Int. J. Nonlinear Anal. Appl. 11 (2020) No. 1, 259-274
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/IJNAA.2020.4275

Modelling the Cognitive Financial Group Interconnected Risk Network

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(Communicated by Madjid Eshaghi Gordji)

Abstract

In this paper, the new methodology of interconnection network among the various corporations which are the members of a single financial group is studied and developed. For the first time, each company is observed individually and the cognitive risk factors of each are monitored by new introduced indexes. The risk contagion effect on the main node of the holding is calculated respectively. The new indexes help the management to monitor the entire financial group performance. Also guide the main node of the holdings to make appropriate decisions relating to any investment, profit returning and risk of the financial group nodes. It is shown, if a company defaults to meet its obligations, how much this will affect the other companies of the network and the main node of the holding. With the use of new developed methodological indexes, the topology of the financial group network is displayed graphically for the first time and the mathematical structure is developed as well.
Finally, the illustrative results are apparent in a new introduced software which is coded and tested with real data and the results show high accuracy.

Keywords: Financial Group, Contagion Network, Risk Management, Exposure.
2010 MSC: Primary 91B30, 91G70.

1. Introduction

Nowadays, many big and small global organizations and companies think of forming financial groups as one of the strategies of reducing the costs and increasing the incomes because forming a financial group is an effective method employed by the organizations for reducing the costs and focusing on the major procedures of service improvement and skill enhancement [8]. Creating financial group is one of the modern

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Received: March 2019 *Revised:* December 2019

management methods in banks which are running in developed countries for many years and its results are continuously evaluated in order to modify the methods. For instance, presenting figures and statistics, Harvard Business Review Journal evaluated the advantages and disadvantages of forming financial groups in the American banks. This paper provides the banks a complete understanding about the different factors which must be considered for providing services. By adopting the policy of forming financial groups, an organization can focus only on the activities for which they are commission and perform the work which is exactly related to its organizational goals. In a financial group, organizations have interconnected relations include of investment, profit and risk. It is obvious that these interconnected relations within financial organizations and institutes can contribute to transferring the risks among them and their control would be more complicated and entails some thoughts [3, 14]. All the content and modelings can be implemented on both the money market and the capital market and just the definitions and terms are a little different. We provide a framework for studying the relationship between the financial network architecture and the likelihood of systemic failures due to contagion of counterparty risk. We show that financial contagion exhibits a form of phase transition as financial group connections increase: as long as the magnitude and the number of negative shocks affecting financial institutions are sufficiently small, more complete financial group claims enhance the stability of the system[12]. However, beyond a certain point, such interconnections start to serve as a mechanism for propagation of shocks and lead to a more fragile financial system. We also show that, under natural contracting assumptions, financial networks that emerge in equilibrium may be socially inefficient due to the presence of a network externality, even though companies take the effects of their lending, risk-taking and failure on their immediate creditors into account, they do not internalize the consequences of their actions on the rest of the network.

The underlying reasons for forming financial groups are: increasing effectiveness by focusing on what the organization is doing best, accessing to expertise, skills, experience and technologies which have never been accessible, reducing investment on the assets and using them more efficiently for the main goals of the organization, increasing the speed of doing things and removing bureaucracy, increasing the focus of the organization on a specific activity and managing difficult or uncontrollable tasks, moving from a product-oriented organization to service-oriented organization, etc.

Contribution

After the formation of a financial group, regarding the investment made any parent or holding company creates the grounds for risk transfer of the opposite side. If risks increase, the may contribute to the collapse of the whole financial group or holding and may lead to the loss of financial and organizational resources [10]. We seek to answer the question of when a member company of a financial group defaults, how this default impacts on other member companies of the financial group and the main node of the holding. And how would contagion risk affect the main node of the holding? The main goal of this research is to review the interconnected network and rational relations within the different member companies of a financial group[5] The subsequent objectives include manipulating the relations within the member companies of a financial group for the first time and analysis of profits and losses outcome of the relationship among the companies and the risk imposing to the main node of the holding. For illustrative results new risk factors index to the profits and losses indexes in order to help companies and the main node of the holding make decisions on investment and lending are modeled and graphical visualization of the financial group network for the first time and analyzing its structure are constructed.

The results of this research help the senior executives and managerial Board of the companies and the main node of the holdings to have a broader and more proper perspective into their own financial group performance and contagion risks in their network. Using the newly presented indexes and software help the executives to identify the high-risk companies in their group and manage the contagion risks in the group and stop their spread to other sections and to the main node of the holding.

Key Terms Definition

1- Financial Group: by unifying a number of companies and creating a holding company which does not produce goods or services on its own and it only manages the other companies a financial group is formed.
2- Contagion: When a company in a financial system does not function properly, the unity of the members will make the other members of the financial system not to be able to function properly. Contagion may occur for the following reasons:
A) Contagion through correlation: companies that are subject to common market factors may take significant losses across the companies at the same time. This correlation can be intensified during a sell off.
B) Contagion through the risk of counterparty: default of a company may lead to the loss of the assets held by the trading counterparties. This may lead to their inability to pay debts.
C) Contagion through the liquidity shocks: the movement of market or credit events may lead to the payment of derivatives and if they happen to be more than the company liquidity, it it may lead to default.
D) Contagion through indirect costs: even in the absence of counterparty exposures, the effects of sales slump may lead to contagion. For example: a quick sale of assets to reduce debt levels and lowering prices may lead to endogenous volatility across assets.
3- Cognitive Finance: The mapping of cognitive risk management and financial decision making is discussed and adaptive learning mechanisms are proposed for the observed behavioural risks. The construal of a financial personality is proposed in accordance with other dimensions of personality measures, to better acknowledge and predict variations in financial interconnected network behaviour. This perspective enriches economic and financial theories and provides a useful ground for improving individual financial risk management (FGRM) software version 1.1.

Network Representation

We could view the interbank system as a directed network Γ_t for $t = 1,2,...,T$. The interbank system Γ_t is defined as the triplet $\Gamma_t = (\nu_t, L_t, C_t)$;where the vertices $\nu_t = \{1,2,...,n_t\}$ are the existing financial conglomerates on time t, the matrix L_t of dimension $n_t \times n_t$ represents the exposures among these financial institutions and $C_t = \{C_r, C_1, C_2\}$ is the capitalization structure [1, 2]. Each element $\ell_{ij} \in L_t$ represents that bank i has an exposure to bank j, that is, if all exposures should be cleared in time t, bank i should receive from bank j the amount ℓ_{ij} .
From L_t, we may define the adjacency matrix A_t of same dimension as L_t whose elements are defined as the indicator function of the elements of the exposure matrix L_t that is $a_{ij} = 1_{\{\ell_{ij}>0\}}$ for all $a_{ij} \in A_t$. We may also represent the adjacency matrix A_t as a vector ε_t of edges, listing the financial conglomerates that are connected. The elements are defined as positions of the elements of the adjacency matrix that are equal to 1, that is, all the pairs $\{(i, j)\}$ $i, j \in \nu_t$ for which $a_{ij} = 1$.
For a directed network the number of edges in respect to a vertice is denoted degrees and depends on the direction of the exposure[6].The in-degree $k_{in,i}$ and out-degree $k_{out,i}$ of bank $i \in \nu_t$ are defined as

$$k_{in,i} = \sum_{j \in V_{in,i}} a_{ij}, \quad k_{out,i} = \sum_{j \in V_{out,i}} a_{ji} \tag{1.1}$$

where $V_{in,i} = \{j : a_{ij} = 1\}$ and $V_{out,i} = \{j : a_{ji} = 1\}$.
Consequently, the degree of financial conglomerate i is equal to $k_i = k_{in,i} + k_{out,i}$.
In a similar manner, the in-weighted degree $w_{in,i}$, out-weighted degree $w_{out,i}$ and weighted degree w_i of financial conglomerate $i \in \nu_t$ are defined as

$$w_{in,i} = \sum_{j \in V_{in,i}} \ell_{ij}, \qquad w_{out,i} = \sum_{j \in V_{out,i}} \ell_{ji} \tag{1.2}$$

and $w_i = w_{in,i} + w_{out,i}$.

Exposure Size and Connectivity

Another important property that we shall probe is the relationship between degrees and exposures' size. It is intuitive that if financial conglomerate $i \in \nu_t$ has a low (high) level of connectivity, i.e., a small number of degrees k_i, it should have less (more) weighted- degrees w_i. The reverse is also true, the higher the number of degrees, the higher the amount of exposures. However, a more meaningful way to determine whether there is a relationship between degree and exposures is to investigate the relationship between degrees k_i and the mean weighted-degree $\frac{w_i}{k_i}$.

Capital Structure

We will denote $\overline{B}_2$ as total capital buffer adjusted for non-banking activities,$\overline{B}_1$, Tier I capital buffer adjusted for non-banking activities, B_2, total capital buffer. Therefore, the bar means the necessary adjustments that will be made for non-banking activities. We will still continue with the previous notation C_2 total capital, C_1 tier I capital, and C_r required capital. Roughly speaking, the Required Capital C_r, can be computed as

$$C_r = \delta \times RiskBase, \tag{1.3}$$

where the δ is the minimum required Basel II Index and Risk Base is the sum of the following components: credit exposures weighted by their respective risk; foreign cur- rencies and gold exposures; interest rate exposures; commodity prices exposures; stocks prices exposures; and, operational risk exposures.

Capital Buffer

The capital buffer of financial institution $i \in \nu_t$ is defined as

$$\overline{B_{2,i}} = C_{2,i} - C_{r,i} - \delta \sum_{j \in V_{in,i}} \ell_{i,j} \tag{1.4}$$

Default

A financial conglomerate $i \in \nu_t$ is in default if the banking capital buffer is negative, i.e.,

$$\overline{\beta_{2,i}} < 0 \tag{1.5}$$

this situation could mean, in extreme cases, the intervention in the financial conglomerate's management or liquidation of its assets. The default impact DI_j of financial conglomerate $j \in \nu_t$ for $t = 1, ..., T$ is defined as

$$DI_j = \frac{\sum_{i \in \nu_t} \{max(\overline{B_{2,i}}^{(0)}, 0) - max(\overline{B_{2,i}}^{(s^*)}, 0)\}}{\sum_{i \in \nu_t} \overline{B_{2,i}}} \tag{1.6}$$

given that the initial defaulting set is $D_0 = \{j\}$. From this definition it is clear that a financial conglomerate cannot lose more than its capital, and that the DI_j is the sum of the losses suffered by the system, in case financial conglomerate j defaults, expressed as a percentage of the total capitalization of the system [7]. Therefore, $DI_j \in [0, 1]$ for $j \in \nu_t$ represents the percentage of capitalization that is destroyed if bank j defaults [8].

2. Interconnected Network Structure in the Financial Group

Cognitive Network Representation

We could view the financial group system as a directed network Γ_t for $t = 1,2,...,T$. The financial group system Γ_t is defined as the dual $\Gamma_t = (\nu_t, L_t)$;where the vertices $\nu_t = \{1,2,...,n_t\}$ are the existing financial conglomerates on time t, the matrix L_t of dimension $n_t \times n_t$ represents the exposures among these financial institutions. Each element $\ell_{ij} \in L_t$ represents that bank i has an exposure to bank j, that is, if all exposures should be cleared in time t, bank i should receive from bank j the amount ℓ_{ij} .

From L_t, we may define the adjacency matrix A_t of same dimension as L_t whose elements are defined as the indicator function of the elements of the exposure matrix L_t that is $a_{ij} = 1_{\{\ell_{ij}>0\}}$ for all $a_{ij} \in A_t$. We may also represent the adjacency matrix A_t as a vector ε_t of edges, listing the financial conglomerates that are connected. The elements are defined as positions of the elements of the adjacency matrix that are equal to 1, that is, all the pairs $\{(i,j)\}$ $i,j \in \nu_t$ for which $a_{ij} = 1$.

For a directed network the number of edges in respect to a vertice is denoted degrees and depends on the direction of the exposure.The in-degree $k_{in,i}$ and out-degree $k_{out,i}$ of bank $i \in \nu_t$ are defined as

$$k_{in,i} = \sum_{j \in V_{in,i}} a_{ij}, \quad k_{out,i} = \sum_{j \in V_{out,i}} a_{ji} \tag{2.1}$$

where $V_{in,i} = \{j : a_{ij} = 1\}$ and $V_{out,i} = \{j : a_{ji} = 1\}$.

$k_{in,i}$ as the number of companies that are debtors to i and $k_{out,i}$ as the number of companies that are creditors to i.

Consequently, the degree of financial conglomerate i is equal to $k_i = k_{in,i} + k_{out,i}$.

In a similar manner, the in-weighted degree $w_{in,i}$, out-weighted degree $w_{out,i}$ and weighted degree w_i of financial conglomerate $i \in \nu_t$ are defined as

$$w_{in,i} = \sum_{j \in V_{in,i}} \ell_{ij}, \qquad w_{out,i} = \sum_{j \in V_{out,i}} \ell_{ji} \tag{2.2}$$

and $w_i = w_{in,i} + w_{out,i}$.

We consider $w_{in,i}$ as the assets of i, that is, $w_{in,i}$ is the investments that i has made or the lons has paid in other conglomerates, and we consider $w_{out,i}$ as debts of i, that is, $w_{out,i}$ is the profit of other conglomerates from i and received lones from other conglomerate or the main node of the holding [12].

Contagion via Default

A contagion model is concerned with risk propagation. This means that when a financial conglomerate defaults, a natural question arises: What would be the impact of this default to the main node of the holding? To answer this question, it is important to notice that exposures don't represent cash flows until they are due.Therefore, a realistic approach is to consider losses as write-offs to the capital buffer, which is in accordance to banking practices [9]. If in time t, financial conglomerate j has good reason to believe that its counterparty i will not honor exposure ℓ_{ij} when it is due, then, in time t, financial conglomerate i has to write- off exposure ℓ_{ij} from its asset portfolio, and this procedure will negatively affect its capital buffer in the same amount [7]. As a consequence from the initial defaulting state, some financial conglomerates in $i \in \nu_t$ could also default in the subsequent state, and this process of defaulting financial conglomerates causing other financial conglomerates to default could go on for several rounds (defaulting states) until the system achieves an equilibrium (final state). Clearly, write-offs will drive the default mechanism of our contagion model.

Consider an initial configuration of capital reserves $(C(j), j \in v_t)$. We define the sequence $(C_k(j), j \in v_t)_{k\geq 0}$ as

$$C_0(j) = C(j) \quad and \quad C_{k+1}(j) = max(C_0(j) - \sum_{\{i, c_k(i)=0\}} (1-R_i)\ell_{ji} \ ,0) \tag{2.3}$$

where R_i is the recovery rate at the default of institution i. $C_{n-1}(j), j \in v_t$, where n is the number of nodes in the network, then represents the remaining capital once all counterparty losses have been accounted for. The set of insolvent institutions is then given by

$$D = \{j \in v_t : \quad C_{n-1}(j) = 0\} \tag{2.4}$$

The set of defaulted institutions may be partitioned into two subsets

$$D = \{j \in v_t : \quad C_0(j) = 0\} \cup \{j \in v_t : \quad C_0(j) > 0, \ C_{n-1}(j) = 0\} \tag{2.5}$$

where the first set represents the initial defaults which trigger the cascade we will refer to them as fundamental defaults and the second set represents the defaults due to contagion.
The default of an institution can therefore propagate to other participants in the network through the contagion mechanism described above [11]. We measure the impact of the default event triggering the loss cascade by the loss incurred across the network during the default cascade.

Default Impact

The Default Impact $DI(i)$ of a financial institution$i \in v_t$ is defined as the total loss in capital in the cascade triggered by the default of i:

$$DI(i) = \sum_{j \in v_t} \{C_0(j) - C_{n-1}(j)\} \tag{2.6}$$

where $(C_k(j), j \in v_t)_{k\geq 0}$ is defined by the recurrence relation (2.3), with initial condition is given by

$$C_0(j) = C(j) \quad \text{for} \quad j \neq i \ , C_0(i) = 0 \tag{2.7}$$

It is important to note that the Default Impact does not include the loss of the institution triggering the cascade, but focuses on the loss this initial default in icts to the rest of the network: it thus measures the loss due to contagion. The $DI(i)$ is defined as a percentage of the total capital of the system:

$$DI(i)_{percentage} = \frac{\sum_{j \in v_t}(C_0(j) - C_{n-1}(j))}{\sum_{j \in v_t} C_0(j)} \tag{2.8}$$

The $DI(i)_{percentage} \in [0,1]$ for $i \in v_t$ illustrats the percentage of capital that has been lost. The following diagram shows a contagion via default that started with default a and lasts 3 rounds[4].

Susceptibility Coefficient

The susceptibility coefficient of a company is the maximal fraction of capital wiped out by the default of a single counterparty.

$$\mathscr{X}(i) = \max_{j \neq i} \frac{\ell_{ij}}{C(i)} \tag{2.9}$$

A company with $\mathscr{X}(i) > \%100$ may become insolvent due to the default of a single counterparty. Counterparty risk management in financial institutions typically imposes an upper limit on this quantity.

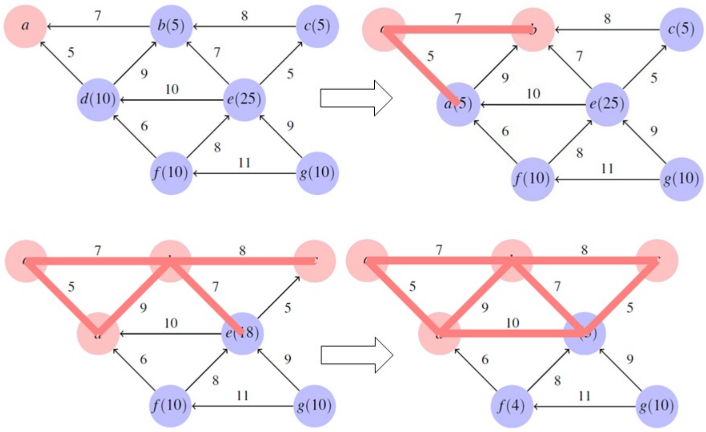

Figure 1: Contagion via Default

Counterparty Susceptibility

The counterparty susceptibility $CS(i)$ of a company i is the maximal (relative) exposure to company i of its counterparties:

$$CS(i) = \frac{\max_{j,\ell_{ji}>0} \ell_{ji}}{C(j)} \tag{2.10}$$

$CS(i)$ is thus a measure of the maximal vulnerability of creditors of i to the default of i.

Local Network Frailty

The local network frailty $f(i)$ at company i is defined as the maximum, taken over counterparties exposed to i, of their exposure to i, weighted by the size of their liability:

$$f(i) = \max_{j,\ell_{ji}>0} \frac{\ell_{ji}}{C(j)} w_{out,j} \tag{2.11}$$

Local network frailty combines the risk that the counterparty incurs due to its exposure to company i, and the risk that the (rest of the) network incurs if this counterparty fails. A large value $f(i)$ indicates that i is a company whose counterparties have large liabilities and are highly exposed to i.

Minimum Capital Ratio

institutions are required to hold a capital equal to or higher than cover a portion θ of their aggregae interbank exposure:

$$\overline{C}(i) = \max(C(i), \theta w_{in,i}) \tag{2.12}$$

Minimum Capital-to-Exposure Ratio

institutions are required to hold a level of capital which covers a portion γ of their largest interbank exposure:

$$\overline{C}(i) = \max(C(i), \frac{\max_{j\neq i}(\ell_{ij})}{\gamma}) \tag{2.13}$$

Contagious Exposure

An exposure ℓ_{ij} is called contagious if it exceeds the capital available to i: $\ell_{ij} > C(i)$
If the link $i \rightarrow j$ represents a contagious exposure, the default of j leads to the default of i in all stress scenarios. Thus, the subgraph constituted of contagious exposures will be a primary support for the propagation of default cascades: the larger this subgraph, the larger the extent of contagion. Previous studies on contagion in financial networks have examined how the network structure may affect the global level of systemic risk but do not provide metrics or indicators for localizing the source of systemic risk within the network.The ability to compute a Risk Index for measuring the systemic impact of each institution in the network, enables us to locate the institutions which have the largest systemic impact and investigate their characteristics[5]. The new indicator of the total risk of each company which is shown by *RI*. Second one is the indicator EPI which represents the profitability of each company for every investment unit. The third indicator is $NEPI$ which specifies net profitability of each company. Applying these introduced tools, a software has been scripted. Obviously, every company based on its activities is faced with different risks; therefore, in order to calculate *RI*, the risks related to that specific company must be considered. In the following sections, the model which has been suggested for calculating the indicator of the total risk of each company (*RI*) is presented [4].

3. New Developed Risk Index

Consider $j \in v_t$. RI_j specifies how much risk the companies in the group which are counterparty of j and are in relation with j such as holding companies have to deal with. Calculating this index for all the companies of the financial group network, the riskiest companies and the risk resources in group are identified.
To calculate the *RI* of each company, three categories of company information are required:

1. Identifying risk factors of each company: as the first step it is required to know that what risks each company of the group is faced with based on its activities. The symbol RF_i in which $1 \leq i \leq m$ specifies the risk factors. The number of these risk factors for each company can be from 1 to m. The main categories of risk factors which are appeared in most companies are introduced.
   What was achieved by this investigation is as the following $m \times m$ matrix.

$$\begin{bmatrix} RF_{Liquidity} & RF_{Credit} & RF_{Operating} & RF_{Market} & RF_{Strategic} \end{bmatrix}$$

2. The value of each risk factor: it is required to allocate a value to each factor. This value which is accumulated from cognitive financial behavior of each company, indicates that how much the presence of this factor affects performance of obligations in real world. The symbol V_{RF_i} is considered for this notion. The index Likert scale has been used for risks synchronization. Therefore, we have $0 \leq V_{RF_i} \leq 9$ and the results of these investigations done by company CEOs will be as the following matrix.

$$\begin{bmatrix} V_{RF_{Liquidity}} & V_{RF_{Credit}} & V_{RF_{Operating}} & V_{RF_{Market}} & V_{RF_{Strategic}} \end{bmatrix}$$

Earnings Per Investment
Net Earnings Per Investment

3. Weight of each risk factor: this variable specifies the importance of each risk which means how much the counterparties of a company care about the presence of a special risk factor. For instance, how important is the existence of some liquidity risk in an insurance company for a holding company and what weight does its value increase with? The symbol W_{RF_i} is considered for the weight of each risk and $1 \leq W_{RF_i} \leq 100$ and in a company we will have $\sum_{i=1}^{m} W_{RF_i} = 100$. The result of this investigation is as the following matrix $m \times m$

$$\begin{bmatrix} W_{RF_{Liquidity}} & W_{RF_{Credit}} & W_{RF_{Operating}} & W_{RF_{Market}} & W_{RF_{Strategic}} \end{bmatrix}$$

The significant point is that each risk factor of the company i for the different j which have invested in i has different weights. For instance, in a financial group network, think of the company i which is in relation with an insurance company and an investment company and these two companies have invested in i. Obviously, the risks involved in i may threaten their investments. To the insurance company, the value of each risk factor has a weight which may different from the investment companys views [3].

To collect the data mentioned before, the managers and experts views in companies and holdings were collected using a questionnaire.

After collecting the required data, we can calculate RI. In every network, each node may face some risks based on the investments it has made; moreover, it may cause some risks based on the investments it has attracted from other nodes. Therefore, we are face with two notions of input RI and output RI in every node; however, based on the point mentioned above, the output RI of a node is different for different counterparties. In other words, supposing that the company j has invested in K, the RI value that the company K imposes to j is equal to:

$$RI_{out,k\to j} = \frac{\sum_{i=1}^{m} W_i V_i}{\sum_{i=1}^{m} V_i} \qquad j \in V_{out,k} \tag{3.1}$$

In which this RI is unique among K and each of $j \in V_{out,k}$. If the company K invests in j, the RI value which is imposed to K, the input RI of the node K, is achieved by an equation as follows:

$$RI_{in,k\leftarrow j} = \frac{\sum_{i=1}^{m} W_i V_i}{\sum_{i=1}^{m} V_i} \qquad j \in V_{in,k} \tag{3.2}$$

Nevertheless, note that if the company K has invested in several companies, risks are imposed to it by different companies. Thus, the input RI of K is as follows:

$$RI_{in,k\leftarrow j} = \sum_{j\in V_{in,k}} RI_{in,k\leftarrow j} \qquad j \in V_{in,k} \tag{3.3}$$

Now, if we want to specify each js share in the imposed RI to the K, we can use the equation below:

$$RI_{in,k\leftarrow j} \ \ Percentage = \frac{RI_{in,k\leftarrow j}}{\sum_{j\in V_{in,k}} RI_{in,k\leftarrow j}} \times 100 \tag{3.4}$$

3.1. EPI Index

EPI is a criterion which can help us identify the riskiest company in a group in order to know that which company has given the least commitment toward the investments made by other companies. EPI_m shows the profit made by each investment unit in the company m. In this equation, P_m is the profit the company m gives to a counterparty company and I_m is the investment made by the same counterparty in the company m.

$$EPI_m = \frac{P_m}{I_m} \tag{3.5}$$

3.2. NEPI Index

The money cost price in different periods may be different. In order to calculate the net profit achieved by each investment unit in each company, we just need to reduce the money cost price from the *EPI* criterion of that company, that is:

$$NEPI_m = EPI_m - Money\ \ Price_t \tag{3.6}$$

The factors affecting on the money cost price are two forms of direct and indirect. Investment profit is, for example, a direct factor; and office expenses, employees; salary, possessions depreciation are among indirect factors which are effective on price of money in banks.

4. Analysis and Illustrative Results

In this paper, the features of financial group network are its default contagion and risk. In addition, FGRMS software version 1.1 software has been developed to calculate the presented indexes and give a broader perspective on business to the executives of the main node of th holdings in order to be able to make better decisions.

The results are approved in all the windows of the software by testing databases [13].

Data collected in 2018 from a financial group that includes 12 companies of an international financial holding. The new model and algorithm calculates their percentage for every entered data of the companies including the investments made by the main node of the holding and the profit paid by the company; then the graph related to relationship network of the financial group are presented and illustrated. Therefore, the profit paid and investments are calculated as follows and the table of FGRM software version 1.1 will be filled out like figure 2.

$$Profit\ \ Paid(\%) = \frac{P_i}{\sum_{i=1}^{n} P_i} \times 100 \tag{4.1}$$

and

$$Investment(\%) = \frac{I_i}{\sum_{i=1}^{n} I_i} \times 100 \tag{4.2}$$

Financial Group Risk Management Software

Rows	Company Name	Profit Paid	Investment	Profit Paid (%)	Investment(%)
1	company A	3296700000	4509340000000	0.37	46.48
2	company B	14355000000	1749000000000	1.59	18.03
3	company C	88440000000	368500000000	9.80	3.80
4	company D	10230000000	45540000000	1.13	0.47
5	company E	13475000000	37730000000	1.49	0.39
6	company F	23760000000	31806720000	2.63	0.33
7	company G	19800000000	66000000000	2.19	0.68
8	company H	181840517210	1820937561943	20.16	18.77
9	company I	337571865400	764513279476.1	37.42	7.88
10	company J	107800000000	108877992300	11.95	1.12
11	company K	61600000000	61600000000	6.83	0.63
12	company L	39916800000	138600000000	4.42	1.43

Figure 2: Financial Group Data in the FGRM Software

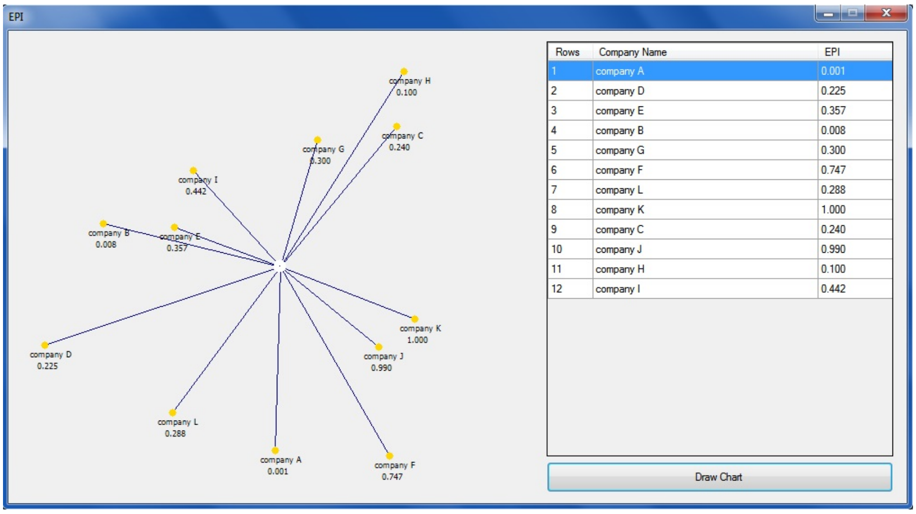

Figure 3: EPI and its network

The profit in this calculation means the bank's total revenue out of the member company of the financial group and it does not mean *EPS* or *DPS*. Furthermore, investment means the total capital the main node of the holding are allocated to the member company of the financial group.

EPI Benchmark Calculation

Figure 3 shows a window of the FGRM software that it is related to the calculation of *EPI* and drawing its graph. The graph seen in this figure is related to the *EPI* network of the group and the weight of each edge is the same *EPI* and it shows the index each company associates the main node of the holding with.

NEPI Benchmark Calculation

We already know that money has different cost at different banks; so, *NEPI* is a benchmark which calculates the net profit per investment unit, since it subtracts the money actual cost from the profit made by each unit of investment. Therefore, before this benchmark is calculated. In figure 4, the results of companies *NEPI* using $moneyprice = 18\%$ is depicted. As can be seen, the results are arranged in descending order

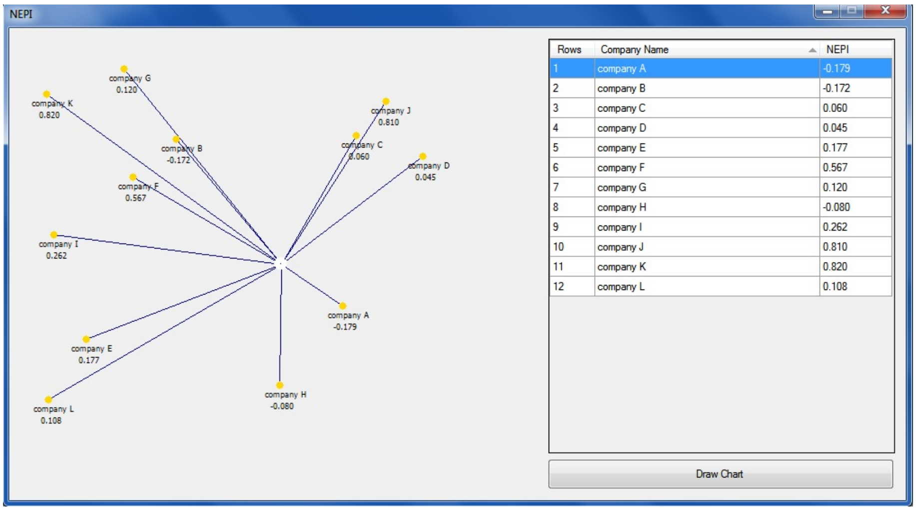

Figure 4: NEPI and its network

and some companies net profit is negative and most of the companies have a net income even less than 18% which indicates that their net profit making is even less than the actual cost of money in the main node of the holding. The graph related to the companies $NEPI$ communication with the center is as follows.

RI Benchmark Calculation

It is natural that in any of the member companies of the group, based on their activity field, there are certain risks. Due to the interconnected structure of the financial group, it is obvious that the main node of the holding opens the path of risk transfer to itself when it makes investments in a company. Here the risk index is calculated for each company to show how much risk each company imposes on the main node of the holding and finally how much is the total risk a main node of the holding accepts. First, we need to identify the risk factors of each company and specify the value and weight for each factor. The identification and weighting of risk factors is done by the executers of the companies and the main node of the holding using a questionnaire. In the information collected, the risk factors of each company are specified; however, we avoid mentioning the exactly here and we use the symbol RF_i.

As observed in figure 5, 10 risk factors are identified for one of the companies and a weight and value is assigned to each and the software shows the index 11.57 for it.

Rows	Company Name	Profit Paid	Risk Index	Risk Index (%)
1	company A	3296700000	11.57	4.52
2	company B	14355000000	10.87	4.24
3	company C	88440000000	13.87	5.41
4	company D	10230000000	36.67	14.32
5	company E	13475000000	20.71	8.08
6	company F	23760000000	30.6	11.95
7	company G	19800000000	20.8	8.12
8	company H	181840517210	36.25	14.15
9	company I	337571865400	30.59	11.94
10	company J	107800000000	16.85	6.58
11	company K	61600000000	13.33	5.20
12	company L	39916800000	14.05	5.48
sum :		902085882610	256.16	100.00

Figure 6: Risk index table of each company and their percentages in FGRM software.

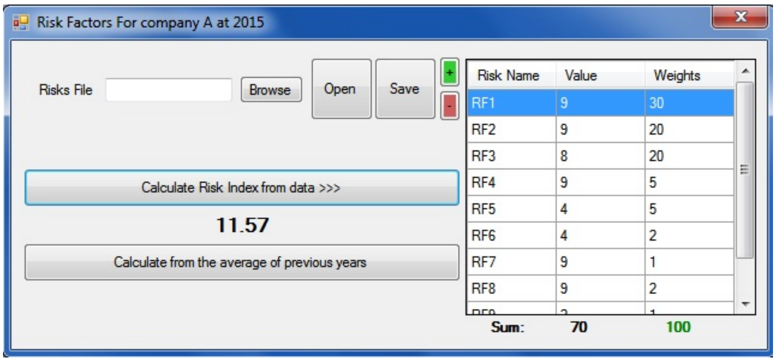

Figure 5: The data entry table of risk factors and calculation of risk index RI. in FGRM software

Likewise, RI will be calculated for all companies and the results can be seen in the figure 6. This table can be arranged sorting and the results are arranged in ascending order.

Now, the companies that impose the highest risk on the main node of the holding can be identified. Even for sake of better calculation, the percentage of each index is calculated. As can be seen, the companies in the rows 4 and 8 show $RI = 36$ and each includes about 14% of the total risk imposed on the center while the companies in the rows 1 and 2 show the lowest RI and each includes almost 4% of the total risk spread to the main node of the holding.

Now, in the graph which shows the relations of the financial group network, 3 types of relationship are developed between each company and the main node of the holding. The relationships which are marked red show the investments that are made by the main node of the holding and the weight assigned to these sides shows the company share of the total investments made by the main node of the holding. The relationships which are marked green show the profit that is paid by the companies and the weight assigned to these sides shows the company share of the total profit made for the main node of the holding, and the blue edges indicate the amount of risk which is spread to the main node of the holding from the companies. The allocated weight to these edges is equal to the percentage of the companys share out of the total transferred risk to the center.

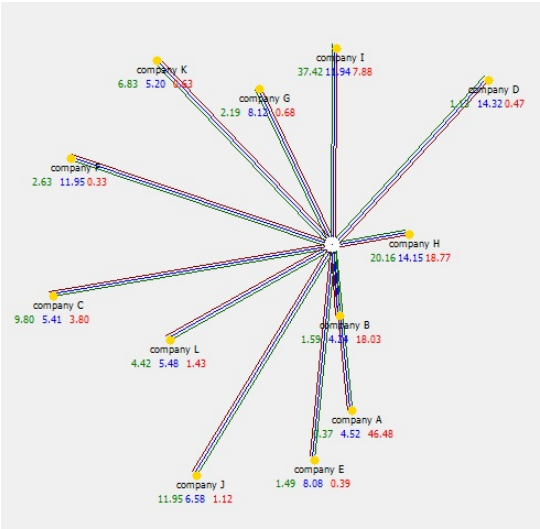

Figure 7: Risk network of a sample financial group in FGRM software

In figure 7, the companies risk index, along with the amount of capital attracted and the interest paid are placed beside each other. In order to be able to compare the outcome of the companies more efficiently bar graphs were drawn so that we have a better visual understanding.

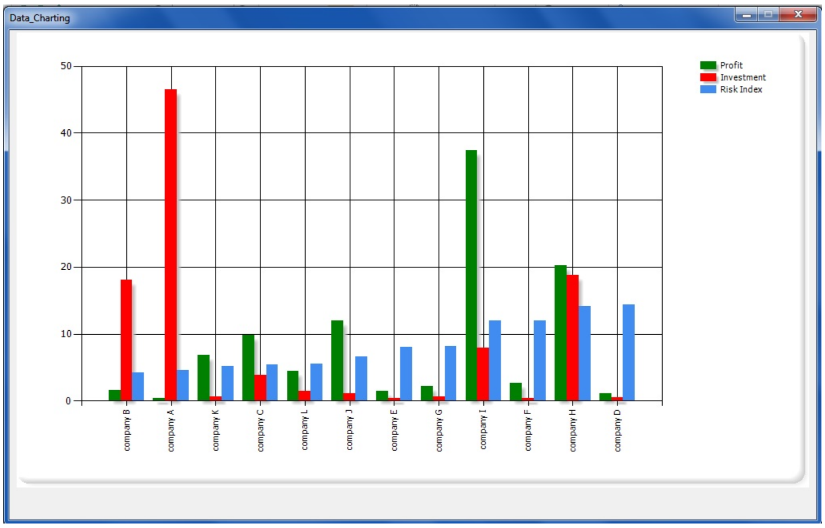

Figure 8: Bar chart of financial group companies performance.

5. Optimized Investment Decision

Summing up the results obtained using the introduced indexes, an optimal decision can be suggested for investments and loans offered. It is obvious that this decision making should be based on the criteria profit companies make for each unit of investment, the total risk index sent to the counter party, the percentage of the attracted investment and the percentage of the interest paid by the companies. According to the following table, the best decision related to investing can be made if it is in the companies seen in the rows 1,2 and 3 respectively and the companies whose *EPI* is higher than their money price.

Suggested Optimized Decision

Money Price 18 %

Rows	Company Name	EPI	Profit Paid (%)	Investment(%)	RI (%)
1	company K	1.0000	6.8286	0.6349	5.2038
2	company J	0.9901	11.9501	1.1222	6.5779
3	company F	0.7470	2.6339	0.3278	11.9457
4	company I	0.4416	37.4213	7.8796	11.9418
5	company E	0.3571	1.4938	0.3889	8.0848
6	company G	0.3000	2.1949	0.6802	8.1199
7	company L	0.2880	4.4249	1.4285	5.4849
8	company C	0.2400	9.8039	3.7980	5.4146
9	company D	0.2246	1.1340	0.4694	14.3153
10	company H	0.0999	20.1578	18.7678	14.1513
11	company B	0.0082	1.5913	18.0264	4.2434
12	company A	0.0007	0.3655	46.4763	4.5167

Figure 9: Optimal decision table of investment

6. Conclusion

We investigated interdonected financial group network with new methodological indexes. Also, the relationship within companies and their relationships with the main node of the holding were studied. According to the research aims to determine the impact of a company defaulting on its other counter party companies, the *DI* was introduced. In addition, to determine the effect of risk of a company on other counter party companies and on the main node of the holding, the *RI* benchmark was designed and presented. This benchmark helps the executives in main node of the holdings make more informed decisions on companies regarding investment and load offering. This entails identifying the risk factor of each company. Additionally, *EPI* and *NEPI* were designed to help the executers have a more detailed view regarding the performance of companies considering the capital they have attracted.

For the first time, a graphical visualization for data and financial group network has been presented. The software was developed using the criteria presented and using the available data, which were limited because of the confidentiality of the information, the performance of the main node of the holding was investigated. Applying the numerical results and the tables obtained in the years 2015, 2016 and 2017 we draw the conclusion that the main node of the holding is unprofitable.

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