333,33	161.660.166,67	501.195.333,33	448.760.750,00	322.913.000,00	57.236.555.866,50

Table 3.b - Total lending of Is Bank's is the largest of all, while Fibabank gives the smallest lending amount to other banks.

Moreover, to show interbank connections in a compact form Table 4 is constituted. As can be seen from the table, the largest total lending amount belongs to Large Banks with approximately 6.7 billion Turkish liras. State Banks and Foreign Associated Banks chase the Large Banks in total lending amounts by 4.5 billion and 4.3 billion Turkish liras, respectively. On the other hand, State Banks have the largest amount of total borrowing about 33.6 billion Turkish liras and Large Banks follow it by 13.3

billion Turkish liras. Clearly, it can be said that State, Large and Foreign Associated Banks dominates the Turkish banking system.

	State	Large	Foreign Associated	Development	Participation	Private	Total Lending
State	2.593.975.571,58	1.030.128.756,17	693.170.841,87	73.495.929,44	24.983.040,25	12.507.277,35	4.428.261.416,67
Large	3.909.554.883,34	1.552.576.266,83	1.044.724.352,66	110.770.653,74	37.653.618,67	18.850.558,10	6.674.130.333,33
Foreign Associated	2.513.337.841,72	998.105.615,60	671.622.557,57	71.211.195,16	24.206.403,92	12.118.469,35	4.290.602.083,33
Development	597.208.871,84	237.165.700,04	159.588.155,34	16.920.907,65	5.751.824,90	2.879.540,22	1.019.515.000,00
Participation	740.036.931,25	293.886.084,30	197.755.147,84	20.967.700,19	7.127.427,35	3.568.209,06	1.263.341.500,00
Private	90.305.644,56	35.862.497,06	24.131.776,86	2.558.658,36	869.749,73	435.423,43	154.163.750,00
Other-banks	23.083.462.589,04	9.166.986.329,99	6.168.440.201,02	654.031.038,79	222.320.935,18	111.300.689,15	39.406.541.783,17
Total Borrowing	33.527.882.333,33	13.314.711.250,00	8.959.433.033,17	949.956.083,33	322.913.000,00	161.660.166,67	57.236.555.866,50

Table 4 - The largest total lending amount belongs to Large Banks and it is chased by State Banks and Foreign Associated Banks. On the other hand, State Banks have the largest amount of total borrowing.

Furthermore, dividing every interbank relation amount of the Table 4 by the total interbank loan amount gives the relative coefficients of Table 5. Colorized parts stand for the interbank loans greater than or equal to 1 percent. It can be deduced that State Banks lead to the total borrowings by 59 percent of all interbank loans; while it is only 23 percent and 16 percent of total borrowings belong to Large and Foreign Associated Banks, respectively. State Banks turn out to be the main borrowers. From another point of view, it could be inferred that the main loan supplier is Other Banks by 69 percent. Large Banks ensue this share of loans by 12 percent, and then come State Banks by 8 percent of share of total lending.

	State	Large	Foreign Associated	Development	Participation	Private	Total Lending
State	0,045	0,018	0,012	0,001	0,000	0,000	0,077
Large	0,068	0,027	0,018	0,002	0,001	0,000	0,117
Foreign Associated	0,044	0,017	0,012	0,001	0,000	0,000	0,075
Development	0,010	0,004	0,003	0,000	0,000	0,000	0,018
Participation	0,013	0,005	0,003	0,000	0,000	0,000	0,022
Private	0,002	0,001	0,000	0,000	0,000	0,000	0,003
Other-banks	0,403	0,160	0,108	0,011	0,004	0,002	0,688
Total Borrowing	0,586	0,233	0,157	0,017	0,006	0,003	1,000

Table 5 – Table shows the coefficients related to the interbank connections. State Banks lead to the total borrowings by 59 percent, while the main loan supplier is Other Banks by 69 percent.

In order to visualize the magnitude of a domino effect caused by a default of a borrowing bank, in Table 6, it is assumed that only just one bank in a lender bank group experience the impact of defaulting of a borrower bank in the borrower bank group due to supplying the entire loan to borrower bank. The coefficients below the bank groups denote one of a lender bank's possible expected ROA in the respective bank group when the default shock of one bank in the respective bank group of the head row strikes. Under the threshold column, maximum, minimum and mean values of $(\alpha - CAR)$ of lender banks take space. $(\alpha - CAR)$ considered as a benchmark for measuring insolvency and when a bank's ROA falls below this level, the bank is regarded as insolvent. In conclusion, it can be said that it is a track of contagion. The colorized areas in the Table 6, demonstrate that one of the banks in the Large Banks group expect to gain an ROA of -17,9 percent if a bank in the State Banks group would default and when the loans of this State Bank's borrowed from the related Large Bank in the Large Bank group. Additionally, it is frankly seen that even a bank in Large Banks with minimum threshold cannot resist such kind of default wave. From a wider perspective, Table 6 shows that not only Large Banks but also every banking category would affect from a default of a bank in the State Banks group when one of a bank inside their category supply all of the loans of defaulting bank in State Banks.

Lender		Threshold	State	Large	Foreign Associated	Development	Participation	Private
State	min	-0,175						
	mean	-0,132	-0,178	-0,060	-0,009	0,009	0,012	0,015
	max	-0,109						
Large	min	-0,153						
	mean	-0,130	-0,179	-0,061	-0,009	0,008	0,011	0,014
	max	-0,117						
Foreign Associated	min	-0,163						
	mean	-0,124	-0,183	-0,065	-0,014	0,004	0,007	0,010
	max	-0,095						
Development	min	-0,544						
	mean	-0,286	-0,175	-0,057	-0,005	0,012	0,015	0,018
	max	-0,130						
Participation	min	-0,188						
	mean	-0,129	-0,181	-0,064	-0,012	0,006	0,008	0,011
	max	-0,102						
Private	min	-0,182						
	mean	-0,132	-0,193	-0,075	-0,024	-0,006	-0,003	0,000
	max	-0,100						

Table 6 - Table demonstrates that only just one bank in a lender bank group experience the impact of defaulting of a borrower bank in the borrower bank group due to supplying the entire loan to borrower bank.

In addition to first assumption, now it is supposed that the loan that would be given to the one bank in the borrower bank groups distributed evenly among a lender group. Therefore, every bank in the lender group bear to equal amounts of shock when a borrower bank in its relative group default in its loans. In Table 7 below, this situation is visualized. It can be deduced from the table that in contrast to the previous table, if the loans distributed evenly in the lender group instead of defraying all loans to one bank in the lender group, it compensates the contagion effect that would be occur in the lender group when a bank in the borrower bank group defaults. For instance, if a bank from State Banks would default; the expected ROA's of State, Large, Foreign Associated and Development Bank groups after suffering from a default wave is still higher than their maximum threshold whereas only Participation and Private Bank groups' ROA's fall below their minimum thresholds and they will affected from the default.

Lender		Threshold	State	Large	Foreign Associated	Development	Participation	Private
State	min	-0,175	-0,048	-0,008	0,009	0,015	0,016	0,017
	mean	-0,132						
	max	-0,109						
Large	min	-0,153	-0,048	-0,009	0,008	0,014	0,015	0,016
	mean	-0,130						
	max	-0,117						
Foreign Associated	min	-0,163	-0,020	0,000	0,008	0,011	0,012	0,012
	mean	-0,124						
	max	-0,095						
Development	min	-0,544	-0,077	-0,018	0,008	0,016	0,018	0,019
	mean	-0,286						
	max	-0,130						
Participation	min	-0,188	-0,181	-0,064	-0,012	0,006	0,008	0,011
	mean	-0,129						
	max	-0,102						
Private	min	-0,182	-0,193	-0,075	-0,024	-0,006	-0,003	0,000
	mean	-0,132						
	max	-0,100						

Table 7 – The impact of possible defaulting of a bank in the borrower bank group when the loan that is supplied to borrower bank, distributed evenly among a lender group.

All in all, in Turkish Banking System, even if a defaulting possibility of a bank in its respective bank group is not exist with respect to Table 2, due to the advanced interbank relationships, the system became fragile to extraordinary defaulting of banks. However, there is no chance to become insolvent for one of a State Bank, if such kind of an unexpected insolvency on loans happen, there will be banks that might affect from this situation even their individual defaulting likelihood is also equal to zero. Thus, it can be concluded that, while Banks show strong performance individually in Turkey, since State Banks is the main borrowers of the system, if an unexpected case have an impact on one of a State Bank, the systemic risk might be triggered for small-scaled banks.

CHAPTER V

CONCLUSION

In this thesis, the relationship between the interbank connections and the systemic risk have been analyzed in the Turkish Banking System. The data is gathered from the 16 banks' financial statements on a yearly basis in between the years 2007 and 2018. Financial statements used in two ways, one is for interbank transactions and the other way is for extracting the α, CAR and ROA of a bank.

In an attempt to find the triggering levels of systemic risk, a study is implemented by only using the number of banks independent of data of banks. With different values of default probability P of a single bank, the likelihood to giving a start to a contagion effect is measured. It is found that, in Turkish banking system, it is enough for a single bank to have a default likelihood of 1 percent to trigger the contagion effect. The probability of 1 percent corresponds to 14,85 percent of chance to occur a systemic risk. When a bank's default possibility reaches to 30 percent, it is almost impossible to flee from systemic risk.

Besides, when the individual data of banks taken into account, the default probabilities have been evaluated based on the strength of banks' CAR level. It is concluded that high level of average CAR of a bank reduces the possibility of default. Since the CAR levels of all banks and bank groups are above the Basel Standards, all the default likelihoods obtained zero and all are negligible. There is no chance for a bank or bank group to become insolvent in Turkey.

Furthermore, entropy maximization is applied to the data, in order to get the interbank relationships. According to the outputs, Halkbank and Ziraat Bank are the main borrowers of the system, while Fibabank and ICBC Turkey Bank have a little share from borrowings. In the lenders side, Is Bank is the pioneer while Fibabank make a little loan to other banks. In addition, the results of grouped study support the individual bank's outputs. Hence, Large Banks' lending amount is found around 6.7 billion Turkish Liras, which is the largest of all lending amounts. State Banks and Foreign Associated Banks come after the Large Banks in total lending amounts by 4.5 billion and 4.3 billion Turkish liras, respectively. From the borrowings perspective, State Banks get into debt with the largest amount of 33.6 billion Turkish Liras. Large Banks chase it by 13.3 billion Turkish Liras. Therefore, it is inferred that Turkish Banking System is dominated by State, Large and Foreign Associated Banks.

Moreover, two different scenarios implemented to data in order to observe the reaction behavior of banks against defaulting banks. It is concluded from first scenario analysis that when one bank in the lender bank group afford the entire loan that would be given to a bank in the State Banks group, in the insolvency situation of borrower bank, for example a lender bank in the Large Banks group expect to gain an ROA of -17,9 percent. It is clear that even a bank in Large Banks with minimum threshold cannot resist such kind of default wave. Also, not only Large Banks but also every banking category would affect from a default of a bank in the State Banks group when one of a bank inside their category supply all of the loans of defaulting bank in State Banks. In addition, in the second scenario analysis it is assumed that the entire loan that would be given to borrower bank distributed evenly among a lender group. Thus, the impulse of a default would affect all banks in the lender group equally and contagion effect would be tolerated. For

instance, if a bank from State Banks would default; while State, Large, Foreign Associated and Development Bank groups compensate the default wave, only Participation and Private Bank groups will affected from the default.

As a consequent, like other countries, in Turkish Banking System, even if dense interbank relationships ensure the financial stability, the system became more fragile to extraordinary defaulting of banks.

APPENDIX

The code below is related to the entropy maximization. First, it constitutes the matrix A that includes 0's and 1's in proper cells. Then by implementing equation **(12)**, it compose the interbank matrix.

```
[data] = xlsread('Bankalar Arası İşlem Döküm0718_G.xl)sx');

r_vct = data(:,3);
c_vct = data(:,4);
B = [r_vct;c_vct];

M = 7;
N = 6;
A = zeros((M+N),(M*N));

for i = 1:M
    A(i, 1+(i-1)*N : i*N) = 1;
end

for k = 1:N
    for j = 1:M
        A(M+k, (j-1)*N+k) = 1;
    end
end

p = zeros((M*N),1);

c = 1;
for i = 1:M
    for j = 1:N
        p(c,1) = r_vct(i,1)*c_vct(j,1);
        c = c+1;
    end
end
```

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