Efficiency of stock exchange network formation as a change in market concentration

The paper focuses on stock exchange network efficiency as related to consolidation and concentration in the finance industry. The study aims to assess changes in securities market concentration in Europe based on analysis of formation of networks among European stock exchanges.

Keywords: stock exchange, efficiency, concentration, networks.

Introduction

Increase in economic integration and financial sector liberalization has brought significant changes in the financial marketplace through increased competition among the market players, as well as through fostering cooperation of various forms among the institutions. Stock exchanges, as specific institutions providing trading services, started operating as regular service firms, with a complex range of activities, including listing, trading, information dissemination, settlement provision, offering platforms for trade on national, cross-border as well as international level. Privatization processes turned them into private companies, executing shareholder value maximization strategies, inducing merger and acquisition transactions among them on regional as well as global levels. Thus, establishment of links and connections, growth of their number and diversity, geographic scale, lead to network formation in European stock exchange sector.

However economic empirical and theoretical literature on financial market network structures and their efficiency is quite limited. Concerning real economic sector, network formation is considered as endogenously efficient. It is proved that network
formation and expansion changes market structure and nature of competition between firms in the market (Noia, 2001). Stock exchange networks bring changes to market structure of the financial sector in terms of number of institutions (market participants), their power distribution, the flow of funds, etc. Referring to Industrial Organization theory, market structure can be defined by concentration and competition degree, thus implying network formation influence on market concentration changes. However, market structure (concentration) research methods are rarely applied for evaluation of network formation.

A few research papers (Hasan, Schmiedel, 2003; Schmiedel, 2001) have dealt with evaluation of formation of network connections by considering changes in market structure (degree of market concentration). Changes in concentration as a measure of efficiency are assessed as profit and cost ratio. Even though this research method was applied for assessment of connections in stock exchange sector, this approach is more common for microeconomic evaluation and captures only changes in production efficiency. From macroeconomic point of view, assessment of functional efficiency of the sector by using price measures is complicated.

The paper aims at evaluation of the efficiency of network formation in European stock exchange sector by assessing changes in market concentration. The research questions: whether structural market concentration indicators can be sufficient measures for evaluation of structural changes in the stock exchange sector, and advocates for use of specific measures to evaluate network formation outcomes in stock exchange sector. For this purpose selected concentration indicators (CRn%, CRn and HHI) are applied and contrasted with indicators related to network clustering levels.

Background

Increased integration and consolidation of financial markets and institutions have been raising the question of efficiency within the stock exchange industry. The concept of efficiency in itself is identified in the economic theory as twofold: production efficiency and allocation (Pareto) efficiency. Production efficiency is defined as maximum result at minimum costs (Cordato, 1980). Allocation efficiency defines the state in economy (market) when there is no way that moving from this point would slightly increase the utility of any individual without at least moderate decrease of others utility (Elgar, 2002). Thus production efficiency, most often measured by cost ratios, defines the state of microeconomic subjects, while allocation efficiency is more suitable for analysis and evaluation of processes on macroeconomic level. More recent research shows a turn in employing a broader definition of efficiency, where changes that increase the value are considered as efficient and changes that decrease the value – as inefficient (e.g. Schenk, 1997).

Empirical research on efficiency in stock exchange industry is twofold. On one hand, it analyzes (Cybo-Ottone, di Noia, Murgia, 2000; Schmiedel, 2002, Bitzam, Wilson, 2007; etc.) the production efficiency of stock exchanges as economy of scale and scope when cooperating in technology development. In the context of network formation gain of stock exchanges form connections should be analyzed. Even though methods for assessment of
network connections are broadly discussed and applied in economic simulations, possibilities for their empirical assessment are very limited. On the other hand, a large number of research is on stock market efficiency from its customers’ perspective. Even though these researches capture the allocation efficiency of the market, they do not take institutional, market structure aspects of the sector into account, thus limiting their applicability for evaluation of efficiency of network formation in stock exchange industry.

Industrial organization theory draws a concept of market structure in terms of concentration and density (van Witteloostuijn, Boone, 2006), relating efficiency of a sector to changes in market concentration. As network formation in stock exchange sector changes their market structure, the efficiency of this process can be assessed by analyzing market concentration measures. However, relationship between market concentration and efficiency changes in stock exchange industry is not straightforward.

In economic theory the opinion that increase in market concentration lowers the efficiency prevails. As M. Malkamaki and J. Topi (1999) noted, optimal allocation of resources is not resulted by perfect competition. That is why the increase of market concentration might have a positive impact on efficiency. The importance of market structure for allocation efficiency is also described by B. Seritsoy and M. Weiss (2003). The authors do not accentuate the single market form that increases the efficiency. They call the market structure efficient if it does not worsen the operational possibilities of market actors in the future. We support application of this approach to stock exchange sector. Network formation in the sector should be considered efficient, if it allows stock exchanges to provide their services better so that the value to their actors and participants could increase in the future.

The main function of the financial markets is to allocate the capital and financial resources, causing increase of the value of the other sectors in economy. However, stock exchanges as institutions do not allocate funds themselves. Their function is to create possibilities (a market) for direct financial exchange between economic actors. Thus their efficiency in terms of possibility for value creation increases, as the distortion of created market declines. Financial market institutions should be considered more efficient if the financial recourse exchange market they create ac-

![Diagram](image-url)

*Fig. 1. Links between network formation and its efficiency*
requires more features of perfect competition market (Wurgler, 2000). Taking into consideration the main features of perfect competition market (many sellers, many buyers, no possibility to make influence on prices, etc.), we suggest, that the closer cooperation among financial market institutions is, the more it approaches perfect competition market. Thus closer cooperation and network formation in stock exchange industry, which increases market concentration, should bring to increased efficiency.

Influence of stock exchange connections to network degree on its production efficiency, as investigated by I. Hassan and H. Schmiedel (2003), can be positive. Their research results showed that growth of a number of connections in selected European stock exchanges had a positive impact on their size, liquidity and efficiency. Despite the authors measured production efficiency of stock exchanges, they explain the results not only by possible increase of economies of scale, but more likely by positive network effect. Analysis of research shows, that there is consensus in terms that stock exchange industry is a network industry with a positive network effect or network externality, assuming that service value for customer increases as more customers are choosing the same service provider. Increase of market concentration with lower number of separate service providers should also increase value for customers. So we should indicate to two sided arguments for positive relationship between market concentration growth and efficiency increase in stock exchange sector, as depicted in Figure 1.

**Research methodology**

As economic network formation among firms changes market structure, we follow the definition of market structure in terms of concentration and density terms. In order to evaluate the network formation and structural changes in the market we concentrate on the measure of market concentration. The logic of the research is presented in Fig. 2.

![Fig. 2. Logic of evaluation of network formation efficiency as a change in market concentration](image-url)
The research was structured in the following way. Market concentration in European stock exchange industry was evaluated in two stages. Firstly, concentration was measured applying non structural market concentration indexes on two different bases. Secondly, indicators that describe concentration level in networks were chosen and applied to measure market concentration in networks of European stock exchange sector, aiming to capture structural changes in the stock exchange sector in addition to market concentration measures.

Market concentration indicators include two different types: structural and non structural indicators. Application of non structural market concentration indicators for measuring efficiency (Borenstein, Bushnell, Knittel, 1999; Schmiedel, 2001; Jansen, Hann, 2003; Boone, van Ours, van der Wiel, 2007; ir kt.) is based on SCP (Structure-Conduct-Performance) paradigm. These indicators usually are used for assessment of a single firm activity. State and changes in market concentration is measured by firm financial results, assuming that different states of market concentration make influence on firm’s activity and its performance. Non structural market concentration indicators usually include such return ratios, as PCM (price to cost margin called market power or Lerner index); PE (profit elasticity to costs); H statistics (production resource price elasticity to income, called Rose-Panzar index).

Non structural market concentration indicators can be applied for measuring efficiency of structural changes in stock exchange industry (Hasan, Schmiedel, 2003; Schmiedel, 2001). The main advantage of non structural market concentration indicators is information needed: there is no need to have information about all firms in a market. As most of non structural indicators are expressed as ratios, their comparison results depend on accounting standards and principles the firms use. In general they measure a firm’s competitive state in the market and are close to production efficiency indicators. As the aim of this paper is to evaluate structural changes in stock exchange industry, non structural market concentration indicators are not used for the research.

Structural market concentration indicators measure market structure, market share distribution among firms and non financial results of a firm. The main problem related with their calculation is difficulties to measure the size of total market. But as our research include most of the stock exchanges in Europe, we overcome this problem. Though there are not many researches where structural market concentration indicators were applied in stock exchange industry, but quite often they were used to measure concentration in bank industry. In table 1 the main structural market concentration indicators that were mentioned in theory and applied in empirical research are contrasted.

Aiming for larger accuracy and reliability of the research results, we chose CRn%, CRn and HHI from all structural market concentration indicators provided in Table 1. Empirical research showed that namely these indicators result to measure market concentration and its changes with largest accuracy. Two of the chosen market concentration indicators – CRn% and CRn – are linked in terms of techniques of measurement and interpretation. But as their accuracy is different for different size of data sets (as it is showed in table 1), we include both of them into analysis. The third indicator, included in the research on market concentration in stock exchange
For calculation of all the chosen market concentration indicators, estimation of market share is needed. Traditionally in the real economic sector market size and its shares are estimated by production sales. Taking stock exchanges as firms, their market size and shares can also be measured by their financial indicators. This method is also applied in research on concentration in banking sector (e.g. Algeria, Schaeck, 2007; Deltuvaitytė, Giziene, 2007). But due to specifics of financial sector in the economy, we advocate for use of specific measures that indicate the scope of stock exchange’s functional activity. As the main function of all firms in the real economy sector is to produce services and goods, most often their market size is measured by sales revenues (income). Majority of research on market concentration in banking industry measure market size, based on specific income of the banks (e.g. interest income, volume of loans, etc.). For the presented research we suggested some specific measures of stock exchange performance that could be used for calculation of market size and shares and evaluation of market concentration. These include capitalization of listed securities.

**Table 1**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Evaluation of indicator</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>Reverse number</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>CRn%</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>CRn</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Zipf’s α</td>
<td>No</td>
<td>Yes</td>
</tr>
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**Table 2**

<table>
<thead>
<tr>
<th>Market share indicator</th>
<th>Definition</th>
<th>Data base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>Income from main activity of exchanges</td>
<td>FSESE</td>
</tr>
<tr>
<td>EBITDA</td>
<td>EBITDA of exchanges</td>
<td>FSESE</td>
</tr>
<tr>
<td>Capitalization</td>
<td>Capitalization of listed securities as the last day of the year</td>
<td>WFE</td>
</tr>
<tr>
<td>Turnover</td>
<td>Annual turnover of share trading in the exchange</td>
<td>WFE</td>
</tr>
</tbody>
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FSESE – Federation of European Stock Exchanges.
WFE – World Federation of Exchanges.
at the end of the year and annual trading turnover. Overall two different methods were used for calculation of market share (see Table 2).

In order to evaluate the efficiency of structural changes in European stock exchange sector, market concentration in the industry was measured by three structural concentration ratios. For their calculation the market size and shares were estimated by two general measures and two specific indicators. In total there were twelve market concentration ratios analyzed. We expected that contrasting the chosen indicators allow to capture effect of concentration of efficiency within the specific sector.

In addition for the purpose of analyzing and evaluating network formation in stock exchange industry, network indicators and measures can be also applied to describe and evaluate these structural changes in the market. In other empirical research network efficiency was measured by assessing its structure (e.g.: Westbrook, 2008; Carayol, Roux, Yıldızoglu, 2005; Mobert, 2006). As N. Carayol, P. Oux ir M. Yıldızoglu (2005) notes, the assessment of network structure efficiency is a complex task. As the concept of evaluation of efficiency through increase in value is used, attempts to assess value of networks are made. C. di Noia (2001) in her model of merger of stock exchanges addresses the value of network link formation. In general network value is expressed as a difference of link formation benefit and its costs ($u - utility, \delta - benefit; c - costs; e - link degree; le - number of links of the same degree):

$$u_i = \delta \sum_{e} l_e e - cl_i$$

When applying this concept for empirical research, network formation utility and its costs are measured by financial indicators. As similar approach is used when calculating traditional market concentration ratios, we may presume that network formation benefits and costs are assessed by these ratios. On the other hand, it is complicated to separate the direct network formation benefits and costs in aggregated financial accounts. So other type of network indicators is needed to measure and evaluate changes in market structure and concentration.

Structure and form of the network depends on its elements and links, their number and distribution. In theory there are many concepts and measures that describe networks: network size, diameter, network degree, length of the path, power, etc. But for evaluation of efficiency of network formation as a change in market structure and concentration all these measures can be only secondary and descriptive. More complex and integrate indicators are needed. R. Kali and J. Reyes (2006) measure economic integration in the aspect of network formation and use these structural network measures: network centrality (or centralization), density, clustering and mix. These indicators might also be applied to measure market concentration due to links between concepts of integration and concentration.

After looking at the definitions of these four network measures, we state that network density and clustering index are closer to the concept of concentration and both of these measures are similar. Network density indicates the proportion of ties in a network relative to the total number possible. It assesses interconnection of the elements in a network. Clustering index was created by D. Watts and S. Strogatz. Its calculation is similar to network den-
sity but the interpretation of results differs. Clustering index measures, how much an element from a network is interconnected with its neighbors; that is a higher clustering index indicates a greater “cliquishness”. As networks in stock exchange industry are undirected, the clustering index of each stock exchange is calculated as the proportion of ties \( e_{jk} \) among neighbors \( k_i \) relative to the total number possible:

\[
C_i = \frac{2|\{e_{jk}\}|}{k_i(k_i-1)}
\]

Clustering index for entire network or total market \( C \) is calculated as an average of its elements’ clustering indexes \( c_i \).

\[
C = \frac{1}{n} \sum_{i=1}^{n} C_i \quad 0 \leq C \leq 1
\]

In fully connected network clustering index is equal to one. In this case we assume that the market is highly concentrated. When clustering index is close to zero, market concentration should be low. When using clustering index for assessment of market concentration, several points should be noted. Clustering index shows average clustering of all networks in the sector. So index increases as clustering of any network grows. However it does not make any suggestions concerning the size of the networks. Clustering index will be higher in the case of small totally integrated networks compared to large but not fully integrated networks. So network formation and its expansion might cause the decrease of clustering index of the sector. In order to capture these effects of network formation in stock exchange industry we calculated the average size and the average degree of networks in the sector. These indicators are applied to reveal structural changes and evaluate the efficiency of network formation.

### Results of empirical research

Research was made on European stock exchange industry. Financial and other activity data as well as information about connection formation of stock exchanges was taken from World Federation of Exchanges (WFE) statistics data base and informational bulletin “Focus” and Federation of European Securities Exchange (FESE). Period of 9 years is analyzed (2000 – 2008). Formal networks among European stock exchanges started to form from the beginning of 2000. Till then network formation was a national process. So we measure market concentration in order to capture and evaluate structural changes in the industry.

First of all we calculated traditional market concentration ratios where market share was estimated by financial indicators of the exchanges. Uniform data about income and profits of European stock exchanges is provided by FESE. But only statistics for 2002–2006 period was available. The shortening of the period analyzed should not have a significance on the results. 5 years should be enough to see the tendencies in movement of market concentration ratios.

Both of the market share indicators – exchange income and EBIDTA – were moving in the same direction. So the concentration ratios calculated from these two market share indicators were fluctuating in the very similar way during the period analyzed. Figure 3 shows the dynamics of concentration ratios in European stock exchange industry.
Fig. 3. Dynamics of concentration ratios calculated on the basis of income of European stock exchanges

Values of market financial concentration ratios were declining till 2004 and remained at the same level till 2006. This makes us think that network formation helps to distribute financial income among exchanges more even. Declining values of CR3 and CR10% ratios indicates that the 3 or 10% biggest stock exchanges in Europe were loosing their market shares in financial terms. We should note that there were

Fig. 4. European stock exchange market concentration (HHI) by source of income in 2006
no changes in the list of top exchanges. So the slight decrease of market concentration in financial terms might have been experienced because of growing income of smaller European stock exchanges.

When collecting the data about European stock exchange income, we noticed that income structure differs quite much depending upon the exchange size. Larger exchanges have more different sources of income, their activities are more diverse. Meanwhile smaller exchanges earned lower income mostly from trading and listing fees. So we measured market concentration indicators by different types of stock exchange income. Figure 4 presents the results of one of the calculated market concentration ratios (HHI). The results showed that market concentration measured by trading and listing income is much lower compared to concentration as measured by total income. It says that European stock exchange concentration in financial terms is higher because of other income (mostly from technology development and derivatives trading) that are concentrated in bigger stock exchanges. We suggest that network development makes a larger influence on such kind of income.

Secondly we calculated traditional market concentration ratios in the aspect of stock exchanges’ activity. Changes in these ratios also did not show the obvious increase in concentration in European stock exchange industry. In Figure 5 we present three traditional concentration ratios that are measured on the bases of annual turnover of exchanges.

The concentration in European stock exchange sector was high: the market share in annual turnover of five biggest exchanges was about 90%. This ratio was also high when based on financial performance data of stock exchanges as well as market capitalization. But network formation made a minimal impact on traditional market concentration ratios as they do not fluctuate much. The calculated value of HHI is decreasing the most. This might

![Graph](image-url)

*Fig. 5. Dynamic of traditional concentration ratios calculated on the bases of annual turnover of European stock exchanges*
be caused by increasing market shares of small exchanges when bigger exchanges are loosing their market shares. Actually, only London stock exchange experienced a moderate loss of its market share. The market share of other biggest exchanges remained. As London stock exchange was less involved in network formation, we may say that network formation helps for larger stock exchanges to maintain their market shares and it provides advantages to smaller stock exchanges as their market shares are increasing.

Traditional market concentration ratios did not clearly show the effect of network formation on structural changes in

![Fig. 6. Dynamic of network clustering index in European stock exchange industry](image)

![Fig. 7. Dynamics of average network size and network degree in European stock exchange industry](image)
stock exchange industry and they do not capture the network effect. So we apply network measures and indicators that were described above. We chose to analyze two types of networks: ownership and technology as the largest and driving the performance and structural changes in stock exchange sector.

Firstly, clustering index for the European stock exchange industry was calculated as an average of clustering of the networks. The dynamic of the index is presented in Figure 6. The concentration in European stock exchange industry, measured by clustering index is increasing. In terms of technology the industry is more concentrated as clustering index of technology networks is about 0.2 points exceeding that of the ownership networks. We suggest that technology network formation might be more efficient. But for detailed analysis and interpretation of results we investigate some other network indicators: technology and ownership network degree and network size. The value of clustering index may increase because of new ties formation among network elements (increase in network degree) or it might be caused by new elements entering the network (increase of network size).

During 2000–2008 the network size as well as network degree in European stock exchange industry was increasing (Figure 7). Network formation and clustering of the sector was caused by both: new exchanges entering networks and increasing inter-relationship among related exchanges. In 2000 the average network size was close to 1. This indicates that there were almost no networks in the industry. At the end of the period analyzed the average network size of technology and ownership networks was less than 3. So there still were separate exchanges not connected to the networks. There should be at least three exchanges to be connected to call them a network, the average network size in the industry needs to be at least 3 to presume all the exchanges are connected to networks. However, as average network size augments, increasing clustering index indicates the increase in market concentration.

Research results show that since 2004 the average degree of technology networks was larger than their average size. The average network degree of technology and ownership networks was growing faster than their average size. So network formation and development is more likely caused by formation of new links among interconnected exchanges. Market structure and concentration changes because of network formation are more complex than in traditional markets. Through network formation market structure may change even though the number of actors and their external size remains unchanged. Traditional attitude towards market structure and concentration as well as traditional market concentration ratios are not capable to capture these changes. In this context network indicators are better measures of structural changes and their efficiency in the stock exchange sector.

Conclusions

Network formation in different industries changes their market structure. Firms get interrelated and they exchange goods and services, information and other resources in different way that they used to do before. As market structure can be defined by concentration and density terms, network formation should change both of them. But probably the largest impact of network
formation should be on market concentration. Several empirical researches aimed to measure changes in market concentration and its efficiency under network formation. Only few of the research addressed stock exchange market, and their scope was limited, including the use of methods of non structural market concentration. So they addressed micro level analysis and measured the impact on exchanges. However, no macro level evaluation was done nor other concentration evaluation methods were applied to evaluate market structure changes in stock exchange market.

After analyzing macro level market concentration evaluation methods as well as network evaluation measures, we chose to apply three different methods to measure market concentration in European stock exchange sector. Firstly, we measured market concentration by applying traditional indicators on two different bases, to derive so called market “financial” concentration (market shares derived from financial performance results of stock exchanges) and market “activity” concentration (market shares derived from specific exchanges’ activity indicators). Secondly, we applied network clustering index as an indicator for network concentration evaluation.

The results of the research showed that traditional market concentration ratios using both methods did not indicate the increase of market concentration in European stock exchange industry. The concentration indices remained rather stable during the period of 2000–2008 or slightly decreased. By contrast, the network clustering index was increasing dramatically during the same period. These findings suggest that traditional market concentration measurement methods are not able to capture all the structural changes in the sector with intensive network formation processes.

Traditional market concentration indicators are aimed to measure the performance of separate firms in the market and they mainly capture changes in ownership of the firms. Measures of network evaluation, such as network clustering index, are more applicable for evaluation of market structure changes due to network formation. Besides, their application is wider, in terms of measuring concentration not only from ownership perspective. Research showed increase in technological cooperation and integration in European stock exchange sector and their influence on concentration to a larger extent. This might explain the difference in results of traditional and network market concentration indicators.

Detailed analysis of market concentration measurement methods and their application in European stock exchange industry, allows concluding that traditional market concentration ratios are rational for industry performance evaluation. However, network concentration indicators have advantages for evaluation of structural changes in the industry and market concentration from different perspectives under network formation in stock exchange sector.
References


The paper submitted: April 20, 2009
Prepared for publication: June 01, 2009
TINKLŲ FORMAVIMOSI EFEKTYVUMAS: KONCENTRACIJOS VERTYBINIŲ POPIERIŲ BIRŽŲ SEKTORIUJE ANALIZĖ

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