OPTIMIZATION OF THE AUTOMOTIVE SERVICE CENTRE NETWORK FOR NEW ENTRANTS INTO CZECH AND SLOVAK MARKETS

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Abstract: *The automotive sector is the main driver of industry in both the Slovak and Czech economies. In recent years, rapid and substantive changes have been seen in the development of automotive distribution channels in the Slovak and Czech Republics and this trend can be expected in the future as well. The purpose of this paper is to present a new approach to determine the optimal location of service centres for customers of the automotive industry. The method proposed maximizes a weighted customer utility in terms of density of car-owning residents and the travel distance they need to overcome to reach the nearest station. The application of the proposed method allows automotive companies which are planning to enter new markets to create an optimal distribution network of service centres for customers in the Slovak and Czech Republics. The optimization model approximates the correct number of service centres according to evidence from other countries in the European Union and calculates their optimal spatial placing based on various criteria.*

Keywords: *Optimization, New Entrants into Markets, Distribution Network, Automotive Industry, Service Centres Location*

JEL Classification: *C61, L10, L19*

Introduction

The purpose of this paper is to present a new approach to determine the optimal location of service centres for customers of the automotive industry.

In recent decades, rapid and substantive changes have been seen in channels of distribution for products and services in developed economies. (Black et al., 2002). All marketers have to decide how to provide target markets with their products. For these purposes it is necessary to use marketing channels. A marketing channel can be defined as a system designed to move products and services from producers to consumers, which consists of people and institutions supported by various facilities, devices, and information (Boveé and Thill, 1992). One of the most important issues which companies have to decide on is the kind of marketing distribution channel. According to Berman (1996), perishable goods require a short channel and non-perishable goods can use longer channels. The choice of an appropriate distribution channel on the basis of the value of the product has to be considered a crucial decision for Marketing Professionals. High value products should be distributed directly while low value products are typically distributed indirectly (Bucklin, 1966).

There are several important flows among companies and consumers or intermediates. Kotler and Armstrong (2004) identify the physical flow of products, the flow of ownership, the payment flow, the information flow and promotion flow. It is essential to know that distribution channels are not only simple collections of organizations tied together by several flows. Distribution channels create complex behavioural systems where consumers and companies interact to meet their needs and accomplish their and their channels' targets.

1 Problem formulation

1.1 Globalization and marketing channels

Growing liberalization in the international marketplace and high domestic competition has forced companies to expand into the global market. Global expansion activities are ever more significant for the growth and prosperity of modern companies. (Morgan et al., 2004). Currently companies increasingly realize that entering international marketplaces is not only an optimal opportunity but rather an urgent necessity (Mehta et al., 2005).

In global marketing four main activities should be measured and coordinated: promotional campaigns, pricing decisions, distribution activities, and after-sale services (Roth et al., 1992). These four activities are the core of the coordination and concentration dimensions in the Global Marketing Strategy Model (see Skarmeas et al., 2008). Reflecting the global environment, distribution channels consist of interdependent institutions which provide a product or service with consumers. (Coughlin et al., 2001). Management of distribution channels includes planning, organizing, coordinating, directing and controlling (Gundlach et al., 2006).

1.2 Automotive Distribution Network of Service Centres

Currently automotive companies face a turbulent market with dynamic changes. The situation in the market can be characterized by stagnating prices and decreasing sales due to high competition. Because of these challenges, the automotive industry is forced to look for new niche markets (Bihlmaier, 2009). Electromobiles may be considered one of the new opportunities for the automotive industry. Moreover, strengthening ecological movements across the whole of Europe can recently be seen emerging, as environmental awareness comes under the spotlight for European citizens. The European Union supports ecological means of transportation through its active policies and programs, such as the European Green Motion Initiative (EGVI, 2013) and its counterpart the Green eMotion Project (Green eMotion, 2015). Automotive companies are incentivized to react to these new challenges and opportunities. A functional distribution network is a basic condition for the car industry.

It is crucial to emphasize the difference between stores and service centres in the automotive industry. The main aim of car stores is to sell cars that are often tailored to consumer needs. It is obvious that customers want the ordered car as soon as possible, although they are willing to wait some time because of special requirements – colour, equipment etc. (Monden, 1993). The typical delivery time on the basis of the customer's requirements ranges from 4 – 6 weeks (Stautner, 2001).

The situation in service centres is completely different because the primary target of these institutions is to provide the customer with immediate service - for instance, car repairmen, information support etc. However, service centres have to be regarded as a significant part of the marketing distribution network because the profit generated by after-sales service is usually higher than the one received with sales; the service market can be four or five times larger than the market for products (Bundschuh & Dezvane, 2003). Service centres can generate three times the sales of the original purchase during a given product's life-cycle (Gaiardelli et al., 2007). Nevertheless, there can exist only a limited amount of service centres, which is defined by the interaction between supply and demand in these markets. Demand refers to the amount of vehicles (customers) that are willing to use the services of service centres at a given price.

1.3 Maximization of customer satisfaction

According to Frazier, management of marketing distribution channels have to be focused on the placement of distribution centres and the allocation of resources among this marketing channel network (Frazier, 1999). The key thing is that the density of the distribution network has to be in balance with the size of demand and, moreover, distribution has to react flexibly to the changing needs of the customer. Customer satisfaction with the distribution network is a significant factor if the company wants consumers to stay loyal. When customers want to buy a new car the quality of after-sales service can play the most important role in this decision-making process. Findings from research demonstrate that satisfaction with after-sales service has a much stronger effect on a consumer's intention to stay loyal to a distributor than satisfaction with the product itself (Homburg and Giering, 2001). Customer loyalty is primarily influenced by satisfaction with customer services (Yang and Peterson, 2004). The service centres of the cars have to provide the customer with the best possible quality for a certain price. If customers are not satisfied with the quality of the service they usually start to find some alternative service centre. If some competitor is able to offer better quality for the same or lower prices the switchover costs are usually the only barrier to customers changing distributor. An appropriate density of service centres is necessary if the company wants to prevent the customer from changing their current service centre.

To define the ideal amount of stores it is worth looking at the situation in other countries of European Union. Automotive companies which produce and sell electric vehicles will focus more on the market of Central and southern Europe in the near future. Currently there are little or no electric car stores which are able to cover customer requirements in these countries.

Tab. 1 shows the market share of electric vehicles (ratio of electric vehicles to cars with combustion engine) in the top 10 European Union countries in this field. The market share of electric vehicles is different in individual countries of the European Union.

Tab. 1. Market share of electric vehicles

Country	Electric Vehicle Market Share in %
Austria	1.19
France	1.14
Netherlands	1
Sweden	0.74
Denmark	0.46
United Kingdom	0.36
Belgium	0.36
Portugal	0.35
Germany	0.32
Lithuania	0.32

Source: (European Alternative Fuels Observatory, 2017)

Austria and Germany are nearest neighbour countries of the Czech and Slovak Republic that are on the list. Other countries have not developed the market to significant size yet. The market share of electric vehicles is quite different in these countries on the list. While electric vehicles in Germany contribute only 0.31% to total car market, Austria is with its 1.19 % on the top in the European Union.

The network of Tesla stores in Austria and Germany can be relevant example as the amount of stores appropriately corresponds with the population and customer requirements. There are 5 Tesla stores in Austria and 25 Tesla stores in Germany. The population of Austria is 8 611 000 and Germany has 81 413 000 inhabitants. It means that there is approximately one store per 1 720 000 inhabitants in Austria and one per 3 250 000 in Germany. The aptly amount of stores in the Czech and Slovak Republic could be similar and range between the numbers for in Austria and Germany. The mean of the numbers is 2 485 000 so it can be the appropriate quantity of people for one store. It represents 4 stores for the Czech Republic (population – 10 550 000) and 2 stores for Slovakia (5 420 000). In terms of the Slovak Republic it is reasonable to increase the number to 3 stores because this country is quite long and in case of 2 stores the customer should travel too far (The World Bank, 2017).

From the different point of view, Germany covers an area of 357 023 km² and Austria covers 83 879 km². This means roughly 14280 km² per store for Germany and 16775 km² per store for Austria. Considering equilateral hexagon as a shape of an area covered by each station, then it is possible to estimate maximal distance as a radius of that hexagon. For Germany it is 74,1 km, for Austria it is 80,3 km, which are two possible values of variable d_j^*.

The current or optimal cover among the countries is indeed country-specific, but at least we compare countries from the similar part of the world (EU).

2 Methods

To deal with the problem of optimal service centre placement we apply problem formulation and optimization technique of operations research methodology (Hillier, 2001), i.e. we create a mathematical formulation of the problem and then we apply proper optimization method for solving it.

2.1 Mathematical model

The goal of the optimization model is to maximize a weighted customer value (satisfaction) in terms of density of car owning residents and travel distance that they need to overcome to reach the nearest station. The constraint in this case is total number of stations, which, of course, has to be limited for economic reasons.

We assume that within the considered area (in further numerical case Czech of Slovak Republic) the service stations should be spatially distributed according to the distance from each station to the nearest customer. It follows that customers are partitioned into clusters in such way, that each customer is exactly in one cluster. The clusters are defined by the stations, specifically by the number of stations and their spatial position. Each cluster belongs to exactly one station. It follows that each customer is served by exactly one station, which is also their nearest station. At this point we face the problem of data availability, since the exact spatial position of each customer is not known. We can however use aggregated data, i.e. we can work with a number of customers within certain smaller area such as district. We apply personal vehicle registration data from Czech Statistical Office (2015) to assign a number of residents to each district. District towns serve here as central points for corresponding district, i.e. all residents of the district are considered to live in district town. This simplification is necessary, because there is no additional information about vehicle owners in terms of their spatial distribution than an address of vehicle registration point. Also we take into account differences between districts, namely difference in purchase power. The purchase power was used as the relevant criterion because automotive companies are aiming to maximize their profits. Automotive companies are obviously interested in locating their service centres in regions where they suppose the high demand and high purchase power of customers. These proposed factors are reflected in following mathematical model:

$$Z = \sum_{i=1}^{N} (w_i \alpha_i c_i) \tag{1}$$

$$d_{ij} = \min_{1 \le j \le M} \left\| p_i - s_j \right\| \tag{2}$$

$$w_i = f\left(d_{ij},\, d_j^*\right), \qquad d_{ij},\, d_j^* \ge 0 \tag{3}$$

$$w_i = \begin{cases} d_{ij} \ge d_j^* & : \quad 0 \\ 0 \le d_{ij} < d_j^* & : \quad \dfrac{d_j^* - d_{ij}}{d_j^*} \end{cases} \tag{4}$$

$$\alpha_i = \frac{e_i}{\min\limits_{1 \le i \le N} e_i} \tag{5}$$

Equation (1) is the objective function Z, which is to be maximized, and it represents total customer satisfaction gained from all service stations. Variable N denotes number of district central points, w_i is distance coefficient, α_i is district income coefficient and c_i is number of cars in the district i. We consider a total number of all cars registered in each district regardless its type, i.e. standard vehicles with internal combustion engine are included in this number. However, the percentage of electric vehicles is derived from this total amount as a cumulative adoption rate.

Distance function d_{ij} is distance from each district central point p_i to the nearest station s_j. The nearest station is the station with minimal distance between point p_i and all of M considered stations. From this value we calculate the distance coefficient w_i in equations (3) and (4). It does not need to be linear, in fact, we use linear function with an assumption that customers diminish their will to travel to reach the service station linearly (with an assumption that they are not willing to travel more than d_j^*). It does not need to be the case, other functions may be better for simulating this behaviour, but there would have be an empirical evidence for it. Otherwise we apply simplified linear version.

District income coefficient α_i is calculated as normalized average income (earnings) e_i for each district i such that the baseline is the district with the lowest income. This means $\alpha_i \geq 1$.

2.2 Solution via genetic algorithm solver

To solve a nonlinear model we employed one of the most commonly used heuristic algorithms in the Mathworks MATLAB software. Genetic algorithms (GA) have been used with success in many types of problems. They can solve a given problem via an iterative solution which improves over time based on several transformative operations inspired by processes in nature. This specific GA solver from MATLAB software allows us to solve an entire model when appropriate settings are used (heuristic crossover function, initial population of 300 vectors, default mutation rate). The objective function (1) requires a given number of service centres (coded as points in 2D space, i.e. defined by latitude and longitude) to place the centres in the most appropriate locations in order to minimize the total distance between the location of service centres and corresponding district towns. The number of service centres must be given in advance, since the algorithm does not have the ability to estimate the appropriate number of them on its own. These numbers for the Czech and Slovak Republics were discussed above. Since one optimization run is quite fast (it finishes within seconds), it opens up the possibility of examining scenarios with different numbers of service centres.

3 Results and Discussion

The optimization process is based on the actual physical distance from district center to the nearest service station, which is weighted by distance and income coefficients. The distance coefficient presumes that there is a distance-based effect which influences the consumer's *perceived* value. The further a service station is, the less a customer is satisfied. In the basic model proposed, the linear relationship is presumed in the distance coefficient calculation (4), although a more complex function dependence might also be used. The income coefficient adjusts the income differences among districts using minimum value-based normalization (5). The model works with the idea of maximal station service reach, which means there is an upper limit of distance that the customer will tolerate. So even if a customer can overcome the long distance to the station, his satisfaction level is zero, because he does not want to travel so far.

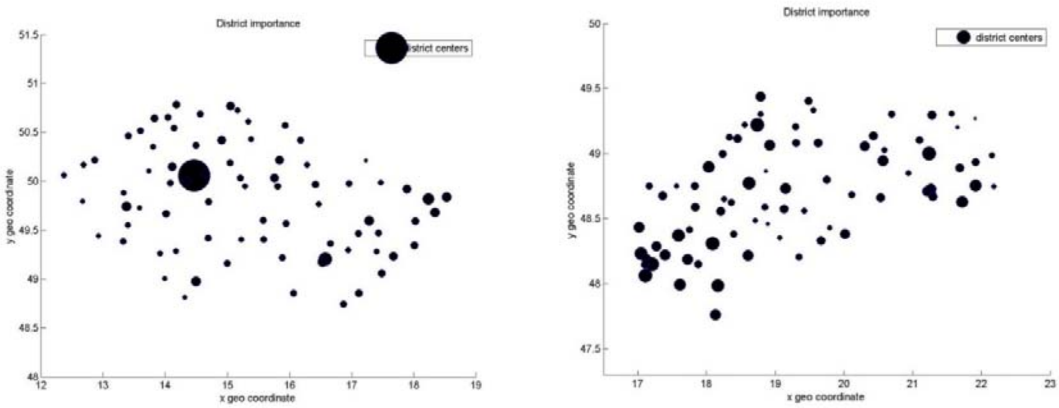
There are two problematic aspects to this approach. The first one is related to the fact that there is no difference in distance-related satisfaction beyond a certain point – service station reach (as a numeric example in the Slovak and Czech Republics, the authors work with a 50 km threshold). The authors admit that a customer can intuitively feel the difference between a station 51 km away and a station 200 km away. This issue might be solved by choosing a different type of function, for instance some kind of sigmoidal function can be employed.

The second aspect relates to the definition of *. Although * is considered to be a "station maximum reach", it is actually the overall distance-related willingness of customers to travel to this station. The station itself does not have any "reach" – an enclosed area from which one cannot get out, as is the case with charging stations (Pekárek, 2015),

- rather it can be reached from any distance, so the question of availability is exogenous to this problem formulation. In order to properly model customer willingness to travel, a satisfaction function of distance for each customer is needed (or in terms of districts – a satisfaction function for each district's residents). It clearly is a practically impossible issue, an aggregation and simplification would certainly be needed thus measures as an aggregated district satisfaction function would be needed. This of course would imply that not only aggregation within one district can be calculated, but also an aggregation of districts related to one station can be calculated as well. If this is carried out, the resulting aggregation would take the form of a distance-based satisfaction function for each station. And that is exactly the function (2).

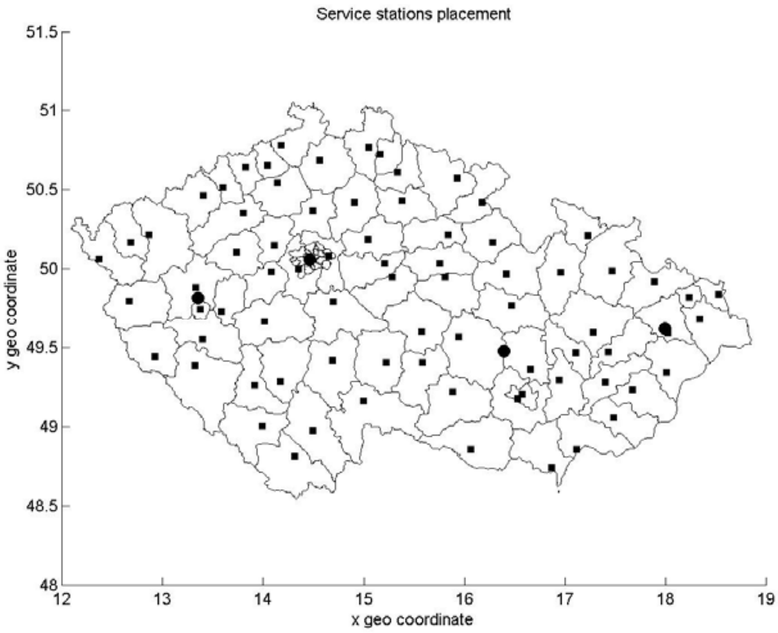
The graphs below show the optimal placement of the service centres in the Czech and Slovak Republic. The data from the Czech and Slovak Statistical Office was used (Czech Statistical Office, 2015), (Statistical Office of the Slovak Republic, 2015). Four service centres in the Czech Republic and three centres in the Slovak Republic were illustratively determined as the minimum required number for the customers of approximately 1,100 cars in the Czech Republic and 550 cars in the Slovak Republic. This number is derived from the ratio between the number of service centres and the number of registered vehicles in Austria (European Automobile Manufacturers' Association, 2017).

Fig. 1: District importance in the Czech (left) and Slovak (right) Republics



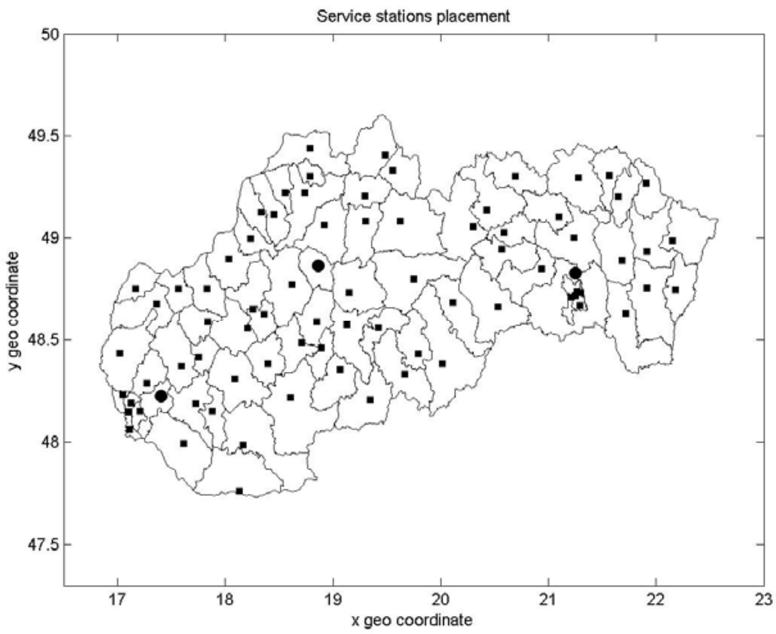
Source: (Author's work)

Fig. 2: Service station location in the Czech Republic



Source: (Author’s work)

Fig. 3: Service station location in the Slovakia



Source: (Author’s work)

3.1 Limits of Suggested Method

This service centre placement problem is formulated as a nonlinear optimization program in terms of operations research (Craven, 2005). There are several constraints and one objective in the proposed version of the model. Since there are minimal distance measures to assign each node to its nearest service station, the objective cannot be considered as a simple weighted summation. The model employs several important variables, although still some simplifying assumptions were made. Those simplifications of the final objective function hold only if the underlying road network is from a high perspective connected and undirected, hence vehicles can travel through it with the same ease as they would travel through an unobstructed space. And also the travelling distance in the road network must be curved along the shortest path in the road network graph and hence be the same or greater than the linear distance, which is true for the majority of road networks.

Another simplification is the fact that the given area is considered a closed system. It might perhaps seem too much, but in fact it does not affect the results at all if a simple transformation is conducted. If there is a service demand behind an absolute border (in a case shown later the borders are country borders), the service demand projects on the border as a sum of all demand emitting nodes beyond in that direction and thus a new node is constructed. So if there is a need to consider a service demand coming from outside the selected area, this measure can simply transform that open area to a closed system.

Perhaps the most intrusive simplification used is the consideration of areas (in our example those areas are country districts) to be nodes in positions of each area-weighted centre (we take the district capital city as a district-weighted centre). That means the spatial distribution of customers within the area represented by a node is omitted. This feature is related to the limited amount of detail contained in the existing data. The database we use contains the exact number of registered vehicles for each district within a country. Even if there was a more detailed database, it still would be an aggregation for some area. The only way to really not simplify is to know each position of each vehicle exactly, but this kind of information is firstly considered to be private and secondly very hard to obtain. It follows that some level of simplification is needed anyway.

Conclusion

This paper deals with the optimization of service centre distribution networks for customers in the Czech and Slovak Republic. On the basis of the results of the method used, four service centres in the Czech Republic and three centres in the Slovak Republic were determined as the minimum required number for the customers of approximately 1,100 cars in the Czech Republic and 550 cars in the Slovak Republic. The method presented is designed to be used by car producers which want to expand into new markets. It could be used as an important and powerful tool by the automotive industry. The method allows automotive enterprises to locate their service centres on the basis of customers' purchase power and customers' requirements connected with the distance of the service centres. A distribution strategy designed by automotive companies has to be adapted to customer requirements and so bring them high added value. For instance, Tesla`s strategy is to create its own network of service centres for direct customers (Bresnan et al., 2015). Customers wish to be as close as possible to a service centre when they need to use its service. It means that the density of service centre network should be as high as possible. An appropriate density of service centres is necessary when an automotive company wants to enter a new market or to prevent the customer from switching to another competitor. However automotive companies have to take into account limited financial and other resources. Automotive companies also have to decide how quickly they are able to create a sufficient distribution network of service centres. The suggested method is a strong tool that allows marketers of automotive companies to model optimal locations for building service centres within the Slovak and Czech Republic.

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