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CAR-SHARING: THE IMPACT ON METROPOLITAN SPATIAL STRUCTURES

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Abstract: Many examples from the past show that new technologies designed to solve particular problems can also create side effects generating new problems. Some unforeseen or unwanted results may influence space use and spatial structures. Car-sharing is an invention to compete with car ownership. It drastically rise efficiency of car use, reducing the number of vehicles per users. Diffusion of car-sharing is going to accelerate in the near future. The spatial consequences of the car-ownership-oriented-century are already known. But things can complicate if everybody could join traffic with shared automobiles. It is therefore appropriate to anticipate potential side effects of this innovation's diffusion to avoid negative consequences, and if necessary – to prepare to encounter them. This led to undertake research on the relationship between modern mobility innovations and metropolitan spatial structures. The earliest implementations of new transport technologies appear in metropolises which also have the highest level of general mobility. The article presents the assumptions and principles of scenario-based research. The example shows how diffusion of innovation determine possible scenarios of the future impacts of car-sharing on spatial structures.

Introduction

Many examples from the past show that new technologies designed to solve particular problems can also create side effects generating new problems (Smolnicki, 2014). This statement was an inspiration for the broader research problem about the impact of modern technologies on spatial structures (Smolnicki, 2015). It led to open PhD Course about *Relations Between Emerging Mobility Technologies and Metropolitan Spatial Structures*. The following article presents part of the research considering the spatial impact of emerging mobility service known as *car-sharing*. The spatial side effect of automobile ownership since over one century are already known. This article is approaching to answer the question if car-sharing services can mitigate or develop the unwanted automobile-related spatial consequences. Today around the world there are hundreds of car-sharing fleets enabling to pick up a car just from the street. The literature review presents selected research about car-sharing services throughout the world. Later the article presents and discuss research results about possible consequences of car-sharing on metropolitan (urban and suburban) spatial structures. The research uses scenario method as the identification tool for the upcoming future. Each scenario results are evaluated and therefore optimal scenario main lines are highlighted. At the end further research on the topic is proposed.

Literature review

Car-sharing idea is developing in Europe continuously since the first post-war years (Neckermann, 2015, loc. 190, Shaheen & Cohen, 2013, p. 7, 2013, p. 5). Susan Shaheen et al.'s define car-sharing as *a program where individuals have temporary access to a vehicle without the costs and responsibilities*

of ownership (Shaheen, Chan, Bansal, & Cohen, 2015, p. 20) dividing it for three categories: one-way car-sharing, round-trip car-sharing and personal peer-to-peer (P2P) car-sharing (Shaheen et al., 2015). Vehicles can be found on the street where the last user finished his travel, or in the dedicated charging stations for electric vehicles (EV's), or through dedicated applications connecting service participants: users and car owners. Car-sharing is more efficient in denser populated urban areas (Rupprecht Consult – Forschung & Beratung GmbH, 2013, p. 4), and when it is available directly in peoples neighbourhoods (Bundesverband CarSharing e. V., 2015). It is estimated that one shared car can exchange between only four to as much us twenty-three cars (dependent on various local conditions) (Badger, 2013/2013, 184; Ceille, November 12-th, 2015, 05:00; Neckermann, 2015, loc. 1640; Shaheen & Cohen, 2013, p. 9). Therefore car-sharing is responsible for car-sale reduce and the trend will continue (Schwartz & Rosen, 2015, loc. 1431). MIT research has shown that 80 percent reduce of cars can be achieved by combining ride- and car-sharing (Ratti & Claudel, 2015). It is due to millennials who pay much less attention for ownership, including owning a car (Gao, Hensley, & Zielke, 2014). The average rental time of different services is between thirty and seventy minutes depending also on local conditions throughout the world (Neckermann, 2015, loc. 1684). While station-based system cars are more populated, the free-floating car-sharing systems are more popular (Bundesverband CarSharing e. V., 2015).

Many automotive OEMs are developing driverless vehicles and the same time investing in car-sharing and similar mobility services (Bertoncello & Wee, 2015). Vehicle manufacturers, together with their suppliers, technology entities and researchers are developing connected and fully autonomous (i.e. driverless, self-driving) vehicles – CAVs (Lander et al., 2016, pp. 9–10). Car-sharing is not for big suburbs everyday ride (Castor, November 12-th, 2015, 1:00:00) but the question is: will driverless-car-sharing change this? It is also estimated that due to automation vehicle sales will continue to grow but with urban (instead of suburban and regional) areas as the main type of segmentation (Mohr, Kaas, Gao, Wee, & Möller, 2016, pp. 4–5). Moreover, the MIT Media Lab study shows that shared driverless mobility in denser urban areas can get rid of all parking with possibility to exchange single parking bay with higher functioning uses equal to few dwellings (Lander et al., 2016, pp. 9–10; Larson, November 11-th, 2015, p. 1:02:00). Lawrence Burns, the director of the Program on Sustainability at Columbia University's Earth Institute estimates that shared-driverless systems could offer customers about 90% savings comparing to the costs of car ownership, while delivering better experience (Mui & Carroll, 2013/2013, 323). Institute of Electronic Equipment Engineers (IEEE) estimated that driverless cars could account for up to 75 percent of all cars until 2040 (Schwartz & Rosen, 2015, loc.3780). Cato Institute warns that transportation services are not prepared for car-sharing diffusion (Neckermann, 2015, loc. 1938). Some anticipate that public transit will disappear due to the drieverless car-sharing (O'Toole, 2016). Self-driving cars are not engaging traveller, therefore people who chose public transit due to the possibility of working instead of "wasting" time during driving can switch to autonomous automobiles (Sullican, 2015, 201; Wadud, p. 2; Wayner, 2013/2013, 1095). Moreover, few

car-sharing fleets already expanded to suburban areas (Shaheen & Cohen, 2013, p. 6). This can promote continuation of suburbanization. In the future car-sharing will not replace privately owned cars but complement with it (Bundesverband CarSharing e. V., 2015). In case of driverless car-sharing the time spent in vehicle could be used productively, therefore suburbs can grow into further distances. Moreover, it can be assumed that car-sharing may result in significant changes on spatial structures, depending on the way of its introduction and diffusion. The future of mobility industry is to simultaneously compete and cooperate with competitors (Mohr et al., 2016, pp. 4–5). Therefore we can also estimate that market together with public sector will balance use of each mode of urban transport but in dependence of other factors, like developing spatial structures.

Methodology

The research study was based on heuristic construction of scenarios. Scenario method is one of the most useful prognostic methods, especially in the case when the social and institutional behaviours play a crucial role (Chojnicki, 1988). The oldest and one of the best definitions of scenarios was formed by Kahn and Wiener who defined the term scenario as a possible, often hypothetical, sequence of events constructed in an internally consistent way for the purpose of focusing attention on causal processes and decision points (cited in: Torrieri & Nijkamp, 2005). Godet defines scenario as *a description (usually of a possible future) which assumes the intervention of several key events or conditions which will have taken place between the time of the original situation and the time in which the scenario is set* (2010, p. 1489). Among the types of scenarios distinguished by Ducot and Lubben (1980) descriptive exploratory scenarios are the best for the subject of described study.

In this article each scenario presents diffusion of car-sharing service and its impact on metropolitan (urban and suburban) spatial structures (related to physical structures – built environment, and spatial socio-economic structures). Presented scenarios are general, therefore does not include detailed migrations between each mode of transport. The impact of emerging innovations and technologies, which can disrupt future mobility, is unpredictable, and not considered in this research.

Few main features of scenarios may be assumed as rules of differentiating scenarios for car-sharing, e.g.: different speed of diffusion, different quantitative share of car-sharing in general mobility, and different spatial spread. In the following research two independent variables were assumed as rules of differentiating scenarios: the type of investor (three types presented in Figure 1), and the decision of business model (three models presented in Figure 1). States of the independent variables are appropriate kind of assumptions (rules differentiating scenarios) in exploratory scenarios (Sołtys, 2014). Abovementioned features of scenarios are dependent variables, and thus will emerge as results in the scenario building process. Therefore it is possible that the so-called main lines of two (or more) scenarios (presented in Figure 1) may crossover or end up at one point. Each scenario's assumed states of the independent variables must be consistent with each other. Therefore Figure 1 presents eight main

lines of consistent combinations. Combinations not included are not consistent (e.g. privatisation of public car-sharing service).

Results and discussion

Figure 1 presents multiple main lines of scenarios of car-sharing diffusion impact on metropolitan spatial structures based on fleet investment sectors and decided business models. The users of the car-sharing service may come from both: automobile owners and transit passengers, regardless they have driving license or not. It is due to assumptions that both: car-sharing system will convince some people to get driver's license, and because more car-sharing fleets will offer driverless vehicles. There is also multiple number of factors that convince travellers to the specific mode of transport. There are six levels representing different scenario variables: (1) contemporary mobility segmentation, (2) investment sectors (3) public expenses needed for project's introducing, (4) business model decisions, (5) their future spatial impacts, and (6) their future public expenses. Scenarios end up with one of three possible results. Car-sharing service is located between individually owned cars (around 400-600 vehicles per 1000 citizens – dependent on location) and public transport (i.e. bus, light-rail, streetcar/tram). Car-sharing service is complementing both car and public transport use. The possible investors for car-sharing fleet are private (i.e. car manufacturers, IT mobility services providers) and public (i.e. municipality, national transportation company). One of the scenarios is based on private-public participation (PPP) where the fleet owner can be a private or public, infrastructure owned by the municipality, and service provided by private sector (i.e. ICT company). Scenario based on fully private ownership-and-service generates zero to very little introduction expenses for public sector. In PPP scenario the costs for municipality can start from little (i.e. connecting EVs charging stations to the city's grid) to medium (i.e. preparing parking bays with EVs charging stations, preparing and opening data, integrating public transport and information systems with car-sharing service). Public ownership scenario has the highest introduction costs for municipality due to the need of buying fleet, preparing infrastructure, connecting and maintaining services. This scenario's costs can be reduced due to the smaller scale implementing but the municipality has to keep in mind the possibility of inefficiency of small scale service.[1]

Car-sharing fleet investor type determines also business model. Market-related model is obviously chosen by private sector. Due to the appearance of new comfortable mobility mode for non-car-owners its consequences may result in suburbanization and also deurbanization of central urban areas, the same as it happened in many cities due to automobile domination and addiction (Davidow, 2015). The possible scenario is that private investor will introduce car-sharing service only in densely populated areas. In this scenario spatial consequences may result similar to PPP based scenario. Public and PPP investment may determine decision in both *sustainable* and *city revival* model. Sustainable model

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[1] The case of Helsinki's Kutsuplus on-demand bus service which worked until the end of 2015 and was hold due to high public costs before it could reach efficient share in all modes of transit – Sulopuisto (2016).

considers both cost effectiveness and smart urbanization. This model is preferred for cities with equally developed and functioning spatial structures, therefore it may generate income without creating additional negative spatial consequences for metropolitan area. For cities fighting with suburbanization and deurbanization the city-revival model is preferred but the system efficiency has to be considered (enough number of vehicles, accessible and popular locations and routes, political willingness to subsidize system using public funds).

Each of presented eight main lines of scenarios finishes with the future indirect costs. Due to the big infrastructure (underground, media, roads and highways) construction and maintenance expenses for low density suburban areas (sprawl) the private market-oriented model will generate high future indirect costs.[2] Therefore, inner city citizens will have to pay-off the city's edge infrastructure maintenance. The sustainable development scenario costs will be distributed equally. This scenario will not be justified if districts functioning will vary. In this case authors propose equity instead of the equality. The scenario based on city revival will heal sick districts, and therefore will generate the low indirect costs in the future.

The research presents simplified model of car-sharing diffusion. It is assumed that car-sharing may result in significant changes on spatial structures, depending on the way of its introduction and business model decision. The diagram ends up with three alternative results. Money-wasting suburbanization is considered as the worst result for the future common wealth. The cost-efficient reurbanization is considered as the best result. There are two main ways for achieving the best result bolded on the diagram: PPP and public investment. Due to the share of investment costs in PPP investment the car-sharing diffusion may have bigger aerial scale and quantitative share and therefore may diffuse faster and more cost efficient but the public sector have to direct its influence promoting equity over equality to reach the most positive result. Second bolded scenario is based on full public investment, therefore it has smaller scale and may be located in the areas of need – for example areas where it is hard to maintain self-owned car, for example due to the lack and high cost of parking space. In these areas car-sharing may improve locals' mobility and reduce private car use and therefore traffic, due to dedication of parking bays for shared cars. The city revival business model results in better life quality (more mobility options), lower costs of infrastructure maintenance (due to higher functional density and use intensity), lower costs of mobility comparing to car-ownership, and less space wasting (due to parking space reduce). Therefore, when planning car-sharing introduction it is significantly important to focus on assumed far reaching results.

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[2] There are also other indirect costs, i.e. sprawl-related diseases (diabetics, obesity, asthma, car-related injuries etc.) – Speck (2013, 531), transportation costs – Schwartz and Rosen (2015, 1520), food transport and storage costs – Frey and Yaneske (2007, pp. 86–87).

Figure 1: Scenario main lines: Impact of car-sharing diffusion on metropolitan spatial structures
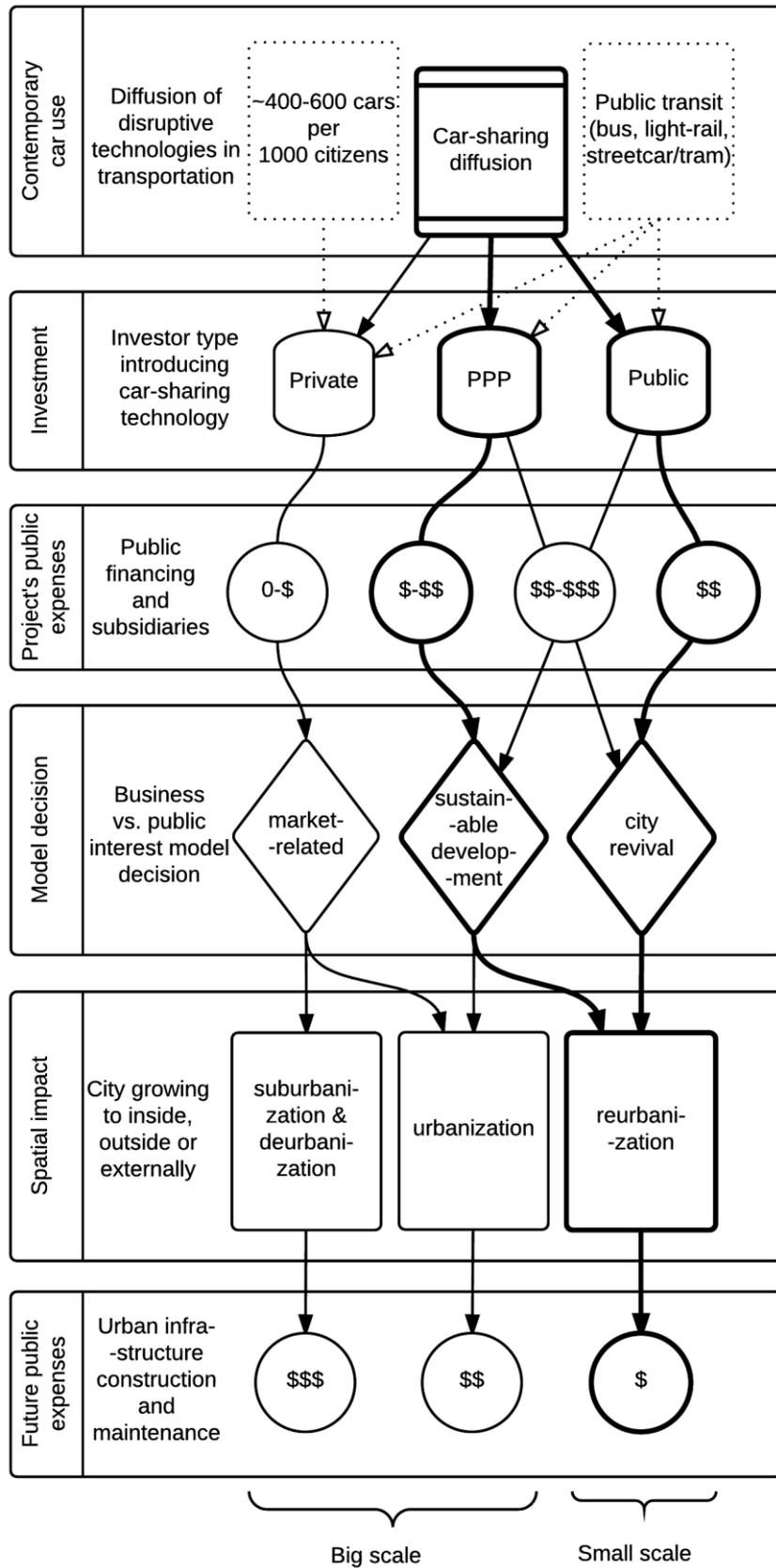
Source: Author. Costs: 0 – very little, $ – little, $$ – medium, $$$ – high; **bold** – optimal scenarios.

Conclusions

The research objectives were met by answering the question how to manage the car-sharing diffusion to approach optimal results in the future and what ways to avoid. It is essential to continue the research before the side effects of technological diffusion will be irreversible. Research should be also repeated with the use of new variables to check if the same answers will be achieved. The results should also be confirmed by multiple surveys: on experts (Delphi method), on representative space of metropolitan area users (citizens, students, tourists, workers), and users of already implemented car-sharing systems.

Contributions

In above article P.M. Smolnicki's contribution is literature review and research of car-sharing scenarios, and Jacek Sołtys' contribution is methodology and supervising for the content quality.

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