A network theory approach to the sharing economy

Petra Soltész (solteszp@eik.bme.hu)
Research assistant, Budapest University of Technology and Economics, Faculty of Economic and Social Sciences, Department of Environmental Economics

Gyula Zilahy (zilahy@eik.bme.hu)
Associate professor, Budapest University of Technology and Economics, Faculty of Economic and Social Sciences, Department of Environmental Economics

Abstract

With the fast growth of the businesses of the sharing economy, scientific evidence is also accumulating describing their characteristics and growth patterns. After introducing the most important concepts and theoretical considerations relating to the sharing economy, we take a network theory approach to analyse the data of a regional driver-share company based in Central Europe.
Our data shows a fast growing, popular service with an interesting internal structure regarding the nodes (settlements) and links (trips) within the network and contributes to a better understanding of sharing economy businesses in the transportation sector.

Keywords: sharing economy, peer-to-peer ride sharing, scale-free network

Introduction

In the last decade new business models have been appearing all around the world and have influenced traditional market structures to a great extent. Among these, patterns of collaborative consumption and especially the sharing economy is blooming in many sectors of the economy. As a result, researchers also put an effort into uncovering the most important features of the sharing economy including the spreading of their networks, the characteristics and motivation of users and their impact on individual lifestyles.

Since sharing economy businesses invariably use internet based platforms to promote their networks, an increasing amount of data is generated during their operations. Still, most of the research efforts do not utilize the databases available to sharing economy businesses and use other methods of data collection, such as questionnaire surveys of users. Researchers also use a wide range of theoretical considerations to anchor their research activities including the concept of disruptive innovations, the theory of self-determination, the social capital theory and others.

This article will introduce the different theoretical approaches used by the literature to explain the spread and characteristics of sharing economy platforms and will propose the use of network theory to explain their growth patterns. We will use the case of a regional ride share company and will benefit from the analysis of the database generated during the use of its platform over an eight-year period.

The concept of the sharing economy

With the rapid diffusion of businesses using one or another kind of resource sharing the concept of the sharing economy has become an often researched topic. Along the way a number of related concepts have also emerged, such as 'collaborative consumption' and 'access based consumption' and are often used interchangeably to describe initiatives aiming at a better utilisation of resources by putting an emphasis on their functions rather than their ownership (see e.g. Möhlmann, 2015, McArthur, 2014, Mallargé et al., 2017 and Ferrari, 2016).

Others emphasize the differences between these concepts. Hamari et al. (2015, p.1) defines collaborative consumption (CC) as a "peer-to-peer-based activity of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services". They argue that collaborative consumption has been expected to alleviate a number of societal problems including overconsumption, the pollution of natural eco-systems and poverty. According to Botsman (2013, p. 1), collaborative consumption is "an economic model based on sharing, swapping, trading, or renting products and services, enabling access over ownership. It is reinventing not just what we consume but how we consume."

While a number of definitions have been coined over the last few years, Meelen and Frenken (2015, p. 1) argue that it is hard to tell "where the sharing economy begins and where it ends". The Oxford English Dictionary defines the sharing economy as follows: "An economic system in which assets or services are shared between private individuals, either free or for a fee, typically by means of the Internet" (https://en.oxforddictionaries.com). According to Böcker and Meelen (2015, p. 1.) "sharing economy is consumers (or firms) granting each other temporary access to their under-utilized physical assets ("idle capacity"), possibly for money." Wosskow (2014) defines the "sharing economy as online platforms that help people share access to assets, resources, time and skills". Meanwhile Botsman (2013) says that sharing economy is "an economic model based on sharing underutilized assets from spaces to skills to stuff for monetary or non-monetary benefits. It is currently largely talked about in relation to P2P marketplaces, but equal opportunity lies in the B2C models."

The definitions introduced above highlight that the sharing economy can operate in both B2C and C2C (also called P2P) contexts. Böcker and Meelen (2015) define it as a for-profit activity, while Botsman (2013) and Frenken and Meelen (2015) also add the possibility of non-profit operations.

The notion of peer to peer markets is defined by Botsman (2013, p. 1.) as "Person-to-person marketplaces that facilitate the sharing and direct trade of assets built on peer trust." Hamari et al. (2015) describes the peer to peer market as part of collaborative consumption. Schor (2014) categorized the sharing economy into four categories: "recirculation of goods, increased utilization of durable assets, exchange of services, and sharing of productive assets" (Schor, 2014, p.1). She also divides sharing economy into P2P and B2P platforms based on their participants (Schor, 2015). In Table 1 we collected examples of the sharing economy based on these categories.

Table 1 – Types of sharing economy businesses with examples (based on Schor, 2014)

	For-profit		Non-profit	
	P2P	**B2P**	**P2P**	**B2P**
recirculation of goods		eBay, Craiglist, thredUP, Yerdle, Mol Bubi (H)	Freecycle, gardróbcsere (H)	
increased utilization of durable assets	Zimride, Uber, Lyft, Airbnb	Zipcar, Turo (Relay Rides), Car2Go, Mol Limo (H), GreenGo (H), redinner.com (H), Tesloop	Getaround, Tapazz, BeeRides, Oszkár(H), Share Some Sugar, miutcank.hu (H), Couchsurfing, Blablacar	
exchange of services			Timerepublik, TaskRabbit, TimeBank	
sharing of productive assets	Skillshare.com			Markerspace

For the purposes of our research a further break down of the types of sharing economy businesses in the transportation industry is warranted. Business models in the car industry have been called car sharing (Car2Go), ride sharing (Blablacar) and ride services (Uber, Lyft) (Schor, 2014, Codagnone & Martens, 2016).

Deloitte's (2017) analysis provides three types of car sharing: free-floating, stationary and peer to peer. The first is a short distance service in which vehicles can be reached anywhere within in a designated geographical area and the service is priced per minute or mileage. The second is to substitute car renting and is characteristic to smaller cities, while the third is based on individuals sharing their cars while not needed by them.

Participants of peer-to-peer ride sharing "use their personal vehicles to transport passengers, and do not work as agency employees" (Masoud and Jayakrishnan, 2017, p. 2.). This definition is also shared by the Martens (2016), which defines P2P sharing as follows: "the platform owner or organizer is often a formal company though individuals supply the service content". The definitions of P2P ride sharing implies the following criteria:

- internet-based platform connects peers to find each other and underutilised cars
- drivers offer rides for a fee
- mostly long-distance rides are provided (between cities, not within the city).

In the following sections we will use the term 'sharing economy' as defined by Botsman (2013) and will also use the concept of peer-to-peer ride sharing as introduced by Schor (2014).

Theoretical considerations relating to the sharing economy

Being a rather new phenomenon, the sharing economy has been examined from a number of vantage points using different theoretical considerations as a backdrop.

Guttentag (2013) and Christensen and Raynor (2003) look at the sharing economy as a disruptive innovation and come to the conclusion that the sharing economy – in their case the sharing of accommodation – is a part of the grey economy and has segments of illegality (e.g. tax avoidance). They conclude that the sharing economy will not be able to 'destroy' well-known products and services but they can find a way to offer better, easier and cheaper solutions (Guttentag, 2013).

Möhlmann's (2015) research concludes that rational thinking and the self-interest of users are typical for users in collaborative consumption. She builds her research on well-established concepts, such as Hardin's tragedy of the commons, the prisoner's dilemma and Olson's logic of collective action (Möhlmann, 2015). According to the results regarding Car2Go (C2B), a car sharing business, the most important five factors influencing the choice of sharing options are as follows: cost savings, familiarity, service quality, trust, and utility (Möhlmann, 2015). She also confirms that utility and social involvement motivates repeated participation.

Somewhat contrary to Möhlmann's conclusions, Hamari et al. (2016) emphasize the importance of the altruistic behaviour of participants of the sharing economy. The authors use self-determination theory to describe the sharing economy and conclude that inner motivation factors promote the use of the sharing economy while motivation factors coming from the outside do not. Similarly to other authors, they also find that using the services of sharing economy businesses provides a certain satisfaction to the users. According to Hamari et al. (2016), economic benefits motivate users more than sustainability perspectives. McArthur (2014) describes experiences of land sharing by using the self-determination theory, which focuses on people's motivation and inner needs for perpetually growing consumption (Ryan and Deci, 2000). McArthur defines five motivation factors to participate in sustainable communities: "sense of community, personal development, spirituality, ethical processes, and more control" (McArthur, 2014). Tussyadiah (2016) uses social exchange and self-determination theory to describe the sharing economy. He concludes that peer to peer accommodation users' motivation are enjoyment and cost savings (like in McArthur, 2014) and that users usually do not consider environmental aspects. Böcker and Meelen (2017) also explain the sharing economy using the self-determination theory. They found that there are significant differences between the types of shared goods and services and the users and providers of these. Users have different motivations by sector as well: while environmental aspects play an important role in the motivation of users of car and ride sharing, apartment sharing is more based on financial considerations. Financial motivations are more characteristic to younger users and those with lower income.

The motivation of collaborative consumers can be analysed in the context of social norms and networks (Ferrari, 2016). The sharing economy connects people who are strangers to each other and thus enables a market equilibrium of demand and supply (Ferrari, 2016). On-line platforms are based on trust between the users (Olaisen and Revang, 2017). Ferrari (2016) explains the sharing economy using the social capital theory: ratings of users play an important role in the choice of 'partners'. Kim et al. (2017) also used the social capital theory to analyse Couchsurfing and conclude that participating users put a high value on being part of a group of likeminded people and also expect to receive similar services in exchange of what they provided.

Another theoretical approach, which may contribute to a better understanding of sharing economy businesses is network theory, which has evolved from graph theory in the mid 1900s. A network is defined as "a specific set of relations making up an interconnected chain or system for a defined set of entities that forms a structure" (Thompson, 2003, p. 54.). "Complex network structures describe a wide variety of systems of high technological and intellectual importance such as the Internet, World Wide Web, coupled biological and chemical systems, financial, social, neural, and communication networks" (Silva and Zhao, 2016, p. 15.). Complex networks have several types, such as random networks, small-world networks, clustered random networks, scale-free networks, and core-periphery networks (see for example Silva and Zhao, 2016).

A spatial network is used to describe geographical links between nodes, but "physical distance could be replaced by other parameters, such as a social distance measured by salary, socio-professional category differences, or any quantity which measures the cost associated with the formation of a link" (Barthlémy, 2011, p.3.).

According to Blondel et al. (2008)" weighted networks are networks that have weights on their links, such as the number of communications between two mobile phone users". The idea of weighted networks can be utilised for ride share initiatives as well: some links are more popular among users than others. Hubs are "groups of vertices within which the connections are dense but between which they are sparser" (Newman, 2004).

According to Sedgewick and Weyne (2011, p.1.) "a directed graph (or digraph) is a set of vertices and a collection of directed edges that each connects an ordered pair of vertices". In other words, directed graphs have a head (from where the link originates) and a tail (the ending point of the link). Weighted graphs' attribute is to have two degrees: an in-degree (link to the node) and an out-degree (link out of the node) (Fortune, 1980).

Another useful approach to examine the sharing economy is social network theory which helps researchers to understand social connections in the framework of network theory. According to Barthlémy (2011) the social network theory is a special type of spatial theory - in this case nodes are people or groups and links are social connections (Potts, 2008). Granovetter (1973) claims that social networks have divergent types of relationships and weak connections are more effective in certain situations (such as job search) than stronger ones.

Bagler's (2008) analyses India's airports by taking a network theory approach and claiming that centrality exists in the airline network. "ANI (Airline Network India), whose topology has a signature of hierarchy, has small-world network features and is characterized by a truncated scale-free degree distribution."

Methodology

In order to highlight the most important features of the sharing economy using a network theory approach, we use the case of a regional drive share company, Oszkár, based in Hungary. Oszkár operates a platform, through which both domestic and international travel is facilitated.

Oszkár started its operations at the end of 2007 when the two founders realised the benefits of internet based platforms for car sharing purposes.

Users of the Oszkár platform can be either 'drivers', 'passengers' or both. Apart from 'casual' drivers, professional drivers also started to offer their services through Oszkár's platform (defined as having more than 40 passengers per month).

Oszkár is a successful business growing steadily over the years and successfully competing with alternative platform operators in the region.

In order to use the insights of network theory for the case of Oszkár, we identify vertices as departure and arrival settlements and edges as the trips taken between them.

Data for the analysis was provided by the company for the period of 2008-2015. This included the followings:

- reservations and actual trips made through the Oszkár platform
- registered users of the platform
- settlement and country of origin and arrival
- date and time of reservation and trip
- age and gender of drivers and passengers
- maximum number of empty seats offered
- data regarding reservations
- type of trip: by casual or professional driver.

The database received from the company required only minor amendments. We removed the trips undertaken by passengers with unrealistic birth dates (i.e. those born before 1920 and after 2005) – this effected less than 0.5% of all trips). We also removed trips where the date of travel preceded the date of reservation (there were only a handful of such records) and those trips, which had passengers registered later than the closing date of the database (0.034% of all the trips), since these also represented errors in the database. This allowed us to examine the full database of more than 860 000 trips over a period of eight years.

Discussion

Analyzing the database we can see a compelling growth in both the number of cities involved (the nodes) and the trips taken (the edges) from year to year as shown in Table 2.

Table 2 – Number of nodes and edges (links) between 2008 and 2015

Years	2008	2009	2010	2011	2012	2013	2014	2015
Nodes (cities)	52	79	145	281	559	758	1200	1591
Edges (rides)	475	668	3352	10319	41320	117576	241311	448631

Millard and Carpenter (2014) present three main phases of social innovations. In the first phase the social platform resembles to the attributes of small-world networks (Watts-Strogatz, 1998): a node has connections with only few other nodes. In the second phase the platform shows features of scale-free networks (Barabási-Albert, 1999): nodes with high number of links are attracting more new nodes and the number of nodes and links are changing in time. In the third phase network's show the features all three types of networks: small-world, scale-free, and random. Oszkár is a ten year old start-up and data provided by the company shows that it fulfils the conditions of a second stage P2P ride sharing system: it has several hubs among numerous nodes and the hubs are connected through more and more links. In Figures 1 and 2 it can be clearly seen that while the first 3-4 years growth was rather slow but after these initial years it picked up speed and started to show the characteristics of a scale-free network. Looking at the growth rates of the number of settlements vs. the number of rides, it is evident that the growth of links (rides) is more remarkable than the growth of settlements involved.

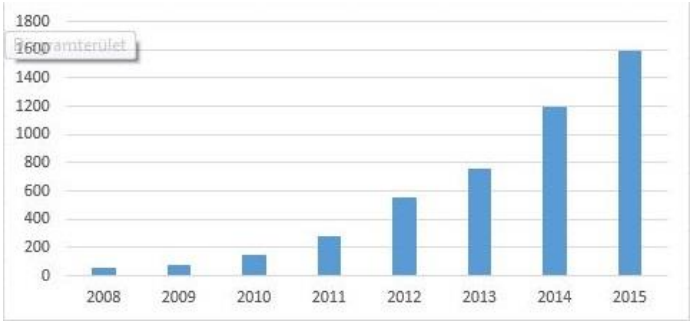

Figure 1 Number of settlements where at least one Oszkár trip started or ended, 2008-2015

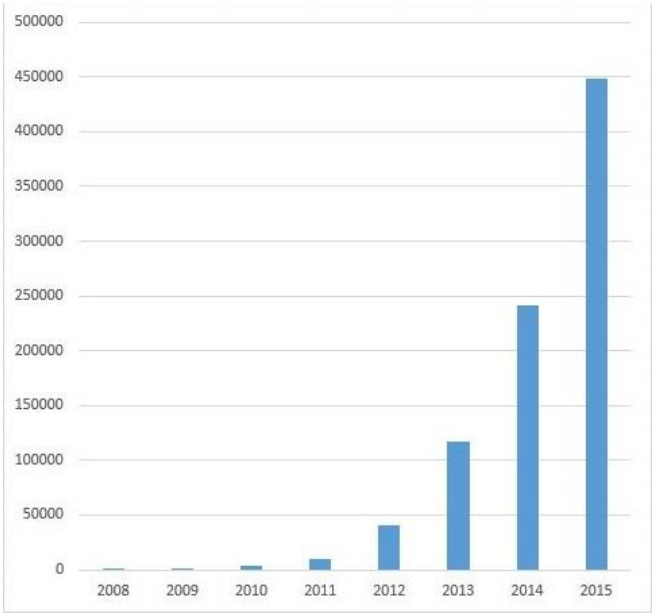

Figure 2 Number of rides using Oszkár, 2008-2015

Using Gephi to analyse the available data, a total of 2 179 settlements are connected by 10 462 routes in the Oszkár database. Although Oszkár is Hungarian-based, its users make numerous trips abroad using the platform. Figure 3 shows the number of domestic and international cities in the period of 2008-2015, while Figure 4 shows the ratio of Hungarian and foreign trips indicating an increase of the latter.

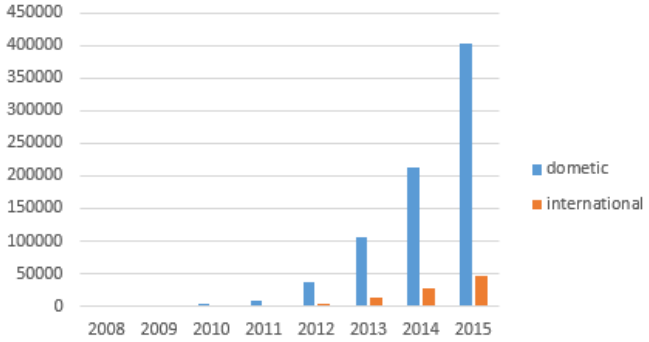

Figure 3 Number of domestic and international nodes (settlements), 2008-2015

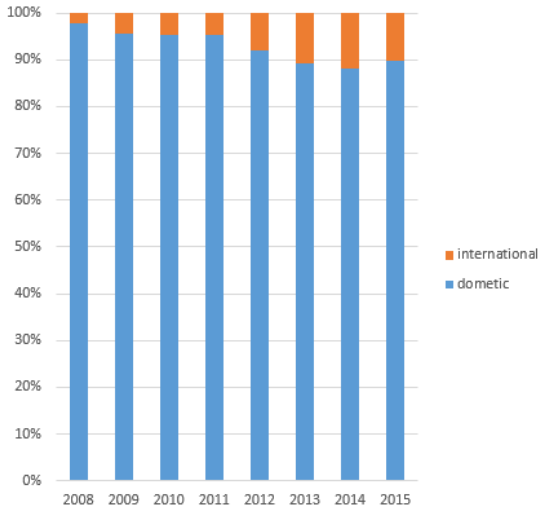

Figure 4 Rate of domestic and international nodes (settlements), 2008-2015

In 2008 international trips were around 2%, while in 2014 they reached almost 12% meaning that almost every 9th trips is an international one. This tendency may be a result of more and more Hungarian citizens working/residing in a foreign country. This is reinforced by the most popular countries as shown in Figure 5.

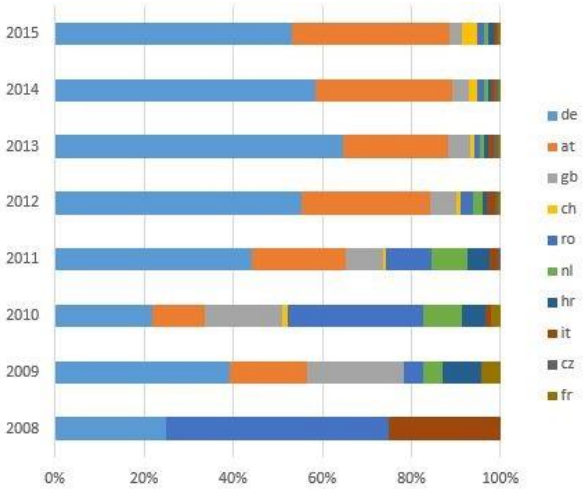

Figure 5 Most popular arriving destinations abroad among Oszkár users, 2008-2015

In 2008 only five countries appear in the database, namely the Slovak Republic, Romania, Belgium, Italy and Germany. Other countries also joined in from 2009 since when Germany became the most often chosen starting point/destination followed by Austria and Great Britain. These countries are the most popular destination for those working outside of Hungary.

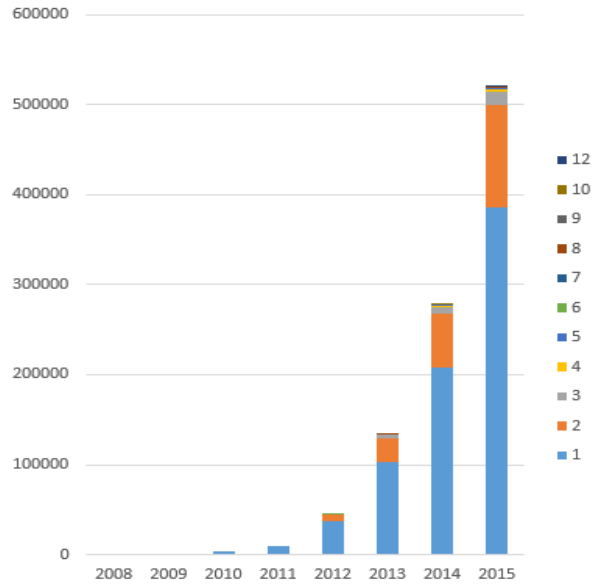

Figure 6 Number of reserved places by Oszkár users, 2008-2015

The growth in both domestic and foreign trips is significant as shown in Figures 6 and 7. In the early years of the platform most reservations were made for one single person, but tendencies show that users book more and more seats each year. This implies that users tend to travel with friends and family and that the growth of the platform is even more pronounced if we look at reservations rather than trips. Figure 7 illustrates the maximum number of passengers accepted by the driver for a certain trip. While most drivers offer 2-4 seats, an increase of seat numbers offered is evident from around 2011. This is a result of professional drivers entering the platform offering up to 8-9 seats per vehicle.

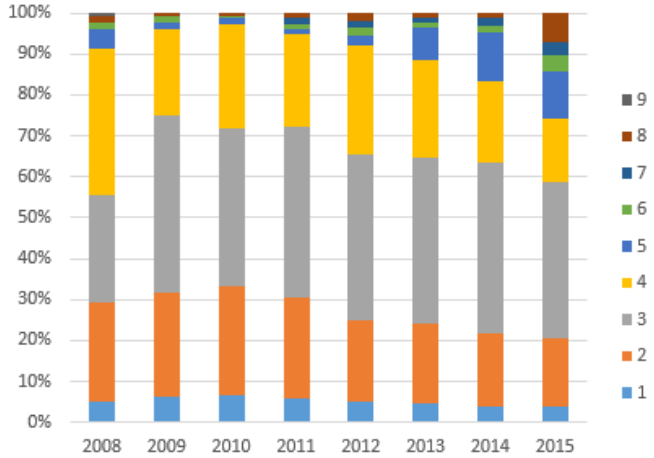

Figure 7 Number of settlements offered, 2008-2015

Apart from a shift in the composition of drivers, a change in passenger behaviour can also be identified by the further analysis of the data. Figure 9 shows the number of days elapsed between the date of the reservation and the actual trip. In the early years of operations passengers booked their trips earlier ahead: the ratio of trips booked on the day of the trip or only one day ahead has increase from around 48% to more than 60% in 2015.

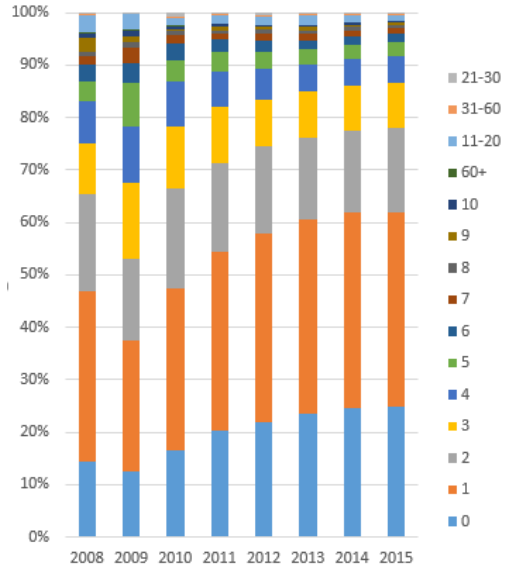

Figure 9 Number of days elapsed between reservation and trip, 2008-2015

As we have seen numerous facts are proving the growth of Oszkár in- and outland as well. Our hypothesis next to fast growing of the users were also that this leads to a centralized system meaning that there is a main city with the most links and some other smaller ones – like cities with universities and high economic impact – with several edges and there are countless of small settlements involved with low number of links.

This was similar what we were experimenting. Figure 10 is showing us centralized network of Oszkár.

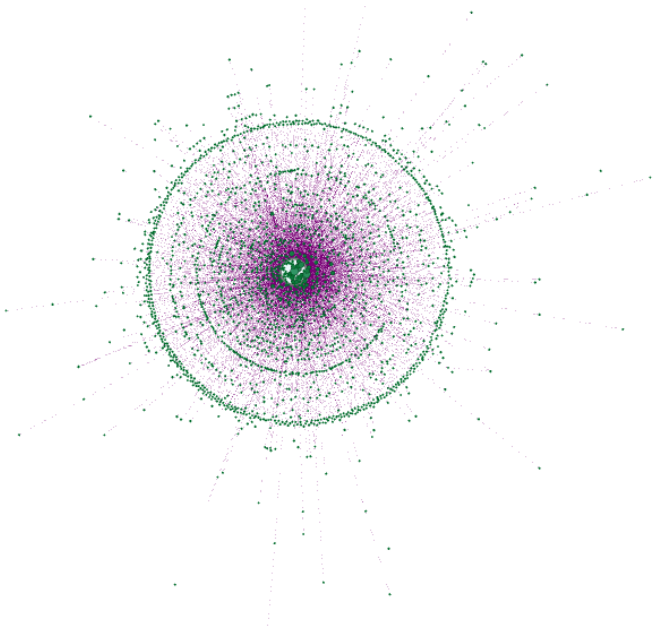

Figure 10 Centralized network of Oszkár between 2008 and 2015

Green points are representing the cities and purple links the trips take between cities. In the center of the circle there is the capital city of Hungary, Budapest, having the highest links being the biggest hub in the network. There are some other hubs as well like cities with less link than Budapest but still important in the network. Four bigger circles are seen as well, which are showing us – from inside to outside – settlements with less edges.

Conclusion

Our research aimed at characterizing the growth dynamics of sharing economy businesses by analyzing the data provided by a regional drive sharing operation.
After summarizing available concepts relating to the sharing economy, we introduced the most important research undertaken to date using a variety of theoretical backgrounds. We chose network theory to anchor our research and quantified the most important features of the chosen regional drive-share company.
We found that the Oszkár network shows the features of little-world and scale-free networks along its development path. As many successful sharing economy businesses, the growth of Oszkár is very fast and by 2018 it extends to more than a thousand settlements in the country serving over 800 000 thousand trips over the last 8 years of operations.
We provided a further characterization of the network by looking at the direction (domestic and foreign) and composition of trips (by 'casual' and 'professional' drivers) and a change in the behavior of users (time elapsed between booking and departure).
While our results are interesting and add to a better understanding of sharing economy businesses, their use for identifying future tendencies is limited as a result of several factors (e.g. changes in legal regulation, new competitors, etc.) not under the control of the company.

References

Bagler, G., (2008), "Analysis of the airport network of India as a complex weighted network" *Physica A* Vol. 387 pp. 2972–2980

Barabási A-L., Albert, R., (1999), "Emergence of Scaling in Random Networks" *Science* Vol. 286 pp. 509-512

Barthélemy, M., (2011), "Spatial networks" *Physics Reports* Vol. 499 pp. 1–101

Blondel, V. D., Gillaume J-L., Lambiotte, R., Lefebvre, E., (2008), *Fast unfolding of communities in large networks*, Journal of Statistical Mechanics: Theory and Experiment

Botsman, R., (2013), "The Sharing Economy Lacks A Shared Definition" https://www.fastcompany.com/3022028/the-sharing-economy-lacks-a-shared-definition (08.05.2018.)

Botsman, R., (2015), "Defining The Sharing Economy: What Is Collaborative Consumption–And What Isn't?" https://www.fastcompany.com/3046119/defining-the-sharing-economy-what-is-collaborative-consumption-and-what-isnt (08.05.2018.)

Böcker, L., Meelen, T., (2017), "Sharing for people, planet or profit? Analysing motivationsfor intended sharing economy participation*" Environmental Innovation and Societal Transitions* Vol. 23 pp.28–39

Christensen, Clayton M., Raynor, M. E., (2003), *The Innovator's Solution: Creating and Sustaining Successful Growth*. Boston, Harvard Business School Press

Codagnone, C., Martens, B., (2016), *Scoping the Sharing Economy: Origins, Definitions, Impact and Regulatory Issues*. Institute for Prospective Technological Studies Digital Economy Working Paper 2016/01. JRC100369, European Union

Deloitte, (2017), "*Car Sharing in Europe - Business Models, National variations and Upcoming Disruptions*"

"Ferrari, M., (2016), "Beyond Uncertainties in the Sharing Economy: Opportunities for Social Capital",
European Journal of Risk Regulation, Vol. 7 No. 4., pp.664-674

Fortune, S., Hopcroft, J., Wyllie, J., (1980), "THE DIRECTED SUBGRAPH HOMEOMORPHISM PROBLEM" *Theoretical Computer Science* Vol.10, pp. 111-121

Granovetter, M., (1973), "The Strength of Weak Ties" *American Journal of Sociology*, Vol. 78 No. 6,

pp.1360-1380
Guare, J., (1990), "*Six degrees of separation*", International Creative Management Inc.
Guttentag, D., (2013), "Airbnb: disruptive innovation and the rise of an informal tourism accommodation sector" *Current Issues in Tourism* Vol. 8, No. 12, pp. 1192-1217
"Hamari, J., Sjöklint, M., Ukkonen, A., (2015), "The Sharing Economy: Why People Participate in
Collaborative Consumption*", Journal of the Association for Information Science and Technology* Vol. 67, No. 9, pp. 2047-2059"
Kim, S., Lee, K. Y., Koo, C., Yang, S., (2017), "Examining the influencing factors of intention
to share accommodations in online hospitality exchange networks" *Journal of Travel & Tourism Marketing*, Vol. 35, No. 1, pp. 16-31"
"Mallargé, J., Zidda, P., Decrop, A., (2017), "*The service evaluation process in the sharing economy: Why consumers seem to be more tolerant towards poor service quality*", IAJBS World Forum 2017, Session 3.a: Sharing economy
Martens, B., (2016), *An Economic Policy Perspective on Online Platforms* JRC Technical Repots - INSTITUTE FOR PROSPECTIVE TECHNOLOGICAL STUDIES DIGITAL ECONOMY WORKING PAPER 2016/05
Masoud, N., Jayakrishnan, R., (2017), "A real-time algorithm to solve the peer-to-peer ride-matching problem in a flexible ridesharing system*" Transportation Research Part B: Methodological* Vol. 106 pp. 218-236
McArthur, E. (2014), "Many-to-many exchange without money: why people share their resources", *Consumption Markets & Culture*, Vol. 18. No. 3, pp.239-256
Meelen, T., Frenken, K., (2015), "Stop Saying Uber Is Part Of The Sharing Economy", https://www.fastcompany.com/3040863/stop-saying-uber-is-part-of-the-sharing-economy
"Millard, J., Carpenter, G., (2014) "Digital technology in social innovation" A publication from the FP7-project: TEPSIE (290771)"
Möhlmann, M. (2015), "Collaborative consumption: determinants of satisfaction and the likelihood of using a sharing economy option again", *Journal of Consumer Behaviour*, Vol. 14, No. 3, pp. 193-207
Newman, M. E. J., (2004) "Analysis of weighted networks" *Phisical Review E* Vol. 70, 056131
Olaisen, J., Revang, O., (2017), "Working smarter and greener: Collaborative knowledge sharing in virtual global project teams" *International Journal of Information Management,* Vol. 37 pp.1441-1448
Ryan, M., Deci, E., (2000), "Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being" *American Psychologist* Vol. 55, No. 1, pp. 68-78
Schor, J., (2014), "Debating the Sharing Economy" A Great Transition Initiative Essay - http://www.greattransition.org/publication/debating-the-sharing-economy (05.08.2018.)
Sedgewick, R., Wayne, K., (2011) *Algorithms*, Princeton University
Silva, T.C., Zhao, L., (2016), *Machine Learning in Complex Networks*, Springer International Publishing Switzerland
Thompson, G. F., (2003), *Between Hierarchies and Markets: The Logic and Limits of Network Forms of Organization*, Oxford University Press, Oxford
Tussyadiah, I.P., (2016), "Factors of satisfaction and intention to use peer-to-peer accommodation*" International Journal of Hospitality Management* Vol.55, pp. 70–80
Watts, D. J., Strogatz, S. H., (1998), "Collective dynamics of 'small-world' networks", *Nature* Vol. 393, pp. 440-442.
Wosskow, D. (2014*), Unlocking the sharing economy - An independent review*, London.