EXTERNAL COSTS OF CRUISING FOR UNOCCUPIED PARKING SPACE

Krzysztof Drabek[1]

Abstract
For several years, in connection with the development of city infrastructure, a gradual increase in the number of vehicles on the road is observed inPoland and the entire Europe. Governments need to solve the problems associated with the phenomenon of urban congestion and general overcrowding of city centers. Congestion can arise from many reasons. One of them is an irrelevant supply of parking space. The situation causes drivers to cruise for parking space, which generates a variety of costs. This article takes up the issue of identifying costs resulting from this phenomenon. The main aim of the article is to answer the question: what costs arise as a result of drivers cruising in search for parking space? The article attempts to develop a methodology for estimating these costs. Therefore, the results may be useful to local governments in making policy decisions concerning the public sector.
Keywords: *congestion, external costs, parking, cruising.*

1. Introduction

For several years, there has been a gradual increase in the number of vehicles on the road, both in Poland and throughout Europe. In 1970, the number of registered passenger cars in Poland was ca. 479,000. By 1992, their number increased to 2.5 million. Another twenty years brought another significant increase in the number of passenger cars to approx. 19 million in 2015 (PZPM, 2015). Poland reached the European average in 2012, where 1,000 population generated about 471 vehicles. The result equated the country with Great Britain, France, Belgium and Spain, outrunning Sweden, Holland, Denmark, Hungary and Czech Republic (Stańczyk & Pyrek, 2013). Such a large number of cars translates into an increase in the share of passenger vehicles in the movement of people; therefore, traffic conditions are worsening significantly, especially in urban areas. Szarata (2013, p. 107) cites the results of research conducted in 2013 in Krakow, which show that the share of travel by car amounted to 33.7% of all journeys. This share is often considered as the effect

1 M.A., Ph.D. Student, Department of Economics for Real Estate and Investment Process, Cracow University of Economics, ul. Rakowicka 27, 31-510 Cracow, e-mail: krzysztofdrabek@o2.pl.

of the economic and social development of urban areas and the inherent cost of the growth of cities.

The choice of a car as a means of transport is dictated by, among others, by the fact that it is more competitive than public transport. In this situation, governments have to deal with the problems of ensuring parking spaces in cities. Despite the measures used by local governments, such as increasing the frequency of tram and bus transportation, fare integration, improvement of the quality of the rolling stock and increasing the availability of public transport, travelers are still more willing to choose the car. A study conducted in six major Polish cities shows that 70% of people who commute to the city center by car declared that they were able to reach their destination without transfers using public transport. The average time to reach the center took, on average, five minutes longer than by car. In the same study, 31% of people who preferred public transport indicated shorter travel time as the reason. However, 61% reported that their choice was dictated by the fact that they did not have to look for a place to park (Kostecka, 2015). As one can see, the problem of the deficit of parking spaces in urban centers influences decisions about the choice of means of transport. Due to the fact that the demand for parking space exceeds the supply, there is a phenomenon of cruising in drivers trying to find space to park. Cruising creates a queue of vehicles that look for parking space and waiting for it to appear. It is difficult to estimate how many drivers wish to park because they are mixed up with other drivers who want to go further. For this reason, the problem is not visible, and the phenomenon is not taken into account as a source of congestion and thus of related costs. Drivers looking for parking space tend to move at low speeds. As a result, congestion,[2] accidents and collisions, air pollution, noise and other costs associated with these effects arise. Another significant problem is that, so far, there have been no serious attempts to calculate these costs. These problems, the solution of which is usually expected from the public sector, are increasingly becoming the subject of research and analysis in the field of public economics. Especially much attention is paid to the issue of external costs arising from the increasingly expanding economic activity and its impact on the environment. As pointed out by Nobel laureate Stiglitz, issues, which economics of the public sector deals with, are among the most impressive in the whole economy (Stiglitz, 2013).

This article takes on the issue of cruising and the related phenomenon of external costs. Its purpose is to identify the external costs arising from cruising resulting from drivers searching for parking space and creating a model that would allow us to calculate these costs. The main objective is to say that it is possible to create a model that would allow the calculation of the external costs

2 Congestion is defined in detail further in the article.

arising from the phenomenon of cruising during the search for parking space. In the first place, to achieve this objective, the literature was reviewed and existing research on cruising analyzed. The rest of this article selects the most significant external costs associated with cruising and proposes a rough model which can be used for the calculation of the external costs of the examined phenomenon. It concludes with a summary, presentation of conclusions and an indication of further research.

2. External costs in economic theory

The concept of external costs is derived from the considerations by Marshall who, in his 1890 work "Principles of Economics", used the following terms: *"internal economies"* and *"external economies*". The first one concerns the issue of what is going on inside the enterprise, while the second is related to the benefits that result from the impact of the external environment (see e.g., Kachniewska, 2013; Łuczka & Przepióra, 2012). Marshall was referring his concepts to the notion of external benefits in relation to an enterprise and the internal benefits in relation to the sector in which it operates. He referred to the situation in which the presence of many companies with a similar profile in a region generates benefits for the individual companies in the form of economies of scale effect resulting, e.g., from specialization, a transportation network or the availability of skilled workforce in the area. The concept of externalities in the proper understanding of modern neoclassical economics was introduced only later by Pigou in his welfare economics. Pigou, in his work *The Economies of Welfare* (Pigou, 1932) distinguished the concept of private and social benefits and the cost of personal and social development, on top of recognizing the discrepancy between the social marginal product and marginal social product. These disparities appear when all costs and benefits of a market entity's activities are not borne by it and not taken into account in the decision-making processes (Huderek-Głapska, 2014). Table 1 shows the popular definitions of externalities.

Given the above definitions, it can be stated that the negative external effect is the same as an external cost. This reasoning is also adopted by Famielec (1999, p. 33) who wrote that "*external costs are harmful external effects, implying production costs and consumption incurred by people not participating directly in the production, consumption or replacement of the goods"*. Further in the article, externality will be understood as a component of external costs and benefits.

Table 1. Selected definitions of "*externalities*"

Author/source and date of publication	Definition
Black, Hashmizade & Myles (2009)	Externalities – cost or benefit arising from activities that do not directly affect the person or organization engaged in this activity.
Blaug (1996)	The benefits, i.e., positive externalities (external economies), or losses, i.e., negative externalities (external diseconomies) always occur when the production function of an enterprise includes variables that are not expenditures in the physical sense, but rather result from activities of other enterprises.
Baumol & Oate (1997)	External effect is present if the utility or production dependencies of a certain entity, such as A, are a function of real (non-cash) variables whose values are determined by other entities (individuals, businesses, governments) without particular regard for the welfare of the entity A.
Kamerschen, McKenzie & Nardinelli (1991)	Externalities are positive or negative effects which may be caused by an exchange/transaction with people who are not directly involved in the production, consumption or exchange of goods. They are, therefore, impacts on third parties arising from the scarcity of the market.
Samuelson & Nordhaus (1995)	Externalities (or leakage effects) occur when businesses or individuals impose some other expenses or certain benefits on others, while the "others" do not receive proper payment, or incur the respective costs.
Samuelson & Nordhaus (1996)	An externality occurs when the conduct of one unit affects the welfare of others, and this is not reflected in monetary transactions on the market.
Stiglitz (2013)	Externalities are divided into positive and negative externalities. Negative externalities arise when the actions of one person give rise to costs the incurred by others. In contrast, positive externalities occur when the actions of one person confer benefits to others.
Begg, Fischer & Dornbusch (2000).	Externalities arise when the decision a unit of production or consumption has a direct impact on the production or consumption of others in another way than through market prices
Famielec (1999)	An externality occurs when a manufacturer or a consumer directly experiences the effects of production or consumption carried out by another entity.

Sources: Based on Stiglitz (2013, p. 9), Trela (2012) and Famielec (1999, p. 23).

This article raises the problem of cruising for parking space for vehicles and thus is closely related to the transportation sector. Huderek-Głapska (2014), however, draws our attention to the difficulty in defining and classifying externalities in this sector. The literature lacks consistency and a clear approach to the characteristics of externalities generated by the transport sector. These approaches depend on a variety of criteria that guide the authors, among other things: the subject of research, time range and level of spatial analysis, as well as the type of impact. Simply put, external effects of transportation can be divided into those associated with the provision (construction and maintenance) of infrastructure and those associated with the use of this infrastructure. The division of the effects of transportation infrastructure for the consequences arising from its supply and those resulting from the use of infrastructure facilities is a basic classification. At the same time, these effects are interrelated and in practice, it is difficult to distinguish which changes in the economy are the result of supply and which are the result of the use of infrastructure (Huderek-Głapska, 2014, p. 91). For the point of view of the above distinction, this article deals with the distribution of costs arising from the use of infrastructure.

In the literature, you can meet with a number of classifications of externalities in transportation (Table 2).

Table 2. Classification of the effects of transport

Author	Classification of the effects of transport
Heggie (1978)	Direct impact: – shortened time of transport – reduced cost of vehicle use – improved safety of transport – fewer accidents – savings resulting from lower cost of transportation Indirect impact: – effects on the operation of other sectors of the economy – effect on the land use
Rietvield & Bruisma (1998)	Short-term demand effects: – the effect of the investment – the effect of pushing out Long-term demand effects: – the effect of the operation and maintenance of infrastructure Long-term supply effects: – effect on productivity (including the process of production, trade, labor market, monopoly prices) – impact on the location of activity and the distribution of production factors – impact on property prices
Kamińska (1998)	Social benefits of transportation: – private benefits of direct and indirect users – external benefits beyond transportation – external benefits generated by the infrastructure Social costs of transport – private costs of movement of persons and goods – infrastructure costs – costs related to the creation and maintenance of infrastructure and operation of the means of transport
Banister & Berechman (2000)	– externalities in cash – allocative externalities – environmental effects —network effects – impact on the labor market – agglomeration effect – reduced production costs – spatial and organizational changes

Author	Classification of the effects of transport
Rothengatter (2000)	Effects associated with the provision of transport infrastructure: – external benefits in the form of encouraging regional development Effects related to the use of transport infrastructure: – external costs including congestion, cost of providing infrastructure, environmental costs, accident costs
OECD (2002)	User advantages: – change of travel time – change the operating costs of vehicles – impact on traffic safety Effects of transport networks: – creating new services – intermodal shift in demand – improvement of the reliability of transport – better quality of the transportation services Socio-economic effects: – changes in the availability – changes in employment in the region – changes in the efficiency of production – changes in social integration – changes in the value of real estate – environmental effects
Rosik & Szuster (2008)	Economic and security effects: – financial flows (costs of construction, maintenance, and repair of infrastructure, income from fees for the use of infrastructure) – direct benefits for users (shorter travel time, reduced operating costs of the means of transport, improving traffic safety) – direct network effects (induced mobility, intermodal shifts, changes in the quality of transport services); Socio-economic effects: – changes in the region's availability of transportation – changes in the productivity of the means of production – short-and long-term changes in the size of income and employment – redistribution of employment and income between regions – intra- and inter-regional migrations of the means of production – changes in the value of real estate Environmental effects: – climate change – air, soil, surface water and groundwater pollution – noise and vibrations – consumption of natural resources – reduced biodiversity of natural species – impact on national heritage
Grzelakowski (2005)	– spatial, shaping the system infrastructure vs. the city and the closest region – social, determined by the mechanism of functioning of the labor market – environmental, as the impact of infrastructure on the environment

Sources: Based on Huderek-Głapska (2014).

Given the above classification (Table 2) and the scope of this article, it is assumed that the external costs of transport can be divided into:

- the cost of congestion,
- the costs of environmental pollution,
- costs of accidents and collisions,
- costs of noise.

This division is appropriate for further considerations presented in this article.

3. Problems arising from cruising for parking space

Cruising for parking is characterized by the fact that the drivers move at low speeds to approx. 15km/h (Shoup, 2007), or stop in the street to wait for the release of parking space. Cruising for parking causes a kind of a moving queue of drivers who are waiting. Cruising causes the formation of blockages and raises many negative effects. In slow traffic or traffic jams resulting from cruising for parking, people who do not want to park, just cross through the area are also involuntarily involved. Some studies might have both a theoretical and empirical character that discuss the issue of cruising for parking. One can include study such authors as Shoup (2006, 2007), Commenter, Wentink and Rietveld (2012), Arnott, Inci and Rowse (2015) or Geroliminis (2015). More detailed studies on solutions to help prevent cruising for parking are presented, among others, by Gallo D'Acierno and Montella (2011) and Arnott (2014). However, it is difficult to find studies showing how high the costs of generating the phenomenon of cruising for parking are. In previous studies, the problem of external costs generated by cruising for parking is merely identified and reported. However, no studies examining the external costs of this phenomenon have been published. Most public studies on cruising for parking come from the United States. For example, Shoup (2007) writes that in a study conducted in 2006, interviews with drivers standing at the traffic lights in a Manhattan neighborhood, 28% of them cruised in the search for parking space. Similar studies carried out in Brooklyn showed that 45% of drivers cruised in search of a place to park. The situation was similar in many other streets of New York. Shoup (2004) indicates that cruising for parking is due to the inadequate parking policy of cities. When the city has very low parking fees, or sometimes even parking in the street is free, cruising, from an individual point of view of the driver, is rational. As a result, however, the effects of individual rational decisions cause externalities such as congestion, traffic jams, fuel consumption, accidents and air pollution. This study indicates that drivers do not necessarily insist on free parking spaces. They are willing to pay for a convenient place to park, and the most important role here is played by the price and availability and location of parking space – near to their destination (Stienstra, 2007). On the other hand, Geroliminis (2015) believes that existing research shows that cruising for parking is the source of congestion. According to studies, during peak hours around Harvard Square in Massachusetts, 30% of vehicles were searching for a parking space, and the average time to find a spot was 12 minutes. Research carried out in Germany, and the UK showed that the average ratio of time getting to the destination to the time spent on searching for parking space was 2 to 1.

As indicated by Shoup (2006) in the period from 1927 to 2001, studies on cruising for parking in crowded cities have shown that cruising in order to find free space on the curb is from 3.5 to 14 minutes and that from 8% to 74% traffic jams are caused by cruising for parking. The parking maneuver is often difficult to do and takes a relatively long time, so not only cruising for parking creates congestion, but also the very function of parking, too. In France, the time needed to find a place to park, especially in the afternoon and evening, was up to 10% of the total driving time. Studies in Copenhagen show that in the evening (20:00 to 24:00) approx. 15% of the local drivers lost more than 15 minutes to find a spot to park their vehicle (Igliński, 2009, p. 115). Research as mentioned above shows that cruising for parking is a phenomenon that causes external costs. Publications are exploring the general issue of congestion, which describe external costs of its occurrence, they refer to the entire transportation sector. There is a lack of studies investigating the external costs of the particular phenomenon of cruising for parking.

4. External costs generated by cruising for parking in the search for parking spaces

Cruising usually happens in the intensively used areas such as city centers and around tourist attractions. The costs generated by cruising for parking thus relate to places where there are large concentrations of people, therefore, they are particularly harmful. Cruising for parking has a negative impact on other road users and residents of the area, generating costs comparable to the costs of congestion (Ommerman, Wentink & Rietveld, 2012). The authors Shoup (2006) and Pierce and Shoup (2013a; 2013b) in their publications indicate that while curb parking is cheaper than in parking lots, there are problems such as congestion, collisions, wasting fuel, air pollution and negative impact on the infrastructure of pedestrian paths. In his other publication, Shoup (2007) also indicates that the search for parking spaces on the curb also generates time costs. Given the division quoted by Huderek-Glapską (2014) of the external costs of transport, it can be stated that the cost of cruising also fits in this division. Therefore, external costs arising from the cruising for parking can include congestion costs, costs of accidents and collisions, the cost of air pollution, and noise costs.

4.1. The cost of congestion

In the literature, one can find publications about congestion in cities and their external costs. These studies generally relate to congestion regardless of the reasons that caused it. Congestion can be caused both by cruising for parking

by vehicles as well as by bottlenecks (OECD, 1999), due to insufficient capacity of the individual sections of roads, road works, incidents, accidents and collisions, events, weather conditions, social actions or demonstrations. A popular definition of congestion, quoted in the literature, is suggested by Goodwin and Dargay (1999): *"Congestion is mutual blocking of the movement of vehicles, due to the existing relationship between the objective speed of a moving vehicles and the volume of flow under conditions in which the capacity of the transport system is approaching exhaustion."* The effects of congestion include lower speed and longer travel time.

The most significant expenses resulting from congestion include the loss of time by road users who participate in the congestion (Gołębiowski, Jacyna-Gołda, Kłodawski, Lewczuk & Żak, 2014; European Commission (EC), 2007; Maibach et al., 2008). Further in this article, the cost of congestion is understood as the cost of time lost as a result of participation in congestion.

4.2. The costs of air pollution

As a result of fuel combustion in engines of various means of transport, a number of harmful compounds it produced that enter first into the atmosphere causing its pollution and also affect the hydrosphere and lithosphere. These compounds include sulfur dioxide, nitrogen oxides, methane and other non-methane volatile organic compounds, carbon monoxide and carbon dioxide, nitrous oxide and heavy metals, particularly lead and aluminum as well as carbon black (Igliński, 2009).

4.3. The costs of accidents and collisions

Everywhere where there is traffic, we have to deal also with traffic accidents and collisions. An accident is an event where people are wounded (more than 7 days in hospital), or killed. A collision is a traffic incident, which involves only material damage or where an injured person or persons are hospitalized less than seven days. The occurrence of road accidents and collisions causes significant social costs. As a result of accidents, following cost groups occur (in order of their creation) (Igliński, 2009, p. 94): material losses resulting from damage to the vehicle and the immediate surroundings of the accident site; costs associated with calling the police, ambulance, fire brigade or roadside assistance; medical care or burial costs, and insurance costs. This can follow up with legal services; compensation for pain and suffering and moral prejudice of people involved in the accident and their loved ones. Also, a loss in the production of goods and services resulting from injuries or death of persons involved in an accident. Finally, lowering the "social values" resulting

from death; the related potential contribution of individuals to the general welfare.

The effects of road traffic collisions are not as serious as accidents, but their occurrence is much more frequent. Accidents and collisions take place also during the parking attempts and cruising for parking. Although collisions during parking are typical, accidents occur much less frequently (Iron, 2007). It is worth noting that the risk that the driver, who is cruising for parking will result in an accident is low. The chance of an accident is much greater when irritated or hurrying drivers who are following the cruiser try to rapidly overtake their vehicle or do other dangerous maneuvers, thereby exposing other road users (particularly pedestrians).

4.4. Costs of noise

Noise in transportation causes a number of diseases which can result in the loss of health or even life. Noise can cause, among others, trouble sleeping, headaches, fatigue caused by limited possibilities of recreation in one's free time (Igliński, 2009, p. 90). In addition, noise causes annoyance, disturbance of cognitive function (learning and understanding), cardiovascular disease as well as adverse effects associated with mental health (Trela, 2012).

Methods for calculating the costs incurred as a result of the above phenomena are described in detail, among others, in reports prepared for the European Commission (Maibach et al., 2008; Korzhenevych et al., 2014).

5. Methodology of studying cruising for parking externalities

In response to the problem of the lack of research on external costs generated by cruising for parking, it was decided to build a model that would allow the estimation of such costs. To build the model, one needs to make several assumptions:

1) External costs arise from cruising for parking from the moment when the first vehicle begins to look for parking space and decelerates to this end. At this point begins the time in which they begin to form external costs. The longer the time, the higher the level of costs we face.
2) When the first vehicle starts cruising and does not interfere with other vehicles in traffic, as no one is behind it, it still entails the costs of incidents and accidents, air pollution and noise.
3) Congestion and the costs associated with it start to emerge when the vehicle that is cruising makes it difficult to move for at least one other vehicle, which is not necessarily looking for a parking space.

4) In a situation when one or more cars are moving behind the vehicle which is cruising are treated in the same as the users who are driving in order to reach a different destination than the vehicle doing the rounds to find a spot to park.
5) Where the phenomenon of cruising for parking involves two vehicles (e.g., one vehicle cruising and another participant who is not searching for parking space), you can already use the proposed model.
6) It is assumed that the known individual unit costs of all types of costs in the model vehicle, which ultimately participates in the cruising for parking congestion.

This methodology is the simplest form of the model treating each vehicle in the same way (fuel consumption, pollution, the number of passengers). The model assumes that the external costs of circulation depend primarily on the amount of vehicles that are involved in congestion. This model can be refined at the research stage. With the appropriate tools and methods of measurement one can, for example, include categorization of cars, which affect, in different ways, the environment and fuel consumption (motorcycles, cars, trucks, buses, etc.) In the constructed model, the external costs of cruising for parking are treated as an indicator showing that the cost in monetary terms was generated in a given unit of time. In the proposed model, the external cost of cruising is expressed in zl/h. Thus, the individual costs in the model must also be expressed in the same units of measurement. The general form of the model shown in the following Formula 1.

$$ECOC(zł/h) = \sum_{i=1}^{n+1} P_i + \sum_{i=1}^{n+1} A_i + \sum_{i=1}^{n+1} N_i + \sum_{i=1}^{n} C_i \qquad (1)$$

Where:

ECOC – External cost of cruising (zl/h)

n – the number of cars participating in the congestion (followers of the cruising vehicle)

P – cost of air pollution produced by the vehicle

A – average cost of accidents and collisions caused by the vehicle

N – cost of noise generated by the vehicle

C – cost of congestion caused by the vehicle

In order to use the model to calculate the external cost of cruising for parking, it is proposed that in the chosen areas (e.g., a city section) and period (e.g., a week) one should investigate how many cars cruised for parking, how much time it took and how many cars were involved in congestion caused

by cruising. After collecting the above data, the model will calculate what externalities in the selected area were generated by the phenomenon of cruising for parking. As a result, local governments will have a picture of the costs arising from the phenomenon and will be able to apply a specific policy to limit it. It follows that the applied model can be used for the calculation of externalities of cruising by cars in search of parking space, which confirms the hypothesis presented in this article. The biggest hurdle in the application of this model is the problem of quantitative measurement of cruising drivers and other participants of congestion. Only a method of empirical examination of the actual number of the drivers involved in the phenomenon will allow the use of the model and thus enable us to calculate the external costs.

6. Conclusions

The phenomenon of cruising is known to every driver. Few, however, realize that what external costs it generates. So far, no serious studies of the external costs generated by cruising for parking have been conducted, despite the fact that this phenomenon has been described by many authors. The basis for the calculation of the external costs of cruising for parking is to build a suitable model that would serve as a base for research. The answer to the problem of the lack of serious studies in the calculation of the external costs of cruising for parking is the model proposal presented in this article. The model is shown in its simplest form and can be adapted to specific research based on the studied area and the specificity of vehicles or infrastructure. In order for the model to be applied in practice, one should first estimate the single costs (generated by one vehicle) for the different types of costs in the model. This issue, however, is wide enough to make a topic for a separate article. The phenomenon of the cruising for parking in Poland is a subject that is described sporadically, and there are no studies in the literature in this field. The few studies have been published abroad, in particular in the United States. They examine the problem of cruising for parking space in cities with different characteristics than the Polish cities. Therefore, there is a need for a broad study of the phenomenon as manifested in Polish cities and the of the costs associated with its occurrence. There is also no methodology for measuring the numbers of drivers who cruise in search of parking space and the participants of congestion caused by cruising. Only after the development of such methodology will we be able to calculate the exact scale of the phenomenon and apply the presented model in order to calculate the external costs cruising for parking causes. The results of such studies may become rather valuable for local authorities in making decisions in the area of the public sector policy and particularly – transport policy.

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Biographical note

Krzysztof Drabek, Ph.D. student at the Department of Economics for Real Estate and Investment Process, Cracow University of Economics, Poland. President of the Association of Ph.D. and Ph.D. students of the University of Economics in Krakow. His main interest and research areas include: the economics of the public sector, the effectiveness of investing and property management. He professionally engaged in commercial property management.