Leibniz Universität Hannover

Wirtschaftswissenschaftliche Fakultät

Institut für Wirtschaftsinformatik

Ecological and Profitable Carsharing with Heterogeneous Fleets

Masterarbeit

zur Erlangung des akademischen Grades „Master of Science (M. Sc.)“ im Studiengang Wirtschaftswissenschaft der Wirtschaftswissenschaftlichen Fakultät der Leibniz Universität Hannover

Vorgelegt von:

Name: Möller [redacted]

Vorname: Max [redacted]

Prüfer: Professor Dr. Michael H. Breitner

Ort, den Hannover, 22. September 2016

Abstract

In the course of an increasing environmental awareness, issues like sustainability, reduction of emissions such as CO_2, traffic congestion and noise in cities arouse global attention. The mobility concept of carsharing supports sustainability by including alternative propulsion systems like hybrid and electric vehicles into the fleet. In this thesis, the development of a tactical optimization model is presented which considers the determination of the monthly optimal fleet composition and size in a station-based two-way carsharing system optimizing the monthly net profit of a carsharing organization. In order to satisfy the demand in a carsharing organization, the availability and distribution of vehicles within a fleet is a crucial success factor. Therefore, several vehicle classes and propulsion systems are regarded. To show the applicability of the model, demand variations are assumed throughout the year. Additionally, a limitation of CO_2 emissions is included to fulfil individual or local requirements for emissions. Furthermore, some benchmarks and sensitivities are given using the example of San Francisco, USA. The results show the applicability of the introduced optimization model and indicate that demand variations and selected CO_2 emission limits mostly influence the distribution and size of a heterogeneous carsharing fleet. The results further indicate that carsharing operations with alternative vehicles are profitable. In the context of the benchmarks and sensitivities several input parameters are varied and discussed subsequently. In order to achieve cost efficiency it is not essential that the heterogeneity of the fleet is high. Furthermore, vehicles with hybrid propulsion systems should represent the main part of the fleet.

Keywords: carsharing, heterogeneous carsharing fleet, electric vehicles, fleet size, optimization model, emissions, tactical planning

Table of Contents

1 Introduction

1.1 Motivation

In a constantly evolving world new ideas and innovations arise every day and new knowledge is continuously generated by the humanity. Besides, the resulting experiences increase the requirements in different sectors. Some of those growing needs are environmental awareness, desire for freedom and independence as well as the society's focus on mobility [91]. Growing environmental awareness in the private and public sector and an increasing percentage of the world's population living in cities, lead to an exchange in car usage and private vehicle ownership [39, 96]. Nowadays, 50 percent of the world's population live in cities, whereas the expected share increases to 60 percent in 2030 [96]. In accordance with a survey by the Bundesministerium für Verkehr und digitale Infrastruktur [21] 90 percent of the surveyed people are mobile on the road on the due date and 58 percent of all distances are travelled by car [21].

Due to the good public transportation network, a car ownership is often not worthwhile in big cities [102]. The reason is that journeys to the town center are travelled faster with the public transportation network and seeking for parking lots is not necessary [95]. However, many people do not want to give up the advantages of a private car ownership. A car, for example, facilitates regular purchases of groceries and trips to remote locations because of the higher comfort. On the basis of the ecological aspect the means of transportation is questioned because of economical uncertainty, increasing energy costs and the desire for carbon dioxide (CO_2) reduction. Since sustainable mobility concepts constitute the current and future demand, an alternative to a car ownership that enables economical hiring of a car is the concept of carsharing [8, 95]. Carsharing is a sustainable and eco-friendly mobility service in public road transport. Individuals have access to a fleet of shared-use vehicles in an urban area and only pay for the time they use the car and/or the distance they go, while the fixed costs must be taken by all users [97].

According to Stiftung Warentest [102], carsharing is profitable for individuals with an irregular need for a vehicle [102]. Therefore, carsharing is economic, if the average annual distance is between 10,000 and 20,000 kilometers [102]. Due to technological progress and modern communication and information technologies the carsharing market is continuously growing [61]. Today, carsharing organizations (CSOs) are able to provide a high service level to the customers [67]. Thus, the total number of carsharing members has strongly increased in recent years. Figure 4 shows that the total number of carsharing users increases from 116,000 in 2008 up to 1,260,000 in 2016 [22].

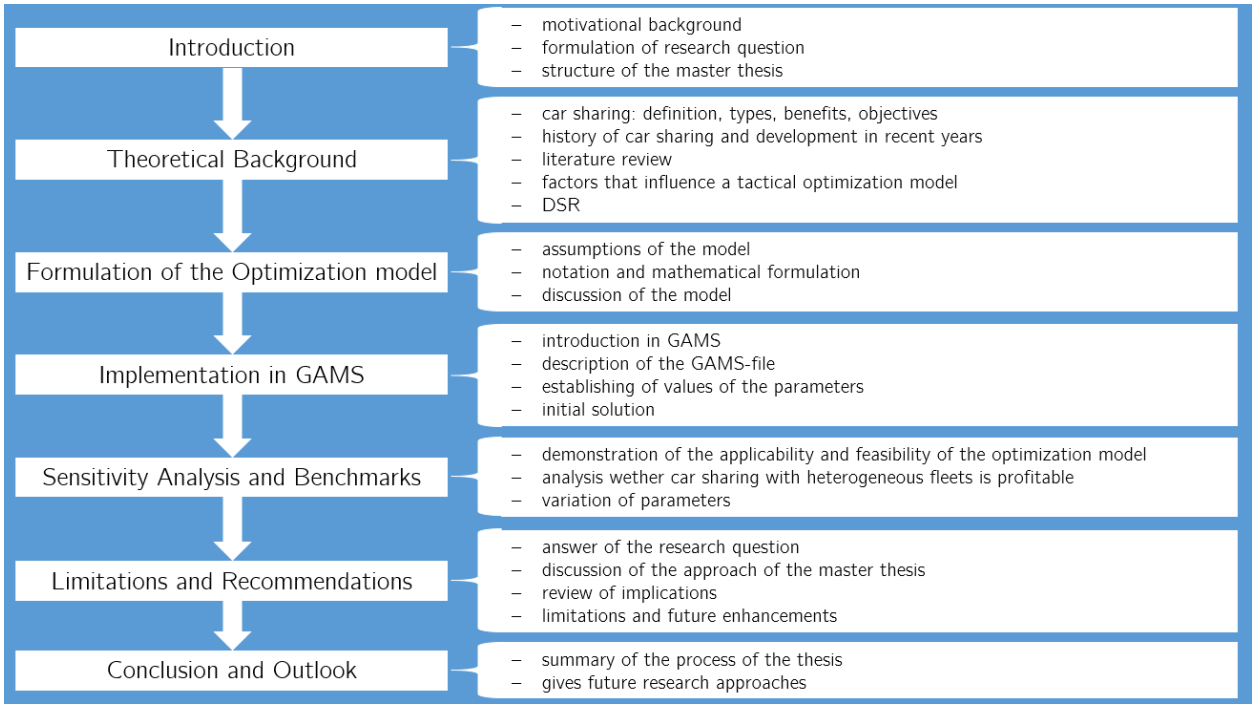

Figure 2: Outline of the Master Thesis

The last section 7 concludes the thesis with a short summary and an outlook. To ease the structure, Figure 2 summarizes the overview of this master thesis.

7 Conclusion and Outlook

Due to the constantly generation of new knowledge innovative ideas emerge almost daily and are transformed into new business models. However, the leadership of any company is continuously facing challenges that need to be overcome [73]. One of these challenges, for example, deals with the optimization of eco-friendly technologies, such as alternative propulsion systems. Due to an increasing environmental awareness and a raising percentage of the world's population living in cities, research deals with reconsideration and modernization of current modes of transportation. Accordingly, people review their need for personal vehicle ownership.

One alternative for a car ownership that enables hire of a car is the concept of carsharing, including electric and hybrid vehicles in the fleets, in order to consider the ecological aspect [8, 95]. Therefore, the objective of this thesis is to develop a tactical optimization model to provide a sustainable mobility concept maximizing the net profit of a CSO. With regard to a sustainable composition of a carsharing fleet, a maximum average admissible CO_2 emission must be set by any CSO to identify their individual importance of environmental awareness. In order to limit the organizational effort, a maximum distance between demand locations and established station is included, additionally. However, the focus of this thesis is the development, formulation and application of a tactical optimization model that determines the composition and size of a heterogeneous carsharing fleet. The model faces time-dependent demand as well as several vehicles classes and propulsion systems. The applicability of the model is presented by the case example of San Francisco, USA. Certainly, the model is adjustable for any other city in the world by taking the individual city characteristics into account. Due to different weather conditions or big events in certain months, the proposed optimization model provides the possibility to react on demand fluctuations monthly.

The results show, that a varying amount of demand has an enormous influence on the number and distribution of the vehicle fleet. Thus, the number of vehicles within the fleet increases as well as the number of electric cars with the growing demand. Additionally, a reduction of *comax* leads to need of electric vehicles. Furthermore, the diesel price has a strong influence on the distribution of vehicles. In the context of an increasing diesel price, electric vehicles become relatively cheaper than other vehicle types. Totally, the fleet is characterized by a tendency of two vehicle types. Only a few benchmarks suggest the usage of all propulsion systems. With regard to the benchmarks hybrid vehicles reveal cost advantages in comparison to diesel and electric vehicles. Thus, hybrid vehicles seem to be profitable and sustainable, simultaneously. The results also show that a certain amount of trips is unsatisfied. Since the demand is higher during peak times as on the rest of the day, it is more profitable to reject several trips than to provide more vehicles to serve the demand

completely in peak times.

Summarizing this thesis, it can be pointed out that the presented optimization model is an essential tool to determine the composition and size of a carsharing network. In order to develop this tool, the tactical, strategic and operational decision making is connected. Therefore, preceding strategic planning such as location, number and maximum size of carsharing stations is done as well as operational aspects, like pricing and revenue optimization. Along with those considerations the determination of composition and size of a carsharing fleet can be done accurately in the context of the tactical decision process.

Finally, it must be noted, that tactical decision making within a CSO faces a high need of further research. Since an increasing relevance of tactical and ecological aspects is to be expected in the future, the proposed optimization model must be improved further on in order to achieve constantly increasing sustainability through Green IS. Therefore, the suggested limitations and recommendations should be taken into account in further research. Since most limitations concern the determination of peak and off-peak times of demand during a day and a week with the help of associated time frame factors, estimations of time-dependent demand should be improved appropriately. Along with additional model extensions, this work can form a reduced emission and low noise environment in agglomerations where carsharing is feasible.