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DEVELOPMENT OF LOGISTICS CENTRES BY NETWORK THEORY

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Abstract

Logistics centres with huge product-stopping capacity and having the ability to create added value have emerged in recent decades. These centres have become network nodes between the co-operating organizations which accomplish the management of supply chains (networks) by connecting different modalities and networks with their infrastructure and informatics background. The effective operation of logistics centres appearing in business networks are usually managed by logistics supplier businesses (3PL/4PL). Defining the supply net as a complex network, logistics centres may be called hubs, the routes and relationships connecting the centres, or – by borrowing the term used in network theory – may be called edges. Taken into consideration the earlier results of network research, the present paper aims to find the correlations between the principles proved by Barabási and the growth possibilities of the centres (hubs) operated by logistics service providers. The conclusions drawn by Csermely concerning cellular networks provide further opportunities for the application of the results of theoretical network science to logistics systems. Considering the references above and the results of empirical research and experience gained among domestic logistics companies, the best responses to the challenges posed by business networks can be recommended to domestic logistics service providers. Furthermore, the results of network research can be set in parallel with the research conducted by Reszegi - Juhász on performance enhancement involving 4,600 Hungarian businesses. At the end of the

paper, an attempt is made to describe a system of correlation between network phenomena and the activities employed in implementing the strategies of logistics service providers.

Key words: networks, corporate performance, alternatives for supporting growth

1. INTRODUCTION

Each era has particular periods which determine what can be and what is worth for research. Network research can be an area of science which deserves undertaking now. As well as our biological existence, our communication and also our professional and social life depend on networks. Understanding them is not only necessary for scientists and laymen alike, but also indispensable since in one way or another we need to navigate the 21st century. The technologies of the future, our would-be communication and our whole biological existence will depend on networks. Networks are already present in the 21st century and we completely depend on them, are embedded in them in such a way that they have become an issue of such importance that without networks we are not able to "wonder about" the world anymore (Barabási, 2014a, based on interview). Man lives in symbiosis with nature surrounding him, although we tend to continually abuse it (environmental pollution), for which we are getting punished ever more often (natural disasters).

Our personal experience shows that the longer we stay in nature, the more observations we make about the life of animals for example, the more principles we will discover that can be utilised for mankind as well. The same applies to our inland scientists doing research in network theory, who are able to draw conclusions from the movement of pigeons and the relationship of individual specimens of the bird species examined that can be employed in the development of human communities (Vicsek, 2014), as well as solutions supporting the trends of future technological development (e.g. experiments with drones within the frames of Alibaba, Amazon, Google and UPS companies operating in the logistics market). It is interesting to note that Google's drone testing is not allowed by the administration on the territory of the USA, so they are obliged to conduct them in (Világgazdaság, 2015). In nature the overwhelming majority of animal species live in groups just like we humans live our days in different communities. The conclusion has almost become a commonplace today that a coherent (working) community is able to give stronger and better responses to the new challenges of a changing world than the individual. In the interest of corporate competitiveness it is inevitable to deal with this issue since "the employees also constitute vital foundations of a corporation" (Reszegi - Juhász, 2014, pp 14). However, we Hungarians are not doing very well in our work with our faith in the success of team work and our productivity. According to the results of a recent survey, only 50% of domestic employees

show a higher performance when working in a team than working individually. Furthermore, the variegation of the composition of domestic team workers characteristically differs from the accepted norms in other cultures (Randstad, 2014; Adó Online, 2014).

2. BUSINESS NETWORKS

The quasi structure of the global economy is made up by business networks (Gelei, 2008), which have developed in response to the ever-changing economic environment and as a result of their network building these companies have also gained considerable competitive edge. „A network – and so business networks as well – is a structure in which several nodes are linked to one another through several lines. In business networks these nodes are formed by the individual business units like production companies, buyers, logistics or even financial service providers. The linking lines can be interpreted as the connections between these nodes". (Gelei, 2008, p 4) The roots of business networks can be traced back to Japan where the keiretsu operate with the support of a major bank and clustered around a large company possessing massive supplier contacts (Fukuyama, 2007).

In view of the international models and knowing the distribution of domestic companies by their size (Central Statistics Office, 2014), we can only hope that the Hungarian small and medium-size enterprises will be successful as part of globalising business networks (Gelei, 2008). „According to the figures of the CSO on corporate added value published for 2013, in Hungary, similarly to international experience, productivity was much higher with companies in foreign ownership. In 2011, companies in Hungarian ownership produced 4,461 thousand forints added value, while the figure for companies in foreign ownership was 11,334 thousand forints. The latter figure is two and a half times bigger". (Reszegi - Juhász, 2014. p 14) This is one of the reasons why it is so important for domestically owned SMEs to find those success factors (e.g. logistics solutions based on the results of network research or strategic decisions resulting from the integration of business networks), which could significantly narrow the currently existing gap.

Building on the results of network research we can find several domestic (Duma, 2005, 2007) and international (Barabási et al., 1999) publications or even on college students as a target group (Cserjés - Záborszky, 2011). However, in connection with logistics service providers taking part in business networks, we have not seen research results published that - based on a thorough revision of trade literature and built on practical experience – tried to draw parallels between the results of network research and corporate performance as well as the selection of activities supporting the strategies of logistics service providers.

3. LOGISTICS AND THE NETWORKS

Naturally, since the appearance of the logistics approach, not only the relations in production, but the whole economy must be treated as a network (Chikán, 2002 in Egri, 2014). With the emergence of the large product-stopping and added value producing logistics centres, such network nodes came into being within the co-operating organisations that by connecting different transport routes and sub-branch courses with the help of infrastructure and informatics can achieve the management of supply chains (networks). The flow of information within these systems is greatly supported by the Internet, and their efficiency is significantly increased by the application of innovations and technological development. The effective operation of logistics hubs appearing business networks is normally ensured by logistics service providers (3PL/4PL) that in their strategic planning also favour the network arrangement forms (Duleba, 2009). By interpreting supply nets as a complex network, logistics hubs can be considered as nodes and the connecting paths, borrowing the term used in network theory, can be called edges. If we accept the claims of Barabási that „behind the existence of complex networks there must be some laws" (Barabási, 2013, p 82.), we need to find the correlations between the laws already proven by him and the growth potential of the hubs operated by service providers integrated in logistics systems. Leaving behind the description of static, randomly constructed networks, let us turn our attention to the examination the results of the dynamically growing, scale-free networks.

4. GROWTH OF NETWORK POINTS

Barabási's first conclusion stipulates the principle of „linkage on the basis of **popularity**" accepting the fact that we are more likely to choose the node which has twice as many links as another one. Due to the continually increasing, dynamic, scale-free networks and the popularity linkage principle, "a few **central points** with multiple links come into being". (Barabási, 2013, p 99) This can as well be called the second conclusion the consequence of which is that „with the growth of the network the earlier points have more time for acquiring new links than the ones coming later" (Barabási, 2013, p 99). We may consider it the advantage of „**joining in time**", which thanks to the effects of the two rules described above can significantly contribute to the growth of a central point. Returning to the world of business, Reszegi - Juhász point out that "it is not clear yet how much time is exactly needed for the benefits of joining to show, therefore the investigations taking a short time frame can be prove negative even if the impact actually exists" (2014, p 50). However, they allow that "in principle, if the market functions flawlessly, the differences between individual companies within one sector tend to level off. This can be the result of several, sometimes contradictory processes" (2014, p 16).

In their book, the authors quoted above and referring to the publications of Görg, Kneller and Muraközi dated 2012, note that certain products of more productive companies proved to be more marketable in foreign markets. In addition, "products exported in larger volumes and enjoying a longer market presence, the chances of their withdrawal were smaller" (2014, p 58). Since markets generally do not work in an optimal way, consequently „resources tend to flow towards the more productive ones, they employ more means and labour than previously and so their weight increases" (Reszegi - Juhász, 2014, p 16).

In his research into the behaviour of stress proteins, Csermely has concluded that „stress proteins stabilise the network of the cell of which they form a part" (2004, p 7). During his research he discovered the formation of nodes, their importance and necessity, but also found that with the removal of these modes the complex networks generally fall apart. His main interest concerned the observation of the habits of stress proteins and he noticed that „when I block the stress protein, the lack of stability causes a difficult situation, but it does not mean death by itself" (Csermely, 2004, p 7). During his observation he realised that the bonding in the cell network „is stabilised by the elements which are **weakly tied** to one another. It is neither the element nor the number of interactions that are important here, but the **strength** of their interactions". (Csermely, 2004, p 7)

In their seminal paper Watts - Strogatz described the phenomenon and characteristic features of the "small world". Applying dynamic system models they pointed out that in this type of networks group formation and a high level of concentration result in peculiar consequences like increased spreading speed or performance (Watts - Strogatz, 1998, p 440). But what will happen to the latecomers who because of their age or idea enter later into an already functioning business network? By examining the process that separates the winners from the losers, we can see that the competition manifested in complex systems gives a chance to the better adapting companies (in our case points) to gain advantage over their competitors (possibly the older points) due to their "fitness" (Barabási, 2014b).

We can call this the rule of **competence** which basically "does not eliminate the mechanisms regulating growth and popularity linkage" (Barabási, 2013, p 109). Returning again to business relationships, the results of the research by Reszegi - Juhász show that „those lagging behind show little or no affinity to accommodate positive impulses (affecting competitiveness, productivity, etc. – author's comments). Consequently, there is a chance that the weak will remain weak in the future as well" (2014, p 17). A similar description is found in Gladwell's popular book quoting from Matthew, 25:29 "For unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken even that which he hath" (Gladwell, 2008, p 38). Returning to the rules of nature, we can see that most living systems are capable of staying alive even in very diverse

environmental conditions (Barabási, 2013), whereas in the systems operated by man it often happens that due to minor malfunctions the whole man-made structure becomes unserviceable. Therefore, the study of **robustness** (error tolerance and solving ability) may yield important conclusions regarding operability since the operability of every system „is guaranteed by a complex, closely-knit network" (Barabási, 2013, p 125). Applying the above rules, Barabási and his team are able today to undertake to determine of a dynamic, scale-free network whether it follows „the rich will get richer" or "the winner takes all" scheme. This is the so-called Matthew-effect (Mérő, 2012). Let us see what parallels can be drawn between the above rules and the strategy choices and growth potentials of logistics service providers.

In order to do this first we need to clarify how and at what levels the above principles of network theory can be interpreted to logistics. The methodology of logistics differentiates two types of network (Duma, 2005):

- transport routes, in a wider sense networks mapping infrastructure (physical networks),
- non-infrastructural networks, i.e. linkages built on the previous physical networks (potential business links and abstract "routes", or discrete flows of materials.

Duma conducted empirical research and calculations regarding the topology of logistics networks and on their graphs, in the course of which, through the modelling and quantitative analysis of logistics and certain transport and distribution systems he evaluated the topological features of the networks and identified the consequences. As the tool of modelling he applied the graph theory and a statistical analysis of the topological database of the mapped networks and was able to draw the following conclusions (Duma, 2005):

1. Physical transport and distribution networks tend to be rather non-scale free than scale-free that is the occurrence of nodes having multiple links is extremely rare, so the network theory of Barabási can be applied to them only in a limited scope.

2. At the same time, the linkage networks interpreted on existing physical networks represent basically different graphs which are mostly scale-free resembling the so-called small world, consequently the relevant results of Barabási can be applied to them.

3. Physical networks have an impact on linkage networks (e.g. the rail and train networks can be considered two separate ones) and so does the aspect mapping the physical network (e.g. part-networks, i.e. the fractal phenomenon).

4. Without the topology and an understanding of the special features of individual linkage configurations it is impossible to organize and manage a network properly.

In 2005, Duma came to the conclusion that in case of scale-free networks of logistics reference, it is the central points where we should concentrate our intervention resources. On the other hand, constraints of nature geography and infrastructure may arise, so the analysis of network linkage must also be included in the models employed to designate centres.

5. PARALLELS AND RECOMMENDATIONS

Research investigating logistics service providers on the national (Karmazin, 2014) and international (Kotonen, 2012) scene, have tackled the issues of strategy choice and potential development of the actors in the logistics market from different aspects, however, the results of network research have never been drawn a parallel with the activities of logistics organisations. Incorporating Egri's conclusions and recognising the importance of this issue we can see that „network theory is capable of becoming a useful toolbar for logistics, which in international logistics, production logistics and the processes of the global economy can make optimal arrangements more recognisable and by shortening the links can function as an intensifier for economic efficiency" (Egri, 2014, p 28).

The unbroken growth in global goods turnover and the projections and undiminished popularity of e-commerce – only in China an annual 20 percent growth has been forecast in this area until 2019 – (Forrester, 2015) continually ensures the dynamic development of logistics networks interweaving the whole world. The general conclusions and statements on network theory described above and the results of the publications of Duma (2005 and 2007), can be applied to the systems operated by logistics service providers as well. **Table 1** summarises the results and general conclusions of network theory and the recommendations concerning the logistics service providers operating logistics centres and committed to growth and activities supporting business strategies.

The basis for these recommendations is provided by the results of an empirical, primary and representative research conducted among inland logistics service providers (Karmazin, 2014), and the co-author's practical experience gained with his own logistics company as well as the conclusions drawn from the results of national and international research and scientific publications utilised in writing the present paper.

Table 1

Development of network points and the correlations of support activities used in implementing the strategies of logistics service providers

Development of a network point	Support activities implementing the strategies of logistics service providers
attractiveness	effective PR and marketing activities, commitment to high professional standards, openness to the environment, raising the level of trust in business relations, opening up to new sectors, establishing new contacts with Internet support
central point (size)	acceptance of a growth strategy within the company organisation, forming co-operations even with rival companies, strategic acquisitions
joining in time	flexibility, inductive behaviour, entering new markets, introduction and implementation of new services and technologies
strength of weak ties	accession to associations and interest groups, signing co-operation agreements with government agencies, law-enforcement bodies, participation in non-sectoral events, organisation and sponsorship of economic events, non-profit activities and support, belonging to clusters
competence	improving ability for change, sector-specific IT development, continuous training, openness to new phenomena
robustness	high standard application of ISO, implanting correcting mechanism into business processes (PDCA cycle), involvement, delegating, authorising decisions at lower levels, wide service and customer (industry sector) portfolio

Source: author's own design, 2015

With regard to the last point of the table above, a more specific term to robustness is disturbance sensitivity (stoppage sensitivity) and the problem solving ability. Based on the simulations conducted on avalanche error occurrence typical of transport networks, it has been proved that the effect of cascading collapses in the network can be moderated by reducing the stoppage and disturbance sensitivity of the individual discrete access points (Duma, 2005). The obvious conclusion resulting from this is that the production points as discrete sources contribute just as much to the sustainable operability and error sensitivity of a system as the quality, stability and sensitivity of the transport routes themselves. Stoppage sensitivity earlier was not included in the description of a well-functioning supply chain. Summing up, a production point or a whole supply chain may stop not only because it is not being supplied to or in, but also because it is unable to reset its own production to another plant size in case a reduction occurs in the quantity of goods being shipped out. As in such situations, thanks to the networking logistics links, transport is rerouted to other routes and transport sub-channels, we evidently see an avalanche error occurrence, the cause

of which must be sought not in the characteristic of the transport system but in the characteristic and error sensitivity of the sources and drains (Duma, 2005).

6. SUMMARY

The present paper through the acceptance of its statements and recommendations may play an important role in forming the strategy of domestic logistics service providers. However, the paper with its network theory approach and the resulting conclusions may offer a new way of thinking for the decision makers working at domestic logistics service companies operating logistics centres in Hungary. Due to the topicality and importance of the issue, a further investigation of the related areas and the continuation of scientific research seem to be justified. The conclusions and results of the authors referred to above are worth to be investigated, for example, by processing the empirical data of a properly selected actor in the market. Through the analysis of the connections network of the selected logistics company, the opportunity may present itself to prove the scale-free of the (not only) business links, the existence and strength of weak links and that this phenomenon and its consequence really exist. Furthermore, through the network analysis of shipments (i.e. the mapping of the transport of goods between two points) we can prove the scale-free of this type of mapped network.

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