Car Sharing Relocation Techniques: User-based Versus Operator-based

Masterarbeit

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Abstract

The possibility that an imbalance problem between demand and supply in a car sharing system at specific stations respectively areas could occur is due to the implementation of One-Way rentals into the car sharing concepts. One-Way rentals allow the customer to pick up a vehicle at a location and park it wherever the customer wants considering the business area of the provider. In this way, areas respectively stations can get a surplus of vehicles whereby at the same time shortages exists. This could lead to revenue losses of the company due to rejections of possible planned trips of customers. This thesis shows how this problem is supposed to be solved with the implementation of relocation approaches. The different relocation strategies are reviewed and how they are differing from each other in a literature review. Furthermore, several existing relocation approaches are discussed in detail. Advantages and disadvantages of the main techniques, the operator-based and the user-based relocation, are listed. Moreover, two models will be developed, implemented and discussed. The operator-based relocation model is designed to calculate the cost-effective relocation routes to maximize the profit of the company. The objective of the user-based model is also to maximize the profit of the car sharing provider and includes a pricing system to influence the users' behaviour with incentives or disincentives so that the system rebalance itself. A final evaluation of the implementation and application areas of the models takes place.

Keywords: Car Sharing, Relocation, User-Based, Operator-Based, Literature Review, Optimization, Operations Research

Contents

1 Introduction

1.1 Motivation

Economic action and human activities can be described as a target-oriented rational process which is divided into design respectively planning, decision, implementation and control phase. Planning is defined as a systematic-methodical procedure for analysis and solution of current problems and future issues. Operations research is describing a knowledge branch which treats with the analysis of practical relevance complicated problems which are into course of a planning process to the preparation of preferably decisions by using mathematical methods.[1] One of the main tasks of the operations research is to "portray an actual decision problem through an optimization- or simulation-model and the application respectively the development of an algorithm for the solution of this problem."[2]

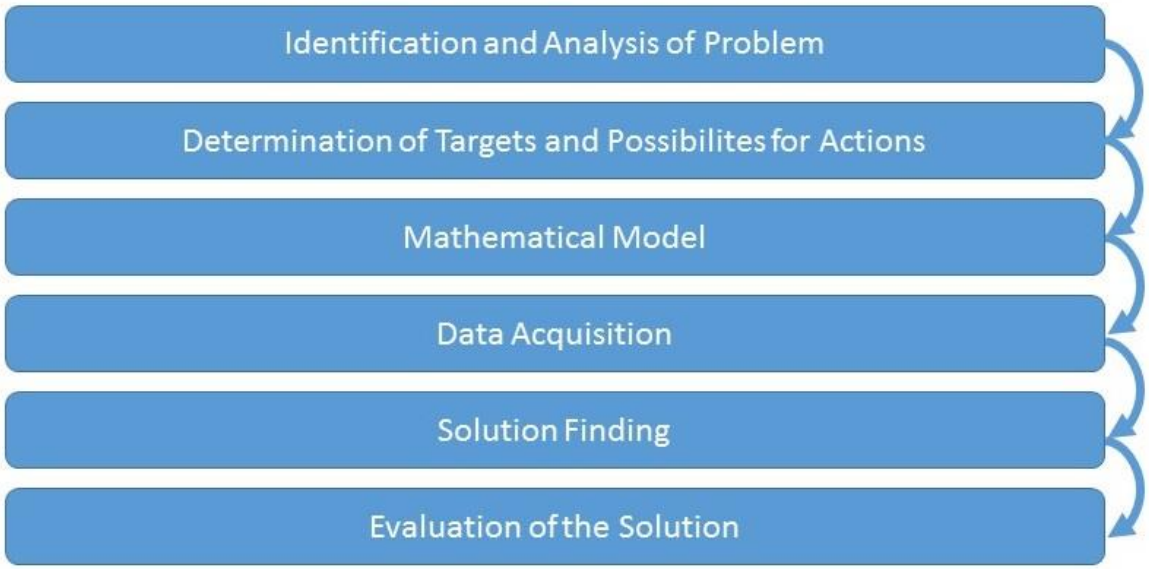

Figure 1: Operational planning process. Own representation, based on Domschke et al. (2015), pp. 1f.

Planning supported by operations research in general performs in a complicated process which is figured in the graphic above. The complicated process is starting with the realization and analysis of a problem. That means that a need for decision and action respectively possibilities to implement further technologies which are more efficient. After that, the defining of targets and possibilities for action takes place to find optimized decisions or actions. Alternative possibilities have to be figured out and com-

[1] Cf. Domschke et al. (2015), p. 1
[2] Domschke et al. (2015, p. 1

pared. At the following, a mathematical model will be developed to evaluate the approaches considering the targets of the process. For the evaluation and simulation of the model, data have to be created or acquired which takes place in step four. The model solution has to be calculated with the help of algorithm respectively procedures and will be evaluate considering the proposed targets at the end of the process.[3] The planning process of the operations research is adaptable to the car sharing object to contain possible problems which could occur with the implementation of innovative ideas to increase the flexibility for and the added value of the customer.

"Over the past few decades the environmental and socio-economic problems linked to the mobility in urban areas have underlined the need of reducing the massive use of private vehicles."[4] Consequently, shared vehicle system such as the car sharing concept have reached great popularity in the public with increasing memberships over the years.[5] A detailed planning process is necessary for a successfully and efficient implementation of car sharing systems.[6] Different car sharing concepts being subjected to optimization approaches to determine the fleet size and allocation of those vehicles to the stations which have to be optimized considering the location and the size of those stations. Planning processes are needed to cover cost-efficient the demand and the functionality of the system.[7]

Traditionally car sharing concepts are using the Two-Way system and are station-based that means that the customers have to bring back the rented vehicle to the same station which their trip started from.[8] Different car sharing companies like "Car2Go" in Ulm and "DriveNow" in Munich have established One-Way systems into their car sharing concepts to increase the added value of the customer by letting the user drive from a location to any destination without the need to bring the vehicle back to the origin.[9] Those One-Way trips making the car sharing service more useful for the customer, but "at the same time introducing management complexities and thus increasing management costs."[10] Management complexities and costs could occur due to a possible imbalance between supply and demand at the stations. This possible imbalance exists due to that "vehicles sometimes get stuck in areas of lower individual mobility demand (cold spots) while needed in zones of higher demand (hot spots)"[11] and can be ad-

[3] Cf. Domscke et al. (2015), p.1
[4] Clemente et al. (2013), p. 250
[5] Cf. Clemente et al. (2013), p. 250; Cf. Bundesverband Carsharing e.V. (2016)
[6] Cf. Clemente et al. (2013), p. 251
[7] Cf. Boyaci et al. (2015), p. 721
[8] Cf. Kek et al. (2009), p.
[9] Cf. Shaheen et al. (2015), pp. 527f.
[10] Clemente et al. (2013), p. 251
[11] Weikl and Bogenberger (2012), p. 355

justed by implementing different relocation strategies to ensures the system functionality and make it more profitable. Those strategies are grouped into two sections of techniques: the operator-based and the user-based approaches.[12]

The main objective of this scientific work is to identify different relocation approaches and divide them into the mentioned sections. Furthermore, it will be researched how the different strategies are constructed, on which optimization aim they are built up and in which context the techniques are adaptable and implementable. This operations research work is based on the following research questions:

- *Which relocation techniques are existing and how can the strategies be distinguished?*
- *How can the operator-based and user-based technique be developed, formulated and implemented into car sharing systems to solve the imbalance and relocation problem?*

1.2 Procedure of this Work

The procedure of this scientific work is based on the development and implementation of an operator-based and a user-based relocation approach for car sharing systems to solve the imbalance problem between demand and supply. Thereby the operational planning process, which is declared at the beginning of this work, can consulted as a rough guideline to set a realistic imbalance problem into an abstract optimization model with the aim of optimizing an car sharing system.

The procedure of the work is portrayed in figure two and starts, after the introduction, which the relevant theoretical background. Thereby the object car sharing will be defined and the history of car sharing in Germany will be explained. Furthermore, the existing car sharing concepts will be mentioned. Optimization approaches of car sharing system will be declared whereby the foundations of the operational part will take the main part. The strategical and tactical optimization are limited in this work and will not be further discussed. At the end of the theoretical foundation, the imbalance and relocation problem will be declared. How it can arise and exists in car sharing system.

In chapter three a presentation of both techniques, operator-based and user-based, will take place. At first, a literature review will be present to show existing approaches for the repositioning of vehicles. A generally comparison between operator-based and user-based relocation is fundable in chapter three as well. Furthermore, specified and already successfully developed and implemented approaches will be portrayed. In the

[12] Cf. Weikl and Bogenberger (2012), p. 355

7 Conclusion and Outlook

One main objective of this work was to demonstrate different relocation strategies and how they differ from each other. Chapter three shows that a bunch of relocation approaches exists. The relocation approaches can be divided into two main groups: the operator-based and the user-based techniques. The literature review shows that already a lot more research at the operator-based exists and only a few papers respectively relocation approaches are working with a user-based concept. Hence, it could be argued that more research has to be done at this issue. Furthermore, the optimizing aim of the different approaches were checked and a several of different targets were detected such as the minimizing of the company costs or maximizing the provider's profit. Key characteristics, e.g. if the model is dynamic or if the car sharing fleet is homogeny or heterogenic were checked and listed in the literature review table. Thereby is to point out that a lot of models working with homogeny fleet and additionally with electric vehicles.

Furthermore, a generally comparison between the main relocation strategies were made and advantages and disadvantages for both of them were illustrated. Advantages for the operator-based relocation are e.g. that the provider can intervene at any time with monitoring, especially with real life monitoring, to rebalance the system if a shortage of vehicles or a surplus exists. Moreover, the company can intervene a priori for special events to challenge the higher demand. Nevertheless, the operator-based approach has several disadvantages. Those are the costs for staff, costs for additional vehicle movement in case of relocation and costs for depots. On the other hand, the biggest advantage of the user-based relocation technique is the low costs due to staff savings and no additional vehicle movement is needed which leads to an environmentally sustainable. As the operator-based approach has disadvantages the user-based got some as well. The biggest disadvantages to mention is the customer by itself. The idea of the technique is that the system rebalances by itself through the users' behaviour, however this is difficult to influence by the provider. The customer acceptance and behaviour is difficult to predict which could rebalance the car sharing system, but it could also be possible that this will not happen.

Furthermore, two already in the literature existing relocation approaches were discussed in detail to show explicit how a user-based and an operator-based relocation technique can be implemented into car sharing system. The procedure of both approaches are promising strategies to support car sharing system with the relocation problem. The car sharing companies which implemented the relative approaches achieved a higher level of service and increased gain. Moreover, a third relocation concept from the literature were discussed which can be a promising approach due to

the fact that this concept combines both main relocation techniques. The auspicious combination of the offline determination of every possible scenario and relocation strategies with the online optimization tool to figure out which relocation strategy would be the best to maximize the profit of the company and to give the customer a high level of service.

The second research question treated the development, formulation and implementation of a user-based and an operator-based technique into car sharing systems with the aim to support the system by solving the imbalance and relocation problem. Firstly, the operator-based model was developed. The model has been designed to maximize the profit of the company whereby the optimum cost-effective relocation routes were calculated. To ensure the maximum profit, the model decided only to allow trips with the most gain if not all drives would be possible due to insufficient allocation of vehicles respectively parking places. Some weakness aspects like that the relocation only performs after an observation cycle ends are shown and further recommendations to implement the model dynamic for better monitoring of the vehicle distribution are given. The small simulation of the model shows the functionality of the model and can easily be expanded.

Secondly, a user-based relocation approach was developed which includes an incentive mechanism to influence the customers' behaviour and mobility to let the car sharing system rebalance itself. Thereby a pricing factor were generated to give the customer a discount or a penalty on specific routes. Calculation of the pricing factor the current allocation and the optimum distribution were set in relation. Trips from a station with a usually allocation to an empty station were rewarded with a discount and trips to full stations were penalized with higher prices. Those pricing differences should influence the customer in their behaviour. The small simulation of the model shows the difference between prices for the same route with and without an incentive mechanism. The value of the pricing factor changes every period in relation to the current allocation. Nevertheless, the small simulation does not lead to a rebalanced system at the off the observation cycle. Reasons were described at the discussion and further research in a long-term simulation with high traffic have to be made to examine the functionality of the user-based model. Compared with the conclusion of the introduced user-based model of Clemente et al. (2013) in chapter three could this model achieve a higher profit for the company and increased level of service for the customer due to the similarities with the incentive mechanisms. The difficulty of the introduced developed model is the customer himself due to the individually behaviour of each of the user. The members are difficult to predict, especially in the acceptance, behaviour and mobility. Further researches have to be made for a better understanding of the customers.

At the end of this work a discussion were made to identify the functionality of the developed model and if they can support car sharing systems to solve the imbalance and relocation problem. The conclusion is that the procedures of both strategies are promising approaches to support car sharing system. At first glance, it could be applicable that the user-based approach reaches a higher profit due to less costs than the operator-based. Nevertheless, the developed operator-based concept is the more profitable approach if the customer satisfaction is taken into account. The customer satisfaction of a user-based technique could be less due to the mentioned problem that the customers are difficult to influence and still shortage of vehicles or empty stations could arise. In the opposite, the operator-based concept can intervene to the current allocation and increases the level of service. Hence, the customer satisfaction increases and it is adaptable that the profit will increase as well.

This thesis represented different relocation techniques, differentiated them under specific characteristics and described in detail three selected approaches. Furthermore, an operator-based and a user-based technique were developed, implemented and discussed. Both are promising approaches to support car sharing system in their decisions. Nevertheless, both of them can respectively have to be reconsidered in further researches.