”Enterprise Theory and Practice” Doctoral School
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Faculty of Economics

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Analysis of the Hungarian clearing system’s operation in the light of the settlement modernization

Thesis statements of the dissertation

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CONTENTS

1. Justification of the topic

Interbank clearing is one of the most important server systems of the economy, major element of every countries' – having two-trier banking system – financial infrastructure. The clearing between the participants comes from the business operations, processes. Analysing it can demonstrate the "circulation" of the economy.

Hungary, thanks to continous development in the past 20 years and the main milestones in the recent past, performs well in this area, corresponding to the expectations of the European Union.

Knowing the clearing system may help to examine the economic processes enabling the planning of the turnover or other infrastructure. Beyond the reach and maintenance of the desirable banking service for clients the clearing system may provide useful information for the macroeconomic forecasts.

I have been dealing with the financial aspects of the European integration since I have started my doctoral studies. Earlier I made examinations concerning the eurozone, and I used the results in conference precentations and publications as well as in the education. During the 5-year education I took part in educating European financial markets and EU policies, I currently educate International finances and International financial management for BSc full-time and part-time students. These two courses' curriculum is related to the field of my researches.

A few years ago I started to show interest in the European payment systems, and the next step was the analysis of the Hungarian clearing systems. It was complemented with my interest in the networks and the opportunities of their analysis. At the beginning I was working on the network theory independently of my economic researches therefore the books I have read were related to other disciplines (physics, mathematics). Later I realised, that the network theory can be a relevant tool of examining the interbank turnover, thus this methodology appears in my dissertation – as well as other mathematical statistical analysis.

The subject of my research is the Hungarian interbank clearing system (BKR), that is, during my analyses I examined the different types of internal transactions of the Hungarian credit institutions. Hereby the segment in the payment system was determined as well as the geographical framework, which is Hungary (though in some cases I also use other European countries' data).

Figure 1: **Time horizon of the research**
Source: author's own work

The period of the automated clearing means the time horizon of the research. The more extended time horizon of the research includes the whole years of the automated clearing, that is, between 1st January 1995 and 31st December 2012. In a narrow sense the interval is between 1st January 2004 and 31st December 2012. (Figure 1)

2. Research objective and methodology

The main aim of my researches is to examine the development of the interbank clearing system by analysing the payment system. In order to achieve this goal I aspired to learn the characteristics of the Hungarian clearing turnover and to explore the global and local characteristics of the network between settlements.

Before and during the dissertation the following major research problems were identified:

1) Which factors affect the most the turnover of the GIRO? What are the reasons for recessions and stagnation? What can be concluded from these tendencies concerning the economic conditions?
2) How do the single clearing events (e.g. payment of wages, pension payments, payment of taxes etc.) influence the seasonality of the interbank clearing?
3) What are the characteristics of the transaction's weekly distribution? Can we say that clients don't prefer to submit payment orders on the last day of the week?
4) What kinds of factors affect the intraday settlement of the interbank clearing transactions? What are the main effects of the realisation of InterGIRO2 project?
5) What kind of network do the bank relations between settlements define? What are the main characteristics of the network?
6) How can the role of the network nodes be quantified? What kind of role does the capital city have in the clearing network?

7) What kind of relationship exists between the network characteristics of the clearing system and the geographical aspects of the clearings?

In order to solve the research problems I divided the dissertation into three larger sections:

- **Formation and antecedents of the Hungarian clearing system**

  - Historical overview: presenting the Hungarian payment system through the formation and development of the clearing services in Hungary (Chapter 3)

  - The greatest milestone of the Hungarian automated clearing system's development is the recently introduced intraday clearing. The detailed presentation of the InterGIRO2 project helps to understand the current operation of the interbank clearing. (Chapter 4)

- **Examining the temporal distribution of the turnover:** During the analysis the different transaction types, the order submitting habits of the credit institution clients and the government's role in the temporal concentration of the BKR items are being presented. (Chapter 5)

- **Network analysis of the clearing turnover:** The clearing system is being presented from a different point of view, by analysing the clearing transactions between Hungarian settlements with network theory methods. This way we can learn more about the topology of the system and the payment role of the settlements.(Chapter 6)

- The necessary databases for the analyses are set-up according to the information from the European Central Bank, European Payments Council, European Banking Federation, Central Statistical Office, Hungarian SEPA Association and the data services of the GIRO Zrt and Hungarian Central Bank.
- In order to solve the research questions mathematical statistical and network theory analysis methods were applied. The related theories, definitions and the methods used during the examination are presented partly in Chapter 2 and in the following chapters, parallel to my analyses.
- For setting up the hypothesis I used scientific basis as well as the practical experience of the banking sector.
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3. Research hypotheses

- In line with the questions previously set, the following hypotheses were formulated (Table 1).

- Table 1: **Research hypotheses**

Hypotheses		Testing methods, procedures
H1	The uneven temporal distribution of the interbank clearing system is mainly because of the treasury items.	Examination of seasonal variations based on specific indicators. Creating „calendar-map" data visualizations showing the clearing turnover.
H2	The clients of the credit institutions in the system that doesn't use intraday settlement usually attempt to avoid transactions on the banking day before bank holidays. This phenomenon does not occur or occurs less in the intraday settlement system.	Analysis of variance (Two Sample t-Test and testing the conditions).
H3	The network of the Hungarian interbank transactions between settlements is a complex, dynamic system which creates a complete, scale-free graph.	Degree distribution, (power function) fit testing.
H4	In the Hungarian interbank clearing system Budapest predominates. The capital is an outstanding key element of the whole turnover system. Removing this element from the graph may cause the loss of the network's complexity and its decomposition into components.	Calculation of the general network indicators, motif statistics, clique identification
H5	Learning the characteristics of the interbank clearing graph's nodes may reveal new, relevant information about the role of the settlement in its network and geographical environment and in the national clearing system. An indicator from the network theory's toolbar can be used to characterize the positions of the settlements in the clearing graph.	Quantification of central indicators, setting up rankings (network nodes).
H6	The operation of the clearing system does not fit into the territorial administration's county and region rankings.	Examining the modularity, clustering based on the Clauset-Newman-Moore algorithm.

- *Source: author's own work*

4. New findings of the research

The change in annual turnover of the clearing transactions was easily recognised from the databases (Figure 3). However, during my researches I also payed much attention to the characteristics and seasonality of the clearing within a calendar year.

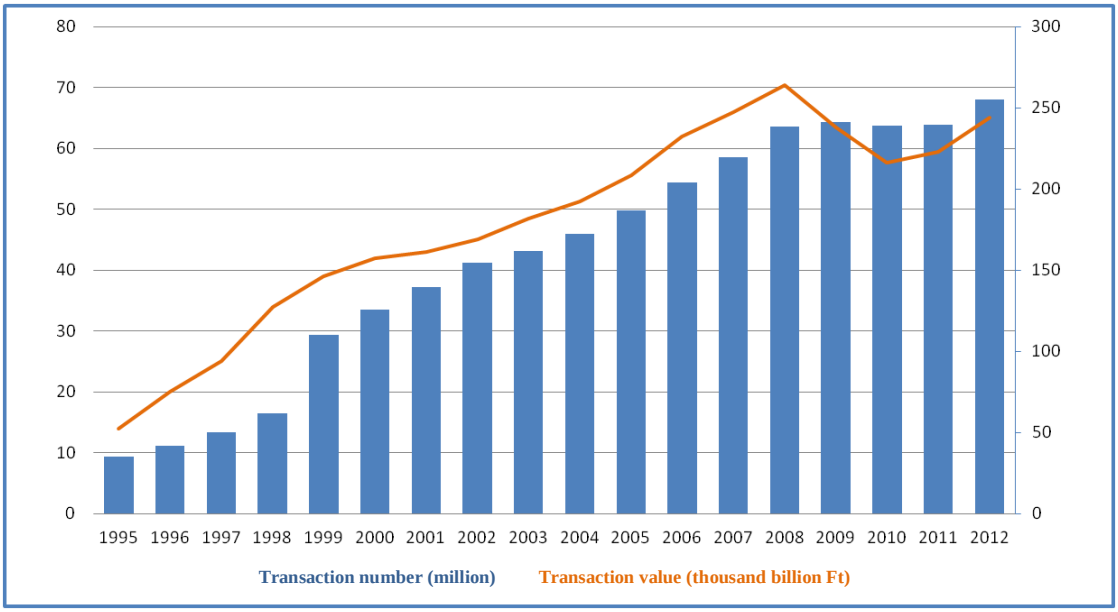


Figure 3: **Trends of the clearing transaction turnover (1995-2012)**
Source: author's own work based on GIRO Zrt. data

For testing the first hyposthesis (H1) it was expedient to examine the behaviour of each transaction by types. During the analyses my objective was a parametrization for showing the node days of the interbank clearing system by traffic – the darker cells stand for them. The effect of the bank holidays is eliminated by taking the averages of the days from the examined 9 years. Thus the only days we don't have data are the fixed national and religious holidays, like 15th March, 20th August, 23rd October and Christmas (since these days were never banking days during the examined period).

Figures demonstrating the clearing data of the years' transaction types are included in the dissertation and its second annex. Figure 4 shows all of the transactions in one visualisation.

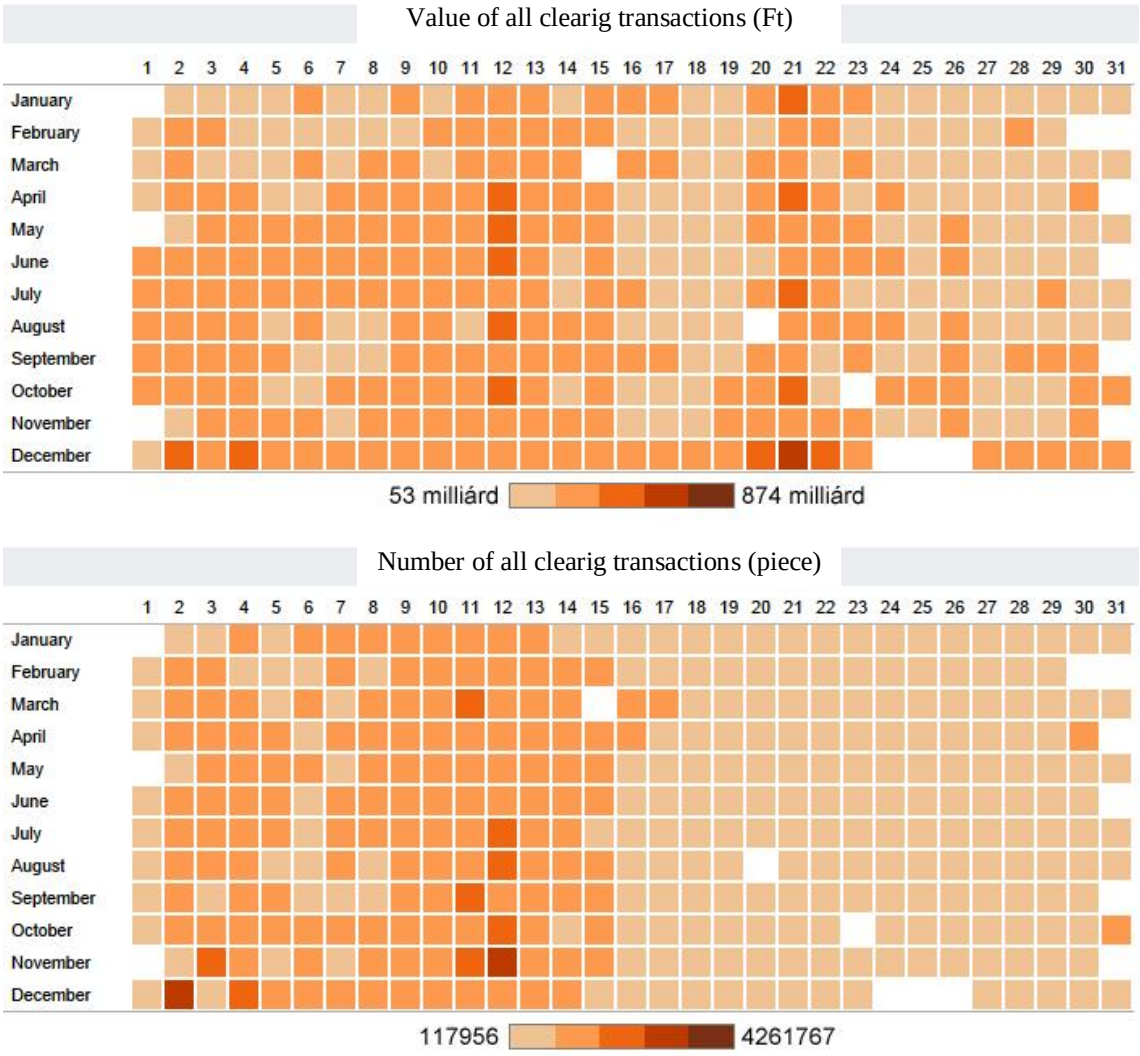


Figure 4: **Distribution of every interbank transaction on calendar days**
(átlagos daily awerage number and volume of transactions, in 2004-2012)
Source: author's own work based on GIRO Zrt. data using Tableau 8.0 software

The individual transfer is the most frequently used payment method thus mainly its effect predominated in the analysis of the transactions.

The impact of the taxing deadlines in the case of individual transfers is significant. Group transactions include the payment of pensions (deadline: the 12th day of the month) and the payment of wages by the larger companies and institutions (on the first 10 days of the month). The group collecting stands for the retail clients' payments (fees of utility and other services). Debiting the client account of the client is concentrated on the period after the payment of wages, to the middle of the month. Thesis 1 (T1) was formulated based on these results.

T1: **The outstanding turnover periods of the interbank clearing system can be explained by the high temporal concentration of treasury related transactions. Aware of the taxing deadlines, payment habits and bank calendar the turnover peak days can be predicted. That makes the planning of the clearing infrastructure more efficient.**

The next step of the temporal analysis of transactions is to examine the numbers and values of the transactions on each day of the weeks. For the analysis I chose individual transfer transaction type, because of the payment anomalies that were learnt previously. Since examining this type makes the – external force-free - preferences of the clients to understand easier.

In the examined period between 1st January 2004 and 1st July 2012 transactions were accounted on the very next banking day of the order. Between 2nd July 2012 and 31st December 2012 the vast majority of the transactions were realised in the intraday clearing system. The first step to compare the two periods was the examination of transactions' distribution between the days of a week (Figure 5).

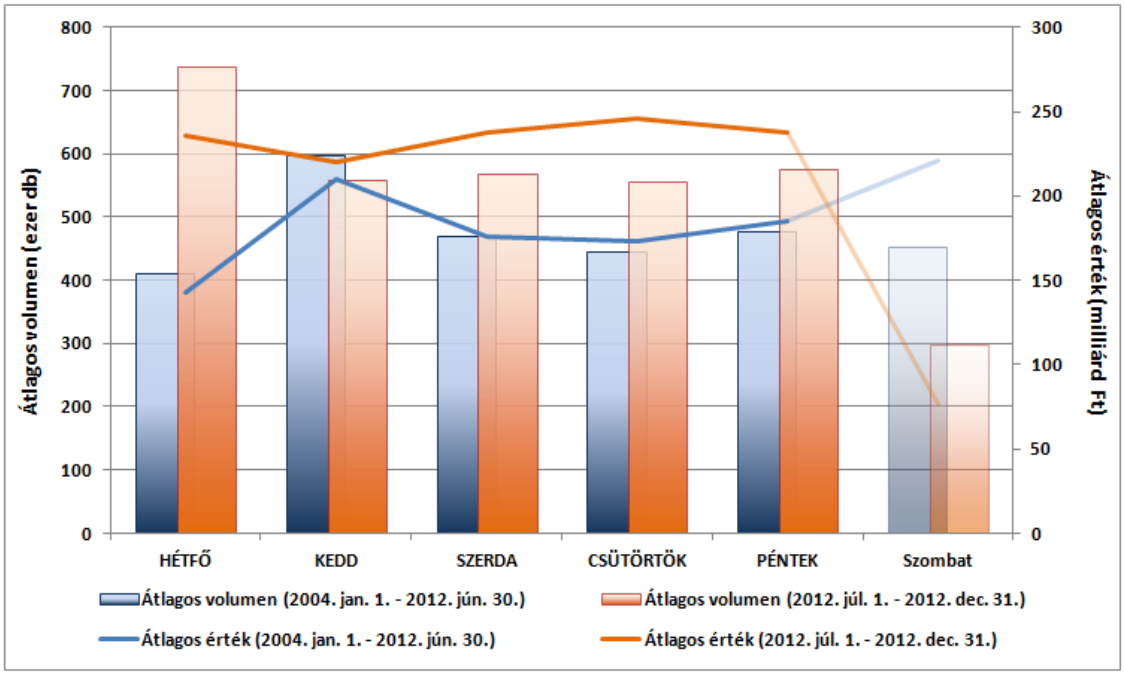


Figure 5: **Daily awerage number and volume of the BKR transactions**
Source: author's own work based on GIRO Zrt. data

The conclusions drawn from the figure proved the H2 hypothesis. However, comparing Fridays and Mondays is not sufficient comparison of the banking days before and after bank holidays has become necessary. It means the examination of the data on the day before bank holiday (BE), the first day after bank holiday (BU1) and the second day after bank holiday (BU2). The analysis made from the period of the intraday clearing system (second half-year of 2012) and the same period of the previous year (second half-year of 2011).

For comparing the simple transfer data before bank holidays and after bank holidays I applied the Two Sample t-Test. The t-Test's result revealed that there's no significant difference (sig=0,090) between the BE and BU1 days' average of the simple transfer value in the second half-year of 2012. Analysing the volume of the individual transfers the t-Test shows significant deviation (sig = 0,003) between the mean values of BE and BU1 days.

In the case of the examination for the same period of the year 2011 the results of the t-Test show that there's a significant difference between the averages of the BU1 and BU2 days' transfer values on the second part of 2011.

Based on the results of the calculations the following thesis (T2a, T2b) were formulated.

T2a: **In the InterGIRO1 clearing system the clients – due to the lost interest as a result of the increased lead-time – used to avoid transactions on the banking days before bank holidays.**

T2b: **The introduction of the intraday clearing system made the weekly distribution of the transactions more consistent. The main reason of this tendency is the rational reaction of the business clients.**

In Chapter 5 the monthly seasonal deviations of the clearing and the distribution of the bank transactions are being examined before and after the introduction of the intraday settlement.

In the following the examination of the interbank clearing is accomplished with network theory methods (Chapter 6). In the examined two months (September and October 2008) the clearing house – an average of one month – transacted more than 22 million transactions in the value of around 6000 billion. The distribution of this turnover according to the geographical "attachment" can be seen on Figure 6.

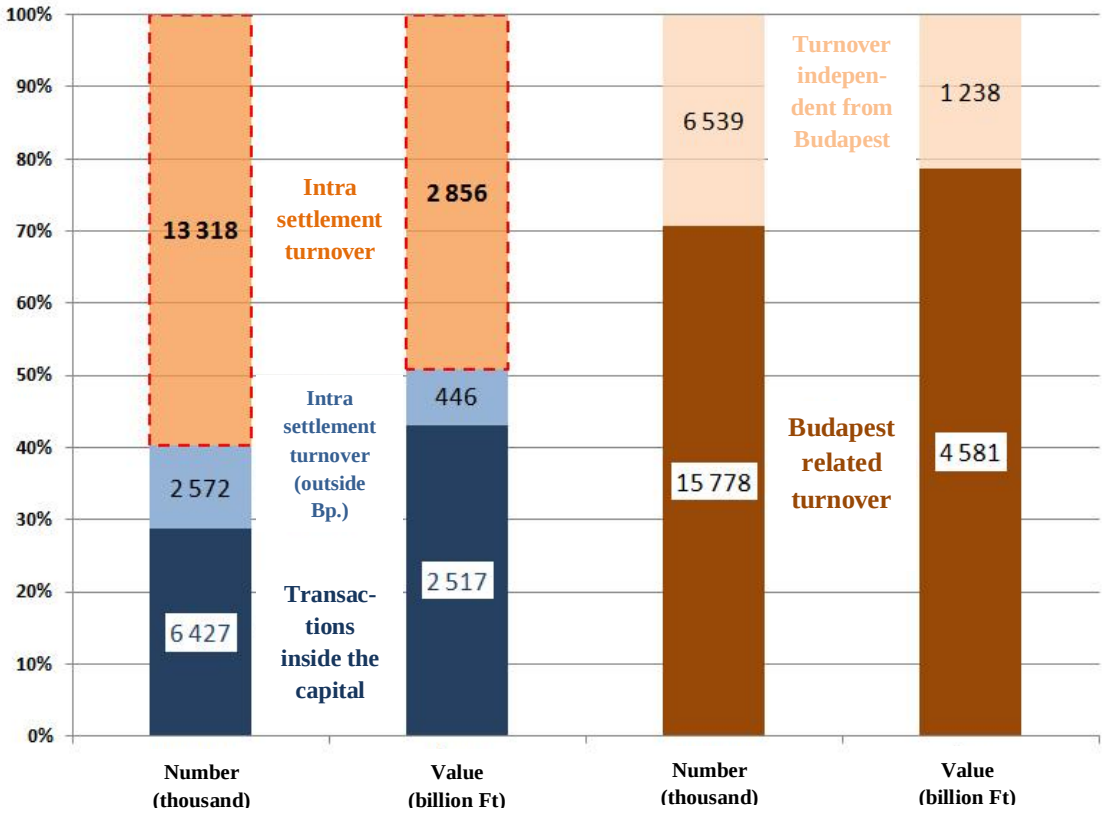


Figure 6: **Geographic distribution of the interbank clearing transaction turnover**
Source: author's own work

For testing the H3 hypothesis it must be examined whether the clearing graph between the settlements can be considered as a random or scale-free network. First I had to determine if the degree distribution of the graph's nodes can be described with a power function. I carried out calculations for the probability of the clearing network's settlements for particular degrees. These probabilities can be seen on the following chart (Figure 7).

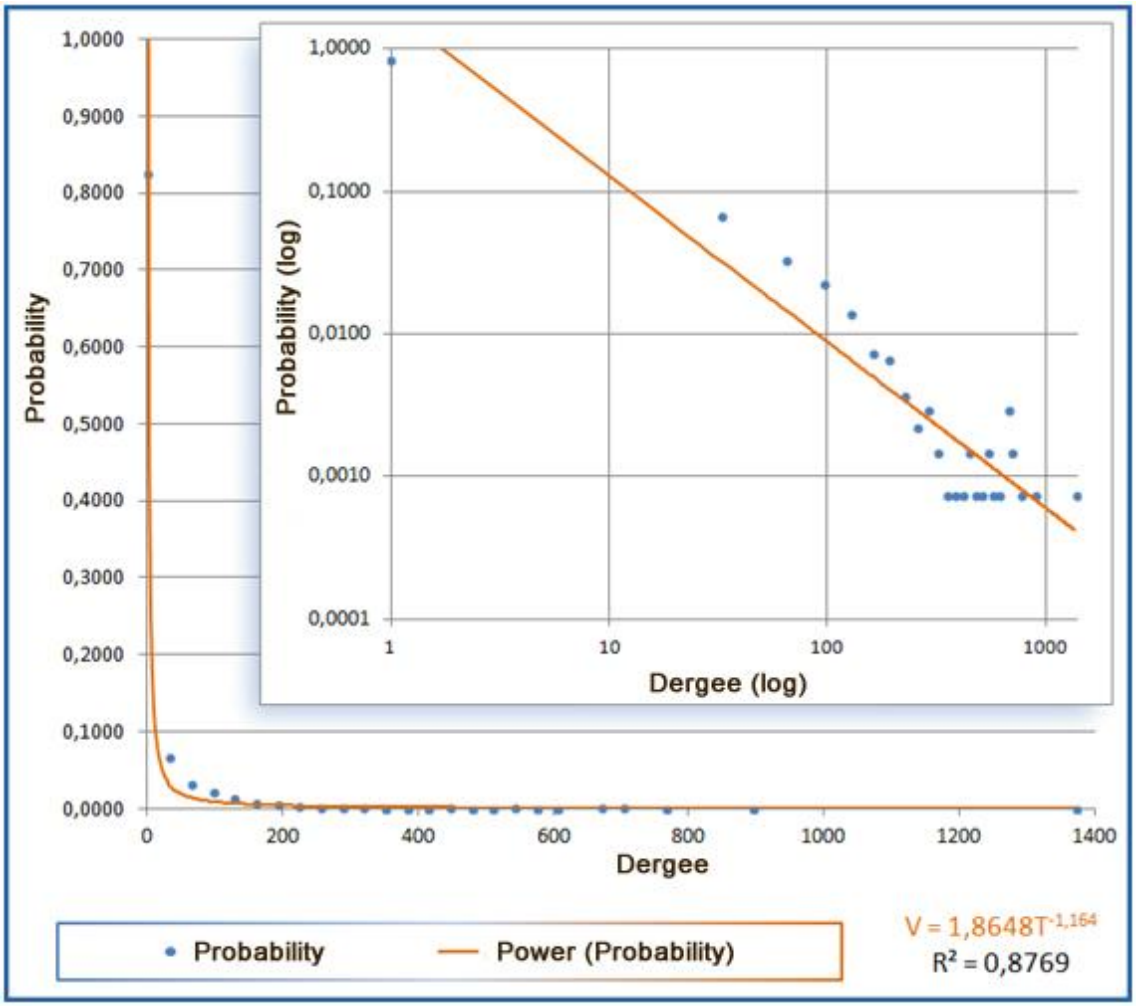


Figure 7: **Fitting the power function to the degree distribution**
Source: *author's own work*

The result of the examination was that the function

fits to the values of the degree probability of the clearing network's settlements with 87,69% accuracy. Therefore the degree distribution of the network's settlements can be described by a power function with 88% accuracy.

Analysing the database with the software showed that the network is single component and dynamic, thus the following thesis was formulated:

T3: **The interbank clearing transactions of the clients maintaining their accounts in Hungary create a complex, dynamic network. This payments graph – partly due to the high degree of Budapest – is a complete, single component, scale-free network.**

Because of the H4 hypothesis it was reasonable to analyse the network's other characteristics as well as the existence of the small world feature. In addition, further analyses, focused on the nodes (clique identification, cluster analysis) were accomplished for the network. For examining the position of Budapest and the other

settlements I attempt to choose a network indicator that is capable to demonstrate the financial centrality of the settlements (H5 hypothesis).

Most commonly in the network theory the roles of the nodes in the graph is demonstrated by using the centrality indicators. In the Chapter 6 (6.5.1) of the dissertation the most important centrality indicators are defined (Figure 8). The indicators are being quantified for the examined network and the 25 best performed settlements according to the given indicator are shown in a table.

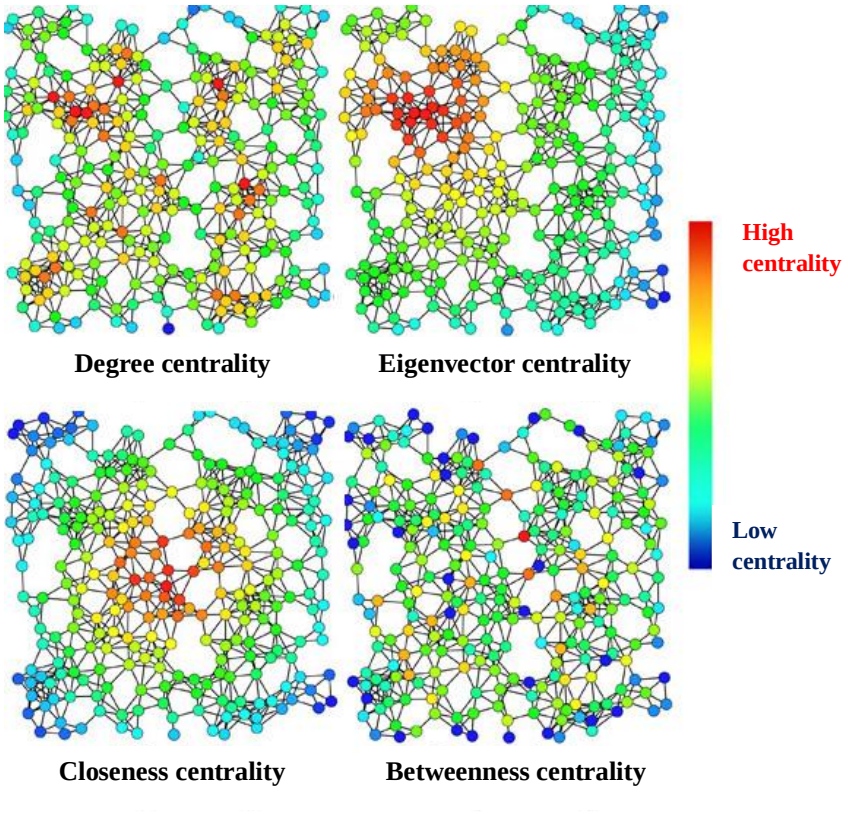


Figure 8: **Meaning of the different centrality indicators**
Source: *author's own work using Claudio Rocchini's network-visualization*

During the examinations I have come to the conclusion that the eigenvector centrality can be used to indicate a settlement's clearing activity.

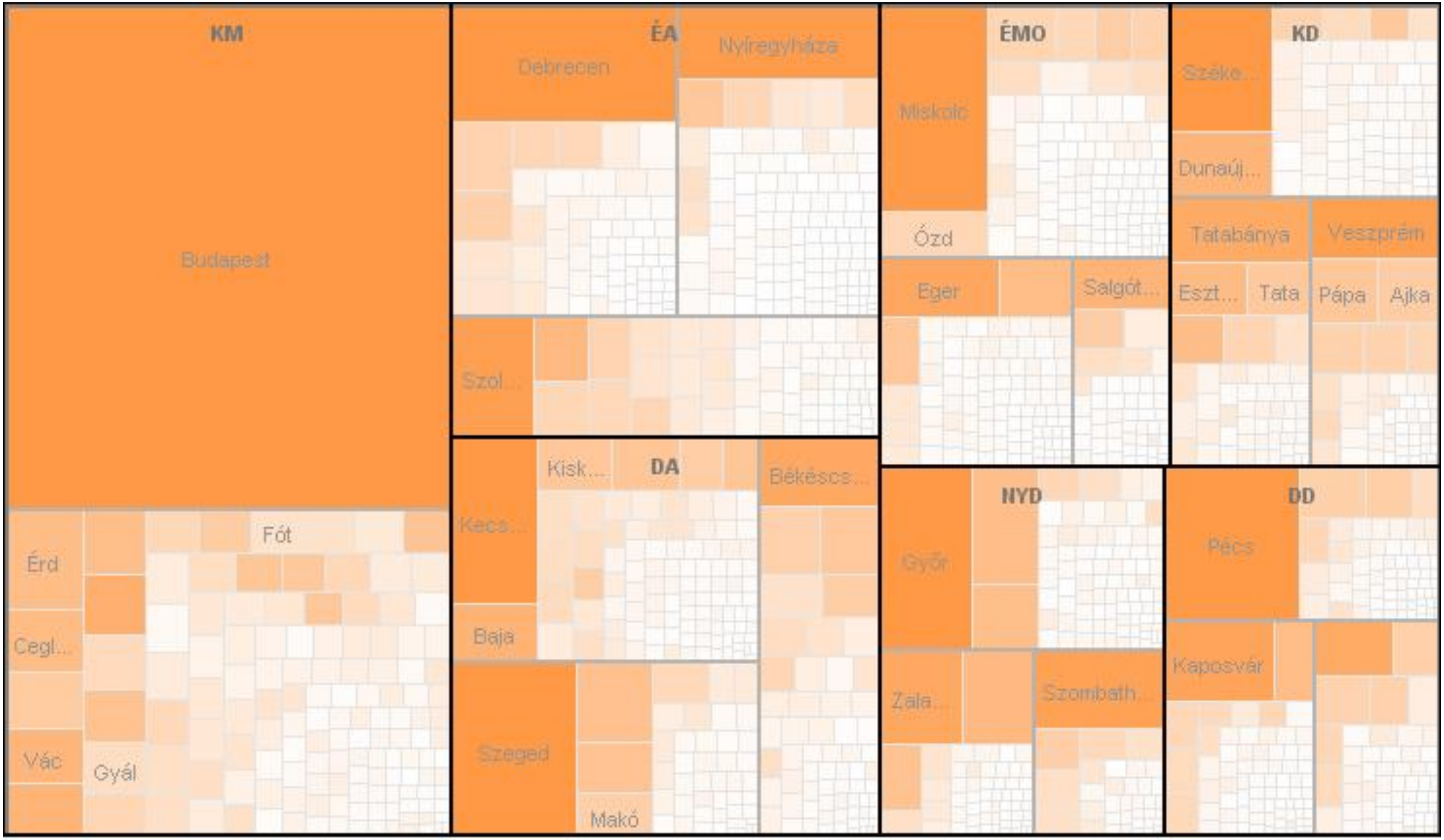
The following treemap shows the settlement's payment centrality (based on the eigenvector centrality) compared to the settlement's population (Figure 9).

Figure 9 (next page): **Financial centrality and population of the settlements in the network**

Source: author's own work using IBM Many Eyes

Abbreviations of the regions:

KM: Central Hungary
ÉA: Northern Great Plain
ÉMO: Northern Hungary
KD: Central Transdanubia
DA: Southern Great Plain
NYD: Western Transdanubia
DD: Southern Transdanubia



Size: **Population**

Color: **Eigenvector centrality** **< 0,000124** **0,005809 +**

To test the indispensability of the capital in the binary network topology I removed Budapest as a network node and I observed the change of the graph. The same was done with the cities of the previously identified 55-clique. (The clique-identification revealed that there are 55 Hungarian settlements that are related to each other regarding to the clearing. This settlement group – included Budapest – considered as a significantly determinant of the network's topology.)

According to the software analyses removing the settlements of the subgaph does not cause the fragmentation of the network. The intra-group transactions of the 55-clique's settlements form a bridge between the certain clusterings of the network. Therefore the H4 hypothesis is only partly proved.

The research experiences were summarised in Thesis 4 and 5 (T4a, T4b and T5).

T4a: **The structure of the Hungarian clearing network is dominated by a group with 55 cities in between there is cash flow to all of the possible directions that creates a complete subgraph.**

T4b: **Budapest is a dominant junction of the binary clearing network but its role in the network is not extremal. Mainly due to the scale-free characteristics and the small-world graph the network outlasts the theoretical cessation of the nude without changes in its topology and complexity.**

T5: **The eigenvector centrality is a network index, which can be used to indicate a settlement and its economic environment's role in the cash flow system.**

At the end of Chapter 6 the testing of the hypothesis 6 (H6) is accomplished. For the testing a modularity index is required that is related to the topology of the network. Modularity demonstrates the quality of the clustering.

The assumption from the hypothesis is confirmed by the low modularity in the case of the counties and regions:

- Modularity of the counties : 0,0977;
- Modularity of the regions: 0,1423

Cluster algorithm was used to determine clusters of the graph's nodes where the modularity is the highest. The clustering is based on the Clauset-Newman-Moore algorithm. The locations of the created groups can be seen on Figure 10.

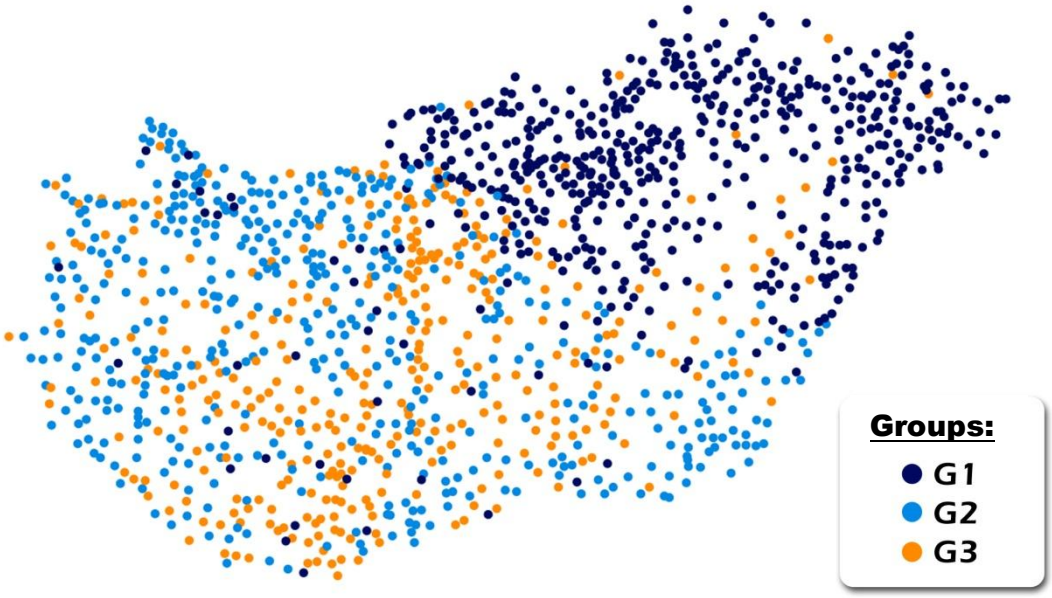


Figure 10: **Geographical location of the settlement groups based on** C**lauset-Newman-Moore algorithm**
Source: author's own work using NodeXL software

Clustering using the algorithm created three clusters according to which the modularity value is 0,2778. Comparing this value with the ones in case of the counties or regions it demonstrates significantly better quality of clustering. The defined units – in particular cluster G2 and G3 – are overlapped with each other with regard to spatial expansion. According to the figure in this case of clustering there aren't separations concerning the counties and regions. The conclusion is that the network topology of the turnover (and the economy) does not fit to the spatial administrative units.

Thesis 6 (T6) gives a short summary of the findings of clustering network analysis.

T6: **In Hungary the interbank clearing between settlements isn't carried out according to regional statistical or administrative units.**

In a lot of cases the attempts of the graph's representation also proved the results in the dissertation. However the high density, intense clustering, the 55-clique and the huge size of the network make the spectacular visualisation of the whole graph nearly impossible. The following network visualisation (Figure 11) is an example for the representation of a part of the graph which shows the most important turnover relations of each settlement. The outgoing arrow demonstrates the settlement's largest amount of outflowing cash and points to the receiving settlement. The capital is not included in the analysis.

Additional remarks to Figure 11:

- the size of the circles (nodes) and the size of the settlement (on the basis of the population) are proportional (shows only the settlements with more than 10000 inhabitants)
- the thickness of arrows (edges) is proportional to the transaction value (Ft)
- the colour of the circles demonstrates the counties
- the county seats are demonstrated by a blank circle
- the locations of the county seats are more or less right but the other settlements' locations may differ from the reality

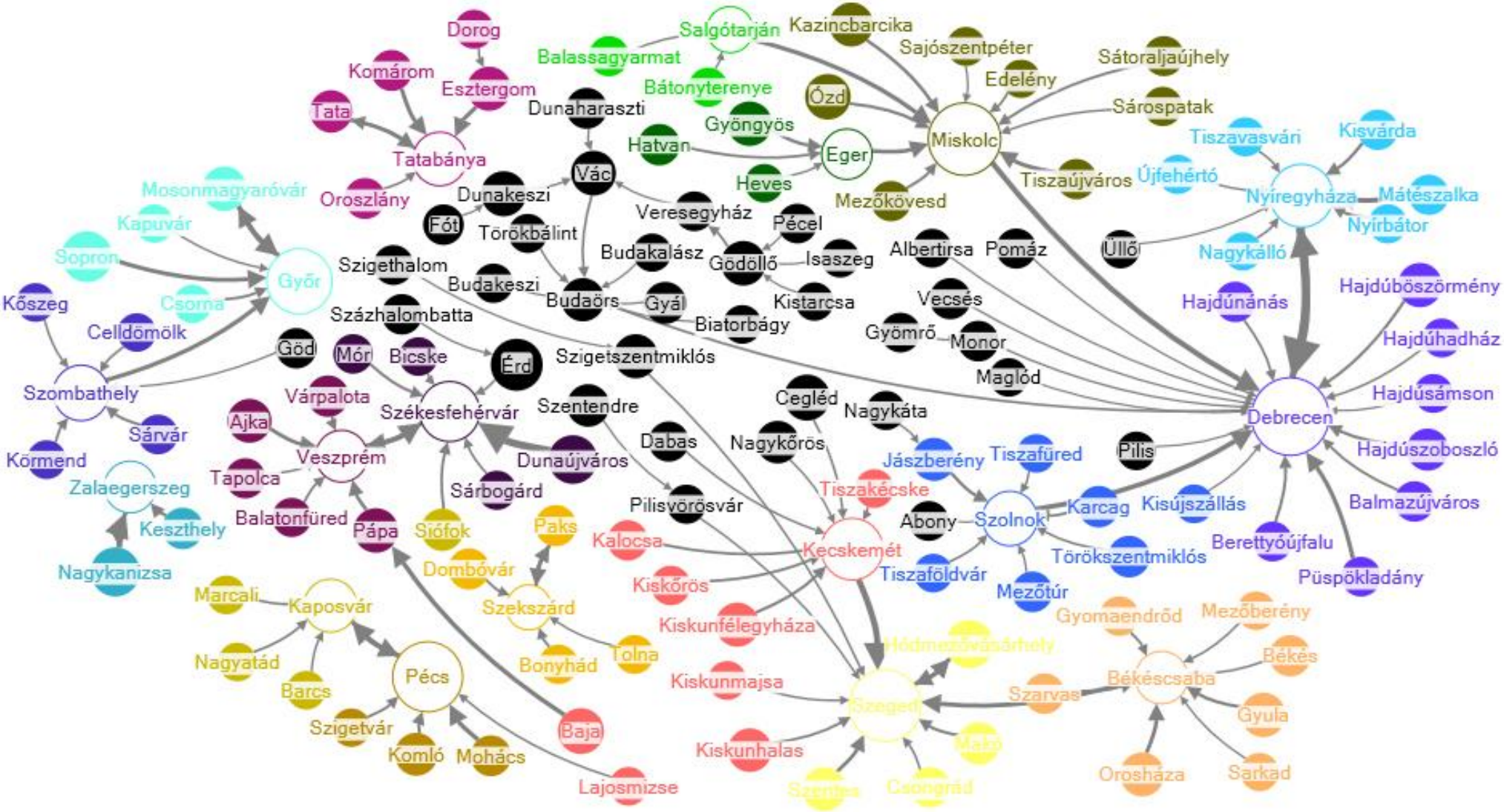


Figure 11: **The most important partners of the settlements**
Source: author's own work using NodeXL software

5. Summary evaluation

In the beginning of my researches the main goal was to find answers for the major questions concerning the operation and development of the Hungarian interbank clearing system and to learn the characteristics of the clearing turnover and the payment habits of the Hungarian bank clients. 6 hypotheses were formulated from the research problems, which problems were identified during the initial phase of my work and came up during the process.

The historical background of the current Hungarian clearing system is included in the dissertation's Chapter 3, demonstrating the institutions, participants and characteristics of the national payment systems. It was the base of the next Chapter, which includes the detailed review of the intraday clearing system what was introduced in the recent past.

After forming the theoretical background I examined my hypotheses. This process appears in the fifth and sixth chapter of the dissertation. I formulated my research theses based on the analysis of the temporal and network distribution of the clearing turnover. I hope these will mean significant and practicable outcomes for the players of bank sector and for other decision makers in the economy.

The past fifteen years have been decisive in the history of clearing services in Hungary, in the emergence and development of automatic clearing. The most remarkable development was the introduction of the intra day clearing and the SEPA standards.

We obtained most of the statistical data (e.g. KSH) related to the economy with a delay of several months. The clearinghouse's data concerning the transactions are partically immediately available, so the analyses – that are not only based on single data services - made from them would place the GIRO in an important economic forecasting position.

The following research plans are, at the same time, my suggestions for the examined areas.

6. Further research directions

Additional questions and problems formulated during my work mark out several new potential research directions:

- In order to keep track of the conformity of clients the effect of the intraday clearing system should be examined again in possession of new data.
- The new (SEPA) standard provides an opportunity to structured data transmission, more detailed than the transactions. The demand on this service by the companies should be assessed.
- I am planning to conduct network analyses in the case if international transactions. (e.g. CLS system)
- I would like to examine the national clearing system in such a way that instead of the settlements the bank branches are considered to be the nodes. This examination would demonstrate competitive position of the clearing participants and would help to explore the economic prossesses within the settlements.

- The network analyses focusing on geographical units or transaction types may provide a solution to local economic problems. GIS supported spatial analyses may complement the network theory's toolbar during these examinations.

In addition, I consider it important to note that the publication of my research results – primarily in English – is among my short-term plans.

It would be reasonable to publish a book which demonstrates the national payment systems and their international relations, because of the lack of research on clearing turnover, and thereby the lack of Hungarian literature in the topic. Publishing a book would be a great help in educating some part of the topic.

In the case of some of the intended researches we may face difficulties in the availability and secrecy of data. However, during the consultations the experts of the MNB and GIRO Zrt. were seemed to be co-operating in connection with solving these problems, thus there is good chance of the examinations being realised.

I hope that with my current dissertation and intended further works I can contribute to the widespread popularisation of the awareness of clearing system's importance. Furthermore, I also hope that the scientific explanation of the research problems, the formulated theses and my suggestions may be useful for other researchers.

7. Publications of the author relevant to the topic

[2007] „Euro or Dollar? – Effects of the euro zone enlargment" microCAD 2007 International Scientific Conference 22-23 March 2007, University of Miskolc, ISBN 978-963-661-756-1

[2011] „A napközbeni elszámolás bevezetésének hazai és nemzetközi előzményei" InterGIRO2 – Napon belüli elszámolás tanulmánykötet, pp. 20-30. Magyar Közgazdasági Társaság Pénzügyi Szakosztály, 2011. TAS Kiadó Bp. ISBN: 978-963-86705-7-1)

[2011] „Hungarian Clearing Turnover in the Context of the Past Fifteen Years" szakcikk (társszerző: Dr. Kovács Levente), Theory Methodology Practice , December 2011, Vol.7./No.1., pp. 41-50, Kiadó: Miskolci Egyetem, ISSN: 1589-3413

[2011] „A napon belüli elszámolás előzményei, megvalósítása és gazdasági hatásai" előadás a Miskolci Egyetem Gazdaságtudományi Kar „Tudásalapú társadalom – Tudásteremtés – Tudástranszfer – Értékrendváltás" VIII. Nemzetközi Tudományos Konferenciáján, 2011. (társszerző: Dr. Kovács Levente, megjelent elektronikusan a konferencia előadás kötetében) ISBN 978-963-661-951-0

[2012] „A pénzügyi infrastruktúra fejlesztése és várható hatásai Magyarországon" szakcikk (társszerző: Dr. Kovács Levente), Hitelintézeti Szemle 14. évfolyam 1. szám, Magyar Bankszövetség, Budapest, ISSN 1588-6883

[2012] „A hazai elszámolásforgalom az elmúlt másfél évtized tükrében" szakcikk (társszerző: Dr. Kovács Levente), Észak-magyarországi Stratégiai Füzetek 2011. VIII. évf. 2. sz., pp. 15-29., Kiadó: Miskolci Egyetem Világ- és Regionális Gazdaságtan Intézet, ISSN 1786-1594

[2012] „A magyar elszámolásforgalmi rendszer jövője" előadás, Zöld gazdaság és versenyképesség – Károly Róbert Főiskola XIII. Nemzetközi Tudományos Napok, Gyöngyös 2012. március 29. (Megjelent elektronikusan a konferencia előadás kötetében) ISBN 978-963-9941-53-3

[2013] „A bankközi klíringforgalom időbeli megoszlása" szakcikk, Hitelintézeti Szemle 12. évfolyam 6. szám, Magyar Bankszövetség, Budapest, ISSN 1588-6883

[2013] „Egyszerű átutalások naptári héten belüli karakterisztikája" szakcikk, Napközbeni átutalás projekt 2010-2012 (tanulmánykötet), GIRO Elszámolásforgalmi Zrt., Budapest, ISBN 978-963-86819-5-9

[2014] „A magyarországi települések közötti bankközi pénzforgalom földrajzi és globális hálózati jellemzőinek vizsgálata" szakcikk, Területi Statisztika /megjelenés alatt/

References

Alba, R. D., 1973. A graph-theoretic definition of a sociometric clique. *Journal of Mathematical Sociology,* pp. 113-126..

Albert, R. & Barabási, A.-L., 2002.. Statistical mechanics of complex networks. *Reviews of modern physics,* 30. január, Vol. 74.. kötet, pp. 48-94..

Backstrom, L. és mtsai., 2011. *Four Degrees of Separation,* Ithaca, New York: Cornell University.

Báger, G., 2011. *Magyarország integrációja a nemzetközi pénzügyi intézményekbe.* Budapest: Akadémiai Kiadó.

Bankszövetség, 2009/12. *Húsz esztendős a GIRO, 15 éves a klíringrendszer - Hírlevél.* Budapest: Magyar Bankszövetség.

Barabási, A.-L., 2002. *Linked - The New Science of Networks.* Cambridge: Perseus Books Group.

Barabási, A.-L., 2006. A hálózatok tudománya: a társadalomtól a webig. *Magyar Tudomány,* 2006/11. kötet, p. 1298..

Barabási, A.-L., 2010. *Villanások.* Budapest: Nyitott Könyvműhely.

Barabási, A.-L., Albert, R. & Jeong, H., 1999. Diameter of the world wide web. *Nature,* 401. kötet, pp. 130-131..

Barabási, A.-L., Albert, R. & Jeong, H., 2000. Scale-free characteristics of random networks: the topology of the world wide web. *Physica A,* 281. kötet, pp. 69-77..

Bartha, L., 2003. Fizetési rendszerek az Európai Unióban. In: *Európai Füzetek.* Budapest: Külügyminisztérium - Miniszterelnöki Hivatal Kormányzati Stratégiai Elemző Központ.

Bartz, B. P., 1979. From Place to Space: The Psychological Achievement of Thematic Mapping. *Cartography and Geographic Information Science,* pp. 5-12.

Becher, C., Millard, S. & Soramäki, K., 2008. The network topology of CHAPS Sterling. *Bank of England's Working Paper Series,* Issue No. 355..

Benedek, G., Lublóy, Á. & Szenes, M., 2007. A hálózatelmélet banki alkalmazása. *Közgezdasági Szemle,* július-augusztus.pp. 682-702..

Biggs, N. L., Lloyd, E. K. & Wilson, R. J., 1976. *Graph Theory: 1736-1936.* Oxford: Clanderon Press.

Bódi-Schubert, A., Ábrahám, Z. & Lajkó, E., 2012. A magyarországi készpénzellátás hálózati szempontú elemzése. *MNB-Tanulmányok.*

Bod, P. Á., 2008. *Bevezetés a pénzügyek és a pénzpolitika világába.* Budapest: Mundus Magyar Egyetemi Kiadó.

Bollobás, B., 2001. *Random Graphs.* Második kiadás szerk. Cambridge: Cambridge University Press.

Bonacich, P., 1987. Power and Centrality: A Family of Measures. *The American Journal of Sociology,* Vol. 92(No. 5), pp. 1170-1182..

Brandes, U. és mtsai., 2007. On Finding Graph Clusterings with Maximum Modularity. *Graph-Theoretic Concepts in Computer Science,* Vol. 4769. kötet, pp. 121-132..

Buchanan, M., 2003. *Nexus: Small Worlds and the Groundbreaking Theory of Networks.* New York: W. W. Norton & Company Ltd..

Castells, M., 2000. *The Information Age: Rise of The Network Society.* Second edition szerk. Oxford, UK: Blackwell Publishers Ltd..

Clauset, A., Newman, M. E. J. & Moore, C., 2004. Finding community structure in very large networks. *Physical Review,* E 70(066111). kötet.

Cohen, R. & Havlin, S., 2010. *Complex Networks: Structure, Robustness and Function.* Cambridge: Cambridge University Press.

Csermely, P., 2005. *A rejtett hálózatok ereje.* Budapest: Vince Kiadó.

Diestel, R., 2005. *Graph Theory.* 3. szerk. New York: Sringer-Verlag.

Divéki, É. & Helmeczi, I., 2013. A napközbeni átutalás bevezetésének hatásai. *MNB Szemle,* január.

Djamasbi, S., Siegel, M. & Tullis, T., 2010. Generation Y, web design, and eye tracking. *ScienceDirect,* pp. 307-323.

Embree, L. & Roberts, T., 2009. Network Analysis and Canada's Large Value Transfer System. *Bank of Canada Discussion Paper,* december.

Erdős, M. & Mérő, K., 2010. *Pénzügyi közvetítő intézmények.* Budapest: Akadémiai Kiadó.

Euler, L., 1913. *Opera Omnia.* Basel: Birkhäuser Verlag AG.

Fellegi, M., 2011. *Pénzügyi ismeretek.* Miskolc: Miskolci Egyetemi Kiadüó.

Ferber, K. & Nagy, K., 1990. *A Budapesti Giro és Pénztáregylet Rt. 1893-1948.* Budapest: Giro Elszámolásforgalmi Rt.

Ferguson, N., 2008. *The Ascent of Money.* New York: Penguin Books Ltd.

Fogaras, I., 1997. *Bankmenedzsment.* Budapest: Saldo.

Freeman, L. C., 1979. Centrality in Social Networks - Conceptual Clarification. *Social Networks,* pp. 215-239..

Friedman, M., 1971. *A Monetary History of the United States.* hely nélk.:Princeton University Press.

Gál, Z., 2010. *Pénzügyi piacok a globális térben.* Budapest: Akadémiai Kiadó.

GIRO, 1998-2013. *Éves jelentések,* Budapest: GIRO Elszámolásforgalmi Zrt..

GIRO, 2/2007/3. *Igazgatósági Határozata a Társaság hosszú-távú stratégiai koncepciójának elfogadásáról.* Budapest: GIRO Zrt..

GIRO, 7/2009/2. *Igazgatósági Előterjesztés.* Budapest: GIRO Zrt..

GIRO, 7/2009/4. *Igazgatósági határozat.* Budapest: GIRO Zrt..

GIRO, 8/2009/4. *Igazgatósági Előterjesztés és Határozat.* Budapest: GIRO Zrt..

Granovetter, M., 1973. The Strength of Weak Ties. *American Journal of Sociology,* 78.. kötet, p. 1360–1380..

Granowetter, M., 1995. Coase Revisited: Business Groups in the Modern Economy. *Industrial and Corporate Change,* 4/1.. kötet, pp. 93-130..

Gubcsi, L. & Tarafás, I., 1983. *A láthatatlan pénz.* Budapest: Közgazdasági és Jogi Könyvkiadó.

Håkansson, H., 1982. *International Marketing and Purchasing of Industrial Goods - An Interaction Approach.* Chichester, UK: John Wiley & Sons Ltd..

Hanneman, R. A. & Riddle, M., 2005. *Introduction to social network methods.* Riverside(CA): University of California.

Helmeczi, I., 2010. A magyarországi pénzforgalom térképe. In: *MNB-tanulmányok.* Budapest: Magyar Nemzeti Bank.

Huszti, E., 2002. *Banktan.* Budapest: TAS-11 Kft..

Jaksity, G., 2005. *A pénz természete.* Budapest: Alinea Kiadó.

Jordán, F., Scheuring, I. & Vida, G., 2002. Species Positions and Extinction Dynamics in Simple Food Webs. *Journal of Theoretical Biology,* Issue 215., pp. 441-448..

Karinthy, F., 1929. Láncszeemk. In: *Minden másképpen van.* Budapest: Athenaeum Irodai és Nyomdai Rt., pp. 85-90..

Karonski, M. & Rucinski, A., 1997. *The Origins of the Theory of Random Graphs.* Berlin: Springer.

Kelly, K., 1998. *New Rules for the New Economy.* New York: Penguin Putnam Inc..

Kertész, J., 2006. Súlyozott hálózatok: A tőzsdétől a mobiltelefóniáig. *Magyar Tudomány,* 2006/11.. kötet, p. 1313..

Keynes, J. M., 1936. *The General Theory of Employment, Interest and Money.* United Kingdom: Palgrave Macmillan.

Kocziszky, G., 2006. *Gazdasági hálózatok tervezése, szervezése.* Miskolc: Miskolci Egyetem.

Kocziszky, G., 2007. *Térségi hálózatok hatáselemzése.* Miskolc: Miskolci Egyetemi Kiadó.

Kocziszky, G., 2008. *Regionális integrációk gazdaságtana.* Miskolc: Miskolci Egyetemi Kiadó.

Kohn, M., 2003. *Bank- és Pénzügyek, Pénzügyi Piacok.* Budapest: Osiris Kiadó - Nemzetközi Bankárképző.

Komáromi, A., 2007. A monetáris bázis hatása a pénzmennyiségekre – Van-e információtartalma a jegybankpénz mennyiségének?. *MNB Szemle.*

Kovács, L., 2010. *Az európai pénz- és elszámolásforgalom jövője.* Miskolc: Miskolci Egyetem Gazdaságtudományi Kar.

Kovács, L. & Pál, Z., 2011. Hungarian Clearing Turnover in the Context of the Past Fifteen Years. *Theory Methodology Practice,* Vol. 7.. kötet, pp. 41-50.

Kovács, L. & Pál, Z., 2012. A pénzügyi infrastruktúra fejlesztése és várható hatásai Magyarországon. *Hitelintézeti Szemle.*

Lengyel, I., 2010. *Regionális gazdaságfejlesztés.* Budapest: Akadémiai Kiadó.

Lengyel, I. & Mozsár, F., 2002. A külső gazdasági hatások (externáliák) térbelisége. *Tér és társadalom,* 1.. kötet, pp. 1-20..

Lublóy, Á., 2006. Topology of the Hungarian large-value transfer system. *MNB Occasional Papers,* 57.. kötet.

Mandják, T., Wimmer, Á. & Juhász, P., 2012. A hálózati pozíció és a versenyképesség kapcsolata. *Vezetéstudomány,* XLIII. évfolyam, különszám. kötet, pp. 14-23..

Marshall, A., 1920. *Principles of Economics.* eight edition szerk. London: MacMillan.

Milgram, S., 1967. The Small World Problem. *Psychology Today,* pp. 60-67..

MNB, 2008. *A Magyar Nemzeti Bank küldetése, jövőképe, értékei és kiemelt stratégiai céljai,* Budapst: Magyar Nemzeti Bank.

Nagy, Z., 2007. *Changes in the Position of the Town of Miskolc in the Network of Hungarian Towns from the Late 19th Century to the Present Day.* Harkov, Harkovi Nemzeti Műszaki Egyetem, pp. 418-432..

Newman, M., Barabási, A.-L. & Watts, D. J., 2006. *The Structure and Dynamics of Networks.* Princeton(New Jersey): Princeton University Press.

Odoran, R. & Sisak, B., 2008. A magyar gazdaság készpénzigénye – továbbra is olajozottan mûködhet a rejtett gazdaság?. *MNB Szemle.*

Onela, J.-P., Kaski, K. & Kertész, J., 2004. Clustering and Information in Correlation Based Financial Networks. *The European Physical Journal B,* B 38.. kötet, pp. 353-362..

Pál, Z., 2012. *A magyar elszámolásforgalmi rendszer jövője.* Gyöngyös, Károly Róbert Főiskola.

Pareto, V., 1935. *The Mind and Society (Trattato di Sociologia Generale).* Harcourt, Brace: ismeretlen szerző

Porter, E. M., 2008.. *On Competition.* Boston: Harvard Business Review.

Radnóti, J., 1929. *Pesti pénzoligarchák.* Budapest: May János Nyomdai Műintézet.

Radnóti, J., 1929. *Pesti pénzoligarchák.* Budapest: May János Nyomdai Műintézet.

Ricardo, D., 1810. *The high price of bullion : a proof of the depreciation of bank notes.* London: Harding & Wright (University of Illinois Urbana-Champaign).

Rørdam, K. B. & Bech, M. L., 2009. The Topology of Danish Interbank Money Flows. *Finance Research Unit Journal,* No. 2009/01. kötet.

Sabidussi, G., 1966. The centrality index of a graph. *Psychometrika - A Journal of Quantitative Psyhology,* december, Issue Vol. 31. Issue 4., pp. 581-603..

Soramäki, K. és mtsai., 2006. The Topology of Interbank Payment Flows. *Federal Reserve Bank of New York Staff Reports,* Issue no. 243.

Szabó, K., 1999. Hálózatok hiperversenyben - Vállalatok szétesése molekuláris egységekre és összekapcsolódásuk. *Vezetéstudomány,* pp. 15-25..

Szakály, D., 2002. *Innováció- és technológia menedzsment.* Miskolc: Bíbor Kiadó.

Szintay, I., 2009. Innovatív szervezetek és a változás dimenziói. *Gazdaság és társadalom,* 1.. kötet, pp. 81-97..

Szintay, I. & Veresné, M. S., 2006. *Hálózat és kapcsolat menedzsment.* Miskolc: Miskolci Egyetem.

Turján, A., 2009. Postai pénzforgalmi szolgáltatások Magyarországon. In: *MNB-tanulmányok.* Budapest: Magyar Nemzeti Bank.

Turján, A. és mtsai., 2011. Semmi sincs ingyen: A főbb magyar fizetési módok társadalmi költségének felmérése. In: *MNB-tanulmányok.* Budapest: Magyar Nemzeti Bank.

Tv., 2012. *Az egyes adótörvények és azzal összefüggő egyéb törvények módosításáról szóló 2012. évi CLXXVIII. törvény 375-376. §.* Budapest: Magyar Közlöny.

Viegen, R., van Wijk, J. J. & van der Linden, E.-J., 2006. Visualising business data with generalized treemaps. *IEEE Transactions on visualization and computer graphics,* pp. 789-797.

Vigvári, A., 2010. *Pénzügyrendszertan.* Budapest: Akadémiai Kiadó.

Watts, D. J. & Strogatz, S. H., 1998. Collective Dynamics of 'Small World' Networks. *Nature,* pp. 440-442..

Weinstein, J., 2008. A Postgenomic Visual Icon. *Science,* p. 1772{1773.