

Article

Impact of Technological Changes and Taxi Market Regulation on the Taxi Vehicle Fleets—The Case Study of Slovakia

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Abstract: This paper aims to analyze the recent development of taxi services in Slovakia on two levels. The first is the area of technological change, which includes the use of digital platforms for the closing of the contract between the passenger and the taxi operator. The second level of perspective is the legislative change. Commonly used taxi digital platforms (applications) have started to require a taxi concession from self-employed drivers, and many other requirements. We will also analyze the issue of value-added tax. This article processes quantitative data on the number of valid taxi concessions. The data were obtained from the unified information system in road transport and supplemented with other statistical inputs. The article describes the distribution of more than 6819 issued concessions in individual regions and analyzes 12,477 taxi vehicles registered in these licenses for operating a taxi service. This article also includes the numbers of performed technical and emission inspections of taxi vehicles. With these data, it is possible to prove a sharp increase in interest in the concession due to the introduction of digital applications. A significant change in business conditions in this area can lead to an increase in the number of businesses by 70% in larger cities, while the issue of sustainability is questionable. In the last part, the article also deals with the issue of electromobility, and environmental aspects connected with taxi legislation changes.

Keywords: taxi; mobility; vehicles; legislation; electromobility



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1. Introduction

Mobile phone technologies have made tremendous progress in the last two decades. Today, mobile phones are no longer just for young people; they have become a regular part of people's lives. According to [1], wireless communication devices have caused a partial switch of users from desktops and tablets. This was possible due to the rapid expansion of features and higher performance of smartphones. Another aspect that has enabled the wider use of smartphones is the feature of an internet connection via Wi-Fi or data services. The European Union has been preparing regulations since 2007 that regulate end-prices for mobile phone use outside the home country (roaming). This caused a decrease in prices for calls, SMS, and, above all, data transmitted in roaming. Considering the last ten years, roaming prices have fallen by more than 90% by 2017 [2]. The data connection has expanded the possibilities of using smartphone communication applications. Now, Messenger, WhatsApp, or Viber are more popular than SMS. According to [3], Messenger was the most downloaded application on Android devices. However, we cannot forget applications with functions other than communication. The applications can also handle various specialized tasks related to entertainment, shopping, travel, etc. Today, smartphone users can choose from a range of transport applications that improve accessibility to public passenger transport systems or complement them with various means of first or last-mile transport [4].

Several authors created studies about shared mobility and mobility on-demand. One study [5] included 1188 respondents in Ghana. It shows several factors which influence

the adoption and use of ride-hailing services. These include socio-demographic aspects, perceived benefits, accessibility, safety, and car-dependent lifestyles. Respondents (70%) consider ride-hailing a convenient travel option that can reduce congestion and environmental pollution. The authors also described the characteristics of users—they are usually in the age group 18–24 (82% of respondents used ride-hailing) and 25–39 (72% of respondents used ride-hailing).

This article deals with transport applications, especially in Slovakia. The global positioning systems contributed to the development of mobile applications in road transport. GPS is a prerequisite for the operation of taxi applications [6–8]. The most famous application available in this area is ‘Uber’, which was launched in 2011 in the USA. In a short time, it became popular in New York, Chicago, and Washington D.C. The study [9] describes how users perceive ride-hailing services. According to this study, the most common reasons for using a ride-hailing service are its characteristics (convenience, cheapness, reliability, comfort, and quick travel option). The mentioned study is from Pakistan, but citizens of western countries also use ride-hail applications such as Uber or Lyft. Study [10] researched the influence of socio-economic factors, ethnicity, and geographic characteristics. Interestingly, the top 10 percent of rideshare users made 94 percent of Lyft Shared trips.

If we look at all the mentioned studies, we found that all focus on users of ride-hail services. Therefore, this article describes the scenario that will occur after the introduction of ride-sharing applications on the market in combination with a change in legislation. Our study focuses on taxi companies themselves. There is no doubt that apps such as Uber or Bolt are competing with the classic taxi service. The example of Slovakia is unique in the speed of change—the court’s decision to stop Uber’s activities (March 2016) and a complete change in legislation (April 2018). These changes brought a sharp increase in interest in doing business in this area.

Uber and similar applications arrived in Eastern Europe much later. In April 2016, Uber’s services were available in 405 cities in 60 countries on seven continents [11]. With such a rapid rise in taxi applications, concerns about the negative externalities of this mode of transport are growing. According to some authors, e.g., [12], these systems can increase traffic congestion and compete with sustainable public passenger transport systems [13,14]. The use of these applications while driving can also have a negative impact on road safety [15]. The Uber and Taxify (Bolt) applications started in Slovakia as an intermediate stage between carpooling and taxi service [16]. Therefore, we will define both passenger transport systems in the following lines.

Carpooling or ridesharing is a form of sharing a private car’s respective passenger seats. The chosen route must be suitable for the driver and at least one passenger [17–19]. The main advantage of carpooling is the sharing of travel costs. Users can be organized orally or via an independent organization such as BlaBlaCar or Motar. According to many studies [20–22], carpooling increases the use and occupancy of passenger cars and thus helps to reduce traffic congestion and emissions from traffic. This system, which is usually regulated by an online website, does not have timetables or fixed tariffs. The goal of carpooling users is not to make a profit. Therefore, the Slovak law does not regulate carpooling.

The opposite extreme of an individual’s passenger transport is the taxi service regulated, in Slovakia, by Act no. 56/2012 Coll. on road transport. According to this act, a taxi service encompasses passenger transport by vehicle with a maximum occupancy of nine persons, including the driver. Its purpose is to transport passengers to the destination according to the transport contract. Only the concession holder can operate a taxi service. A taxi service is a business with financial gain according to special regulations [23].

As can be seen from the previous lines, the definitions of carpooling and a taxi service are significantly different. Nevertheless, the mentioned applications (companies) tried to present themselves as something other than shared mobility services. Some authors [24] also describe Uber, Lyft, Didi, Ola, UberMOTO, BlaBlaCar, Didi Hitch, and Liftago as ridesharing applications. Uber and Bolt (formerly Taxify) used the unpreparedness and

obsolescence of Slovak legislation in Slovakia SR [24]. The authors in [25] mention how smartphone taxi applications are changing the road transport market. According to [26], there are three ways of regulating taxi services:

- Qualitative regulation—regulation of vehicle age, type, appearance, disability requirements, etc.
- Quantitative regulation—limiting the number of valid taxi licenses (concessions) in a city depending on demand.
- Economic regulation [27–29]—state administration issue obligatory tariffs. These must respond to the regular analysis of costs and revenues of the taxi service operators.

Regulation of taxi services is necessary to protect the customer—the passenger in this type of transport. According to [26,30], free-market access leads to lower efficiency, lower wages, and increased externalities.

This article describes significant legislative changes in taxi services after the introduction of digital applications Bolt and Uber. Of course, many other applications have not become very widespread in the Slovak Republic in recent times.

2. Materials and Methods

This chapter describes significant legislative changes in the field of taxi services in Slovakia. We also describe the input data and their sources. At the end of the chapter, there are research questions and hypotheses, which we will verify in this paper.

2.1. Legislative Changes in the Field of Taxi Service

According to the Road Transport Act, only the concession holder may operate a taxi service. It allows him to offer transport services and to conclude passenger transport contracts. The law defines the operation of a taxi service and the operation of dispatching. It is necessary to be a concession holder for both activities.

Slovak legislation of taxi service changed on 1 April 2019. It has several requirements for concession applicants. We summarized these requirements in Table 1. Significant changes are evident.

Table 1. Results of scan cycle times for monitored days according to Road Transport Act.

No.	Until 31 March 2019	Since 1 April 2019
1	Integrity	Integrity
2	Legal capacity	Legal capacity
3	At least one own or rented vehicle	At least one owned, rented vehicle, or leasing vehicle
4	Professional competence	Professional competence
5	Financial reliability	-
6	Owned, rented, or otherwise ensured taxi stand and place for garage or parking of the taxi vehicle	-

It is clear from the table that the government removed the requirement of financial reliability—EUR 1000 for each taxi vehicle. In addition, the concession applicant does not have to prove professional competence.

Some sections of the Road Transport Act have also undergone significant changes. Now, the taximeter is no longer necessary for all taxi vehicles. It is still mandatory if the fare rate is determined based on distance or time traveled. There are also three other options for setting a price of a ride. The price can be agreed upon before the ride via the digital platform, in writing, or by telephone. The phrase “digital platform” included all taxi applications to Road Transport Act.

A significant change is the definition of digital platforms in the Road Transport Act [23]. From 1 April 2019, only those who met the new requirements could continue to use the Bolt application in Slovakia.

From a scientific point of view, we will mainly examine the effects of changes in legislation. They probably caused an increasing number of issued taxi concessions in individual regions. During legislative changes, the taxi application Bolt did not operate in all regional cities. Therefore, we can identify the differences in the statistical data of the region without Bolt services. We also analyzed statistical differences in the number of taxi vehicles in different parts of the country.

2.2. Technological Changes in the Field of Taxi Service

Technological changes in the field of taxi services are also closely related to legislative changes. Now, the customer can use a smartphone with a data connection and GPS to order a taxi vehicle. This technology is advantageous for several reasons. The first is immediate information on whether a taxi is available. The customer also has approximate information about the location of the unoccupied vehicle. From 20 April 2019, it is possible to use the Bolt Comfort service [24], in which it is possible to order a more luxurious vehicle; driving prices are about 30% higher.

Taxi applications also have advantages for taxi operators. In the past, they had to equip their vehicles with expensive and calibrated taximeters. This is no longer necessary. A standard smartphone with a data connection and GPS is sufficient for this purpose. We cannot forget other requirements for a taxi vehicle. From 1 April 2019, it is possible to use a roof lamp of any color (except blue, red, or orange), not just yellow. Restrictions on the age and mileage of the vehicle are no longer in the act wording. We will discuss this issue in the Discussion.

2.3. Input Data, Research Hypothesis and Questions

This article will analyze the data collected from the register of taxi services that contains information for each valid license in the Slovak Republic. The Ministry of Transport keeps this list of taxi operators according to Act no. 56/2012 Coll. on road transport [23]. According to § 41, the ministry must publish the following data: the name of the concession holder, the validity of the concession, registration number, information on concession changes, and reasons for cancelation.

In this article, we will test the hypotheses and answer the following research questions:

- H₁: Digital platforms caused an increase in the number of concessions issued in individual regions by more than 25%.
 - What are the quarterly percentage increases?
 - What is the total number of concessions issued before and after 1 April 2019?
 - Does the Trenčín Region have different data? The Bolt application still does not operate in this city.
- H₂: The number of taxi vehicles increased by more than 25% year on year in individual regions after 1 April 2019. The legislation change caused this increased interest in operating a taxi service.
 - What impact did the change in legislation have on the total number of taxi vehicles in individual regions?
 - What was the increase in the number of performed technical and emission inspections of taxi vehicles?
 - Are the differences in the number of vehicles in individual regions statistically significant?
- H₃: We will decide whether the number of newly established taxi services correlates the most with:
 - The number of passenger cars registered in the region.
 - The number of vehicles registered in the region.

- The population of the region.
- The number of inhabitants of the regional city.

We will address all these research questions and hypotheses in the next chapter. We will use MS Excel for data analysis. We will use definitions of correlation dependency according to the source [30]. It states that the values of the correlation coefficient $|r| = (0.7; 1)$ describe strong dependence. Values of $|r| = (0.5; 0.7)$ are moderate and $|r| = (0.0; 0.5)$ are weak.

2.4. Data Collection and Preparation

This article is primarily based on data that include the unified information system in road transport, which was introduced in Slovakia on 1 January 2016. This system combines the following registers:

- Register of technical stations, their technicians, and inspections.
- Register of driving schools, training centers, and professionally qualified persons.
- Register of administrative offenses of vehicle operators.
- Taxi service register.
- ADR register.
- Register of road transport operators.
- Card register.
- Records of vehicle approvals.

The acquisition of data from this register was as follows:

1. Data were extracted from the system by regions as plain text.
2. Individual rows were converted to a tabular version.
3. Each address was assigned a region for later analysis.
4. The data collection was supplemented with economic indicators that could be matched according to the ID number. These were obtained from the information portal index entrepreneur. These data were not used in the resulting study for the following reasons:
 - It was not possible to access the economic indicators of natural persons operating in the taxi business according to a special regulation.
 - Most of the analyzed companies providing taxi services are limited liability companies that have a range of other economic activities; therefore, the summary indicators were not suitable to use as an input for data analysis.
5. Obtaining demographic data hurts—the number of inhabitants in regions and cities from the system of the statistical office.
6. A preliminary analysis was carried out, considering:
 - The sizes of companies according to the number of vehicles and regions,
 - Comparison of status in April 2019 and January 2022,
 - Number of companies by region.
7. Correlation analysis and analysis of variance were performed.

3. Results

Before the statistical analysis, we should describe the current distribution of registered taxi services in Slovakia. As can be seen from Figure 1, the lowest number of issued taxi service concessions was in January 2022 in the Trenčín Region (TN) 342. Other regions had similar values of registered taxi services—Žilina Region (ZA) 372, Trnava Region (TT) 431, Nitra Region (NR) 469, Prešov Region (PO) 662, Banská Bystrica Region (BB) 635, and Košice Region (KE) 835. The Bratislava Region (BA) has much more concessions, namely 3073. If we look at the statistics of vehicles registered in concessions, we find that the fewest vehicles are in the Žilina (706), Trnava (782), and Trenčín Region (776). More than a thousand vehicles were registered in the regions of Banská Bystrica (1085), Nitra (1178), Prešov (1262), and Košice (1804). In the Bratislava region, of course, there are the most taxi vehicles, namely 4884.

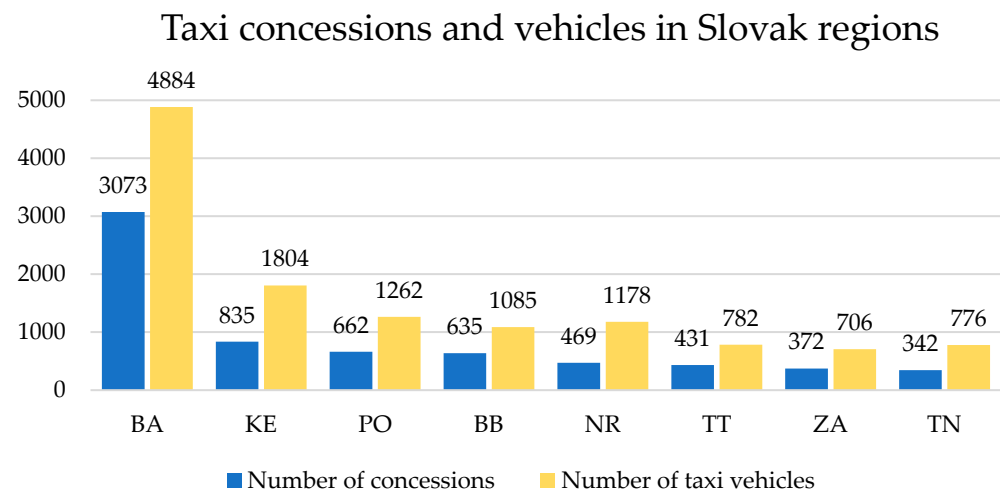


Figure 1. Current state of taxi business in Slovakia (May 2021). Abbreviations of regions: Bratislava (BA), Košice (KE), Prešov (PO), Banská Bystrica (BB), Nitra (NR), Trnava (TT), Žilina (ZA) and Trenčín (TN).

3.1. Taxi Concession

In the following lines, we will analyze the impact of taxi applications on the number of issued concessions. We focus mainly on applications established in Slovakia. The Bolt (formerly Taxify) significantly expanded from Bratislava to other regional and later district cities in Slovakia. Taxify has been operating in Bratislava since 2 December 2016 [31]. This means that from this date, it was possible to use the following taxi applications within Bratislava:

- Hopin—all drivers of the application have been licensed taxi drivers since the beginning. Application with the possibility of payment via credit card and in cash. The customer could filter the taxi providers according to the type of vehicle or the price for transport.
- Liftago—an application with the same features as the previous one, but the available taxi drivers respond to the transport request manually, which prolongs the time but may reduce the price for transport.
- Uber—after its launch, this application only allowed payment electronically (by registered credit card). Due to the outdated legislation, it did not require a concession or a taxi driver's license. It had its own rules for approving the driver and vehicle for operation. According to [32], Uber stopped its activities in Slovakia on 13 March 2018. On this day, the decision of the Bratislava I District Court entered into force.
- Taxify (Bolt since March 2019 [33]) is a company based in Estonia. As in previous applications, drivers could initially drive without a license and a taxi driver's license. However, compared to Uber, this application operated continuously until 1 April 2019. In April, the service outage occurred due to legislation changes. Until 31 March 2019, drivers did not have to meet any conditions, so many drivers performed the service daily. Now, only the concession holder can offer a taxi service in this application. The taxi driver also must have a proper taxi driver's license. However, it was not possible to prepare all formalities before the law came into force. Bolt informed all drivers about these changes, but customers did not know anything about the probably unavailable taxi service.

The number of issued concessions increased after April 2019. Our statistical analysis focuses on the period from 1 January 2018, when there was only one application (Bolt), in which it was possible to perform a taxi service without any official permits. This application was in operation in these Slovak regional cities:

- Bratislava since 2 December 2016;
- Košice since 3 March 2018 [34];

- Prešov, Nitra since 26 October 2018 [35];
- Žilina, Trnava since 30 November 2018 [36];
- Banská Bystrica since 12 December 2018 [37].

From the previous list, it is clear that the only Slovak regional city that is missing here is Trenčín. According to an official source [38], it is the only regional city where Bolt taxi service is still not available. As in other cities, electric scooters are still available in Trenčín.

First, we can display the number of concessions issued in each interval (Table 2). In this case, we used three-month-quarter intervals.

Table 2. Quarterly numbers of issued taxi service concessions in Slovakia. Source: processed by authors.

Since	To	Total	Change (–)	Change (%)
1 October 2017	31 December 2017	2994	-	-
1 January 2018	31 March 2018	3058	64	2.1%
1 April 2018	30 June 2018	3123	65	2.1%
1 July 2018	30 September 2018	3180	57	1.8%
1 October 2018	31 December 2018	3239	59	1.9%
1 January 2019	31 March 2019	3291	52	1.6%
1 April 2019	30 June 2019	4111	820	24.9%
1 July 2019	30 September 2019	4519	408	9.9%
1 October 2019	31 December 2019	4994	475	10.5%
1 January 2020	31 March 2020	5357	363	7.3%
1 April 2020	30 June 2020	5571	214	4.0%
1 July 2020	30 September 2020	5885	314	5.6%
1 October 2020	31 December 2020	6137	252	4.3%
1 January 2021	31 March 2021	6301	164	2.7%

Furthermore, we want to answer the question of whether the place of operation of the application has a significant impact on the number of issued concessions. For this reason, we have also processed quarterly growth factors. They express interest in establishing new companies that provide taxi services. We found that in regional cities, the number of issued concessions increased by 10 to 50% in the second quarter of 2019. However, the Trenčín region did not reach the lowest value. The following table (Table 3) shows the results. This article uses data about Slovak taxi enterprises from Complex Information System for Road Transport—JISCD [39].

Table 3. Increase in issued concessions in individual regions. Source: processed by authors.

Period/Region	BA	KE	BB	PO	NR	TT	ZA	TN
1st Q 2018	2%	2%	2%	3%	4%	1%	2%	3%
2nd Q 2018	1%	2%	2%	1%	5%	2%	3%	3%
3rd Q 2018	1%	1%	2%	2%	3%	1%	4%	3%
4th Q 2018	1%	2%	3%	2%	4%	4%	2%	2%
1st Q 2019	1%	2%	2%	2%	1%	2%	2%	2%
2nd Q 2019	31%	50%	12%	16%	15%	24%	10%	14%
3rd Q 2019	9%	16%	11%	8%	16%	9%	8%	5%
4th Q 2019	11%	14%	12%	9%	10%	15%	5%	7%

3.2. Taxi Vehicle

This section analyzes statistics on the number of vehicles registered in concessions. It is a fact that Bolt launched a massive advertising campaign after entering the taxi market. Therefore, the number of concessions and taxi vehicles also increased significantly. Each concession must contain at least one taxi vehicle in Slovakia.

According to Act no. 56/2012 Coll. [23] taxi vehicles no longer have to be equipped with a certified taximeter. The digital platform makes it possible to set the price for transport

before it starts. However, operating a taxi service without a taximeter was possible even before the amendment to the Road Transport Act (transport price agreed upon in advance by telephone).

The following lines describe the basic requirements for a taxi vehicle according to § 29 of Act no. 56/2012 Coll. on road transport. Vehicle requirements:

- The vehicle must be registered in the concession.
- There must be a copy of the concession in each vehicle operated.
- There must be a taxi service certificate in each vehicle operated.
- The vehicle must be marked with a detachable roof light with the word TAXI of any color except blue, red or orange.
- The vehicle must be at the right front door and inside the taxi vehicle in a place visible to the passenger at the basic fare; this does not apply if the price is agreed before the start of the transport.

We processed individual data from concessions issued in the respective regions for statistical analysis. Figure 2 shows the absolute number of taxi vehicles. Between 2018 and 2019, there was an increase in the number of registered taxis in all regions of the Slovak Republic by more than 25% (BA 68%, KE 72%, BB 31%, PO 34%, NR 31%, TT 40%, ZA 27%, and TN 26%).

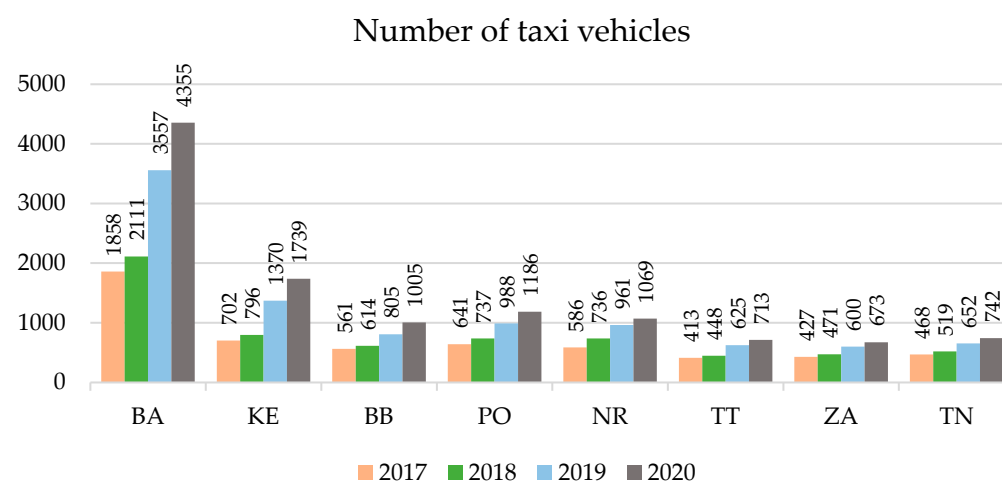


Figure 2. Registered taxi vehicles in Slovak regions. Abbreviations of regions: Bratislava (BA), Košice (KE), Prešov (PO), Banská Bystrica (BB), Nitra (NR), Trnava (TT), Žilina (ZA) and Trenčín (TN).

As can be seen from Figure 2, the increased interest in the taxi business in 2019 caused sharp increases in the number of registered taxi vehicles in all regions, including the Trenčín, where Bolt does not operate. This is mainly because the concession is not limited to a specific city. The Regional Office issues the taxi concessions. The applicant chooses the office according to his residence address. Subsequently, he can perform a taxi service in any city. Therefore, the place of issue of the concession, the place of registration of the vehicle, and the place of real operation can be different.

Supporting data, which also highlight the increased number of taxi vehicles in road traffic, show the number of technical and emission inspections carried out on these vehicles. Figure 3 shows the number of taxi vehicles and the number of inspections. The data of technical inspections before 2018 are not available. However, there is an increase of 41.63% in 2019 in emission inspections and up to 71.67% in 2020 compared to 2018.

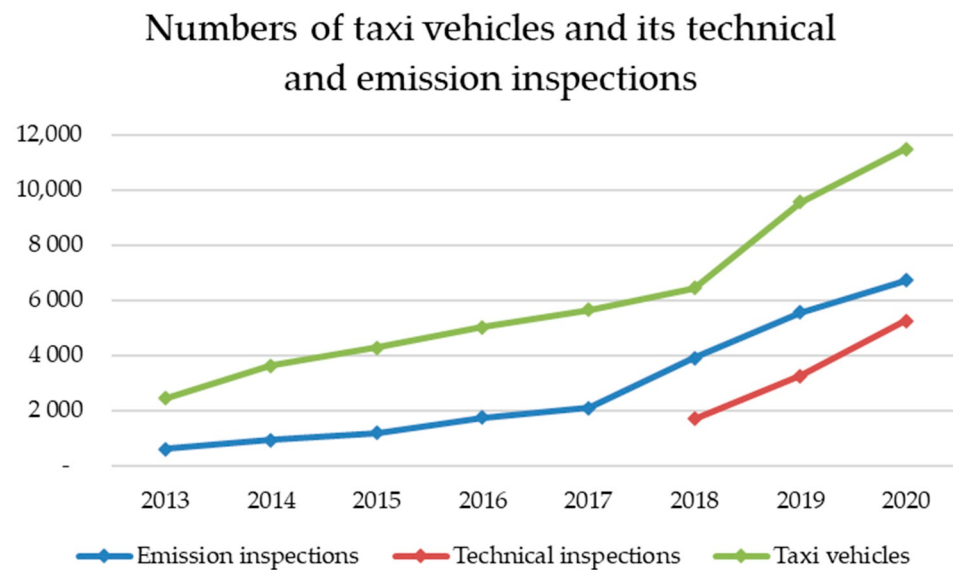


Figure 3. Taxi vehicles and their technical and emission inspections.

In further research, we focused on verifying the hypothesis of whether the differences in the number of vehicles in individual regions are statistically significantly different. We will use ANOVA analysis for this determination (Table 4). The null hypothesis (applies if $F < F_{crit}$) in this case was: The mean values are the same—the value of the independent variable (specific region) does not affect the value of the dependent variable (number of taxi vehicles). The alternative hypothesis (applies if $F > F_{crit}$) was: mean values are different—the independent variable affects the value of the dependent variable.

Table 4. Results of ANOVA analysis. Source: processed by authors.

ANOVA—Single Factor: SUMMARY						
Groups	Count	Sum	Average	Variance		
BA	2886	4476	1.5509	7.2236		
TT	401	737	1.8379	4.0362		
TN	326	761	2.3344	7.7925		
NR	427	1105	2.5878	9.9987		
ZA	368	696	1.8913	3.2089		
BB	622	1053	1.6929	3.5465		
PO	615	1235	2.0081	4.6693		
KE	768	1818	2.3672	12.9654		
ANOVA—Single Factor: RESULTS						
Source of Variation	SS	df	MS	F	p-value	F crit
Between Groups	803.8	7	114.8351	16.1873	0.0000	2.0110
Within Groups	45,437.9	6405	7.0941			
Total	46,241.75	6412				

In this case, we confirmed that $F > F_{crit}$ ($16.19 > 2.01$). We can state that the numbers of vehicles in concessions are significantly different within different regions. In other words, within a given confidence interval, a particular region has a significant impact on the number of taxi vehicles.

3.3. Correlation Analysis

In this section, we will use mathematical statistics to decide whether the number of issued concessions for the operation of a taxi service (variable y_1) correlates with:

- The number of passenger cars registered in the region (x_1).
- The number of vehicles registered in the region (x_2).
- The population of the region (x_3).
- The number of inhabitants of the regional city (x_4).

Alternatively, we will consider the number of registered taxi vehicles (as variable y_2). We calculate the correlation coefficients between the mentioned quantities and verify whether the calculated correlation between y and x (where $i = \{1; 2\}$ and where $j = \{1; 2; 3; 4\}$) is statistically significant or random. The correlation coefficients had the following values:

- The number of issued taxi concessions and
 - The population of the region: $r_{11} = 0.0818$;
 - The number of inhabitants of the regional city: $r_{12} = 0.9497$;
 - The number of passenger cars registered in the region: $r_{13} = 0.9289$;
 - The number of vehicles registered in the region: $r_{14} = 0.8827$;
- The number of taxi vehicles and
 - The population of the region: $r_{21} = 0.1385$;
 - The number of inhabitants of the regional city: $r_{22} = 0.9680$;
 - The number of passenger cars registered in the region: $r_{23} = 0.9426$;
 - The number of vehicles registered in the region: $r_{24} = 0.8942$.

We will deal with the evaluation and verbal interpretation of the results in the Discussion. However, the number of inhabitants in a given region does not significantly affect the number of issued concessions or registered taxi vehicles.

Subsequently, using the test of the significance of the correlation coefficient, we want to verify whether the correlation between the number of issued concessions and the number of inhabitants in the regional city is statistically significant or only random.

The significance test has the following steps:

1. Determination of the null hypothesis (H_0):

H_0 : There is no statistically significant linear dependence between y_1 and x_2 (between the number of concessions and inhabitants of the regional city): $r_{12} = 0$.

2. Determination of the alternative hypothesis (H_1):

H_1 : There is statistically significant linear dependence between y_1 and x_2 (between the number of concessions and inhabitants of the regional city): $r_{12} \neq 0$.

3. Choice of significance level α , in this case $\alpha = 0.05$.
4. Correlation coefficient calculation using the "CORREL" function or using Equation (1). The resulting value of the coefficient is $r_{12} = 0.9497$.

$$r_{12} = \frac{\text{cov } xy}{s_x s_y} = \frac{n \sum x_1 y_2 - \sum x_1 \sum y_2}{\sqrt{\left[n \sum x_1^2 - (\sum x_1)^2 \right] \cdot \left[n \sum y_2^2 - (\sum y_2)^2 \right]}} \quad (1)$$

5. Determination of the test criterion according to (2) and its calculation.

$$T = r \cdot \sqrt{\frac{n-2}{1-r^2}} = 0.9497 \cdot \sqrt{\frac{8-2}{1-0.9497^2}} = 7.4296 \quad (2)$$

6. The critical field of the test is $t_{\alpha}(n-2) = t_{0.05}(8-2) = 2.4469$; where $t_{\alpha}(n-2)$ is the critical value from the tables of t—distributions at the significance level α with $n-2$ degrees of freedom.

7. $|T| \geq t_{\alpha}(n-2) = |7.7296| \geq 2.4469$ therefore, we reject hypothesis H_0 and accept hypothesis H_1 .

In this way, we can determine the significance levels for other correlation coefficients. There is only a random correlation between concessions/taxis and the number of inhabitants of the region. For the others, we determined the significance as follows:

- The number of issued taxi concessions and
 - The number of inhabitants of the regional city: $r_{12} = 0.9497$; $\alpha = 0.001$;
 - The number of passenger cars registered in the region: $r_{13} = 0.9289$; $\alpha = 0.001$;
 - The number of vehicles registered in the region: $r_{14} = 0.8827$; $\alpha = 0.005$;
- The number of taxi vehicles and
 - The number of inhabitants of the regional city: $r_{22} = 0.9680$; $\alpha = 0.001$;
 - The number of passenger cars registered in the region: $r_{23} = 0.9426$; $\alpha = 0.001$;
 - The number of vehicles registered in the region: $r_{24} = 0.8942$; $\alpha = 0.005$.

4. Discussion

Firstly, in this chapter, we will refute or confirm the hypotheses and answer research questions. The first hypothesis of H_1 was: Digital platforms caused an increase in the number of concessions issued in individual regions by more than 25%. We can accept this hypothesis with some limitations. If we look at the number of taxi companies, the change in legislation and advertising campaign caused quarterly increases of more than 25% in the number of issued concessions. The question “What are the quarterly percentage increases?” relates to this hypothesis. The answer is in Table 3. There were no more than 5% of new taxi companies before the legislation change. However, in the second quarter of 2019, there were increases from 10 to 50%, in the third quarter from 5 to 16%, and in the fourth from 5 to 15%. From this, we can confirm the enormous change in demand for taxi concessions.

We also determined the research question: “What is the total number of concessions issued before and after 1 April 2019?”. In this case, we can investigate this issue on two dates. In May 2021, 6751 concessions were valid, and 3290 were issued before 31 March 2019.

In view of transport planning, it is necessary to know how the transport system reflects the activities of service providers such as Bolt. In Slovakia, there was a situation in which the application worked in only seven of the eight regional cities. This situation has persisted since June 2021. For this reason, we specifically investigated the Trenčín region, because in the city of Trenčín, Bolt did not provide a taxi service, only shared scooters. The interest in operating a taxi service company in Trenčín has increased the least if we compare 1Q/2019 and 1Q/2020. However, the differences are not very significant. This situation appears to be due to the following reasons:

- The lowest population of the regional city compared to the other seven regional cities.
- Because the concession allows taxi service to be offered anywhere in Slovakia. This means that a natural or juridical person applies regional authority according to the place of residence, but the person can provide taxi service in any place.

In the next part of the article, we also analyzed the number of registered taxi vehicles. Hypothesis H_2 was: “The number of taxi vehicles increased by more than 25% year-on-year in individual regions after 1 April 2019.” We can also fully confirm this hypothesis because in all Slovak regions, there was a year-on-year increase of more than 25%. The research question was: “What impact did the change in legislation have on the total number of taxi vehicles in individual regions?” We answered this question with the graph in Figure 2. However, we can also compare the number of vehicles falling into one company providing a taxi service. We made this comparison for March 2019 and March 2020. It is shown in Table 5.

Table 5. Average number of vehicles per one taxi company. Source: processed by authors.

Date	BA	KE	BB	PO	NR	TT	ZA	TN	Unit
March 2019	1.50	3.00	1.87	2.22	3.27	2.28	2.00	2.60	vehicles per
March 2020	1.53	2.47	1.74	2.06	2.79	1.98	1.97	2.46	company

It is clear from Table 5 that, especially in the first year after the change in legislation, many app users (drivers) set up a new small one-car taxi company. This caused the average number of taxi companies to fall.

Another question concerning the number of technical and emission inspections was: “What was the increase in the number of technical and emission inspections performed on taxi vehicles?” In this case, we confirmed an increase, although the limitation of this study is its insufficient data on the performed technical inspections of taxi vehicles.

In the end, we investigated the dependence of demographic data and data about taxi services. Based on the correlation analysis, we cannot predict the number of vehicles or taxi companies based on the region’s population. We discovered only a weak dependence. However, at the level of significance $\alpha = 0.001$, we found a strong direct dependence between the population of the regional city and the number of taxi companies ($r = 0.9497$) or the number of taxi vehicles ($r = 0.9680$).

4.1. Reasons of Escalation in Taxi Business

The essential question of our research is what caused the described significant increase in interest in doing business in the taxi service. We pointed out, first of all, the significant change and simplification of legislation. However, these relatively insignificant technical changes would hardly affect the public. For this reason, in addition to the change in legislation, another factor had to work here. We can also consider another reason for the increased interest in operating taxi services. It is a systematic advertising campaign prepared and paid for by the Estonian company Taxify/Bolt. Table 6 chronologically describes the individual steps of the company in Slovakia. It partially informed drivers of legislation changes. As we will show, the company dosed information gradually.

Table 6. Information for drivers in Bolt application. Processed by authors from own e-mail archive.

Date	Concession	Requirements on Driver	Requirements on Vehicle	Additional Services	Taxes	Description of Information
11 February 2019	x	x	x			The first information about legislation changes.
14 February 2019	x	x	x			Other information about legislation changes.
21 February 2019				x		Information about telephone package.
25 February 2019	x	x	x	x		Legislation changes and telephone package.
5 March 2019	x	x				Other information about legislation changes.
7 March 2019						Company name change from Taxify to Bolt.
12 March 2019	x	x	x			Other information about legislation changes.
26 March 2019	x	x				Other information about legislation changes.
27 March 2019			x			Vehicle labeling and taxi roof light.
29 March 2019	x	x	x			Other information about legislation changes.
31 March 2019	x	x	x			Other information about legislation changes.
3 April 2019			x	x		Vehicle labeling.
5 April 2019						Information about changes for passengers.
14 April 2019			x	x		Vehicle labeling.
3 May 2019				x		Introduction of a cancellation fee.
21 May 2019				x		Information about bonuses.
21 May 2019				x		Recruiting drivers.
27 May 2019					x	The first information about VAT.
28 May 2019				x		Introduction of Bolt Comfort.
29 May 2019					x	Other information about VAT.

4.2. Bolt Transformation and VAT Consequences

The previous table (Table 6) shows that the first information on the obligation to pay value-added tax for each driver driving on the Bolt platform came on 27 May 2019. At this

time, most drivers had already applied for a concession. What was the reason for this new obligation? The subject of value-added tax is a person who must file a tax return and pay it to the state budget. In this case, the taxable person can only be a person who independently carries out any economic activity. Economic activity means that the company's goal is financial gain.

Despite the definition of the place of supply under § 15, Bolt still has no registration for VAT yet. The place of service supply to a person other than the taxable person is where the service provider has its registered office or place of business. If the service provider does not have a registered office, place of business, or establishment, the place of supply of the service shall be his residence or the place where he usually resides. In this case, Bolt should issue an invoice with Estonian VAT.

Nevertheless, Bolt refused to register for VAT in the Slovak Republic. This significantly complicated the activity for self-employed drivers, who have to self-tax every invoice received from Bolt in Slovakia. Therefore, Bolt issues each invoice for using the application without VAT. When a taxpayer receives a service from a foreign person from another Member State, he is obliged to apply for tax registration before receiving the service.

All payers registered since 1 October 2012 have a tax period of one month. They must file a VAT return electronically for the previous month by the 25th of each month. After one year, they may request a change to a quarterly tax period. In this case, they will file a tax return every three months for the previous quarter. At the same time, only those entrepreneurs whose turnover in the last 12 months did not exceed EUR 100,000 can apply for this change. Whoever invoiced more must continue to file a tax return each month.

Table 6 also pointed out the non-complex marketing from the Bolt company. Application drivers did not obtain complex information. Many of them have become official drivers and independent entrepreneurs in the taxi service since April 2018. If the application management decided to provide comprehensive information on the obligations under the new legislation, they would probably discourage many drivers. There is an administrative burden associated with doing business. Regulations require a tax return for income tax and value-added tax. In addition, every driver and taxi service must meet the condition of mental and medical fitness and must obtain additional documents.

Detailed research in the field of taxi service would help with data from the Bolt platform itself. However, the company refuses to provide any internal data, not only about taxis but also about their other activities. Bolt also greatly complicates the work of partner drivers. It would be enough if the company would apply for VAT registration in the Slovak Republic. Instead, it forces hundreds of partner drivers to register. For drivers (small businesses), registration is disadvantageous and complicated. Their customers are (VAT) unregistered persons, so the only reason for drivers' VAT registration is the service purchase (Bolt application).

4.3. Environmental Aspects of Legislation Changes

According to the original wording of Act no. 56/2012 Coll. on road transport, the taxi service vehicle in Slovakia had to meet a requirement that was closely related to the ecological and safe operation of a personal motor vehicle. As a taxi vehicle, entrepreneurs could only use a vehicle that had a maximum of five years from the date of entry into service or a maximum of 100,000 km (cars with a petrol or hybrid engine) or a maximum of 150,000 km (vehicles with a diesel engine). Newer vehicles have lower emission limits. Therefore, the vehicle age requirement had a positive impact on the produced emissions. Table 7 shows the European emission standards from EURO 1 to EURO 6. The amendment to the Road Transport Act 1 April 2019 canceled this requirement. However, on the other hand, the Bolt digital platform itself has limited the maximum age of the vehicle to 15 years.

Table 7. Taxi vehicles appropriate for taxi operation according to their emission standard. Processed by the author from the source [40].

European Emission Standard	In Force from	Appropriate Vehicles	
		Requirements of Original Act no. 56/2012 Coll.	Bolt App Requirements
Euro 1	July 1992	No	no
Euro 2	January 1996	No	no
Euro 3	January 2000	No	yes
Euro 4	January 2005	No	yes
Euro 5	September 2009	Yes	yes
Euro 6	September 2014	Yes	yes

The previous table (Table 7) shows the reduced emission requirements for taxi vehicles due to restriction canceling. However, the vehicle fleet in Slovakia is naturally renewed. There was also a mileage limit for the taxi vehicle in the past. With daily taxi rides of only 225 km (average speed in the city 25 km/h and operating time 7.5 h), 250 working days is the annual mileage of 56,250 km per year. Due to this requirement, the taxi vehicle could be in service only for 1.8 years (petrol engine or HEV—hybrid electric vehicle) or 2.7 years (diesel engine).

4.4. Options of Electromobility Support

In the future, the taxi service could represent a suitable transport segment for more significant development of electromobility. According to the literature [41], electric cars reduce greenhouse gases and dependence on oil. According to [42], electrification of taxi fleets is an effective solution to reduce emissions from urban transport.

Electric cars should become the standard for all taxi companies in Central Europe. However, it is necessary to create a legislative environment that will create favorable economic conditions for investing in electric vehicles. Measures should include:

- Lower or zero motor vehicle tax for BEV—Slovakia met this requirement. The vehicles whose only energy source is electricity have a zero motor vehicle tax rate.
- Subsidies for electric cars—in Slovakia, there were two rounds of subsidies for electric cars (BEV—Battery Electric Vehicles and PHEV—Plug-in Hybrid electric vehicles).
- Road network charges—Slovak vehicles up to 3500 kg in total weight pay the electronic vignette regardless of the age, emission class, or type of vehicle engine. On the contrary, in the Czech Republic, BEV and PHEVs with emissions below 50 g CO₂ per kilometer have free vignettes.
- Support from digital taxi applications—in this case, the support should mainly include economic benefits through bonuses for more environmentally friendly taxi vehicles because their operation is more expensive.

The Ministry of Economy of the Slovak Republic launched the first subsidy program to support electromobility in cooperation with the Association of the Automotive Industry of the Slovak Republic on 11 November 2016 [43]. This program had a total budget of EUR 5.2 million. The amount of one financial subsidy was EUR 5000 for BEV and EUR 3000 for PHEV. EUR 5,000,000 was allocated to the project. The total number of correct applications was 831:514 for BEV and 317 for PHEV. Most applications were for legal entities. Applicants obtained funds in three-year installments. According to [44], the subsidy covered:

- BEV and PHEV in the category of passenger cars (M1) or small trucks up to 3.5 tons (N1).
- New vehicles only.
- Vehicles purchased and registered in Slovakia for at least two years.

The last round of subsidies was launched in November 2019. In this case, the subsidy package amounted to EUR 6 million. Support for the BEV was EUR 8000; for the PHEV, it was EUR 5000. The price limit per vehicle was EUR 50,000 with VAT. The results of the approval of applications according to [45] are shown in Table 8.

Table 8. Overview of subsidy applications for BEV and PHEV in 2019. Results of scan cycle times for monitored days. Source: [45].

State of Applications	Number of Applications	BEV	PHEV
Approved	601	624	81
Declined	4	–	–
Canceled	147	–	–
Subsidies paid	277	270	27

It is necessary to compare this amount with the prices of vehicles available in the Slovak Republic to evaluate the economic efficiency of subsidies (EUR 8000 per BEV). Table 9 shows the 20 cheapest electric cars according to [46], while the listed prices represent the lower limit of catalog prices. The Škoda Citigo-e iV and Volkswagen e-Up! are no longer available on the Slovak market.

Table 9. Overview of BEV prices and buyers' surcharges in Slovakia [46].

Car Brand and Type	Price Incl. VAT	Discount	Price Incl. VAT with Subsidy	Buyer's Surcharge	Price Excl. VAT with Subsidy
Škoda Citigo-e iV	17,590 EUR	3600 EUR	9590 EUR	54.52%	6658 EUR
Volkswagen e-Up!	17,970 EUR	4200 EUR	9970 EUR	55.48%	6975 EUR
Smart EQ fortwo kupé	22,726 EUR	–	14,726 EUR	64.80%	10,939 EUR
Smart EQ forfour	23,322 EUR	–	15,322 EUR	65.70%	11,435 EUR
Citroën C-ZERO	26,990 EUR	3000 EUR	18,990 EUR	70.36%	14,492 EUR
Nissan Leaf	27,970 EUR	8160 EUR	19,970 EUR	71.40%	15,308 EUR
Peugeot e-208	29,390 EUR	–	21,390 EUR	72.78%	16,492 EUR
Peugeot e-2008	31,390 EUR	–	22,390 EUR	71.33%	18,158 EUR
Renault ZOE	31,900 EUR	–	23,900 EUR	74.92%	18,583 EUR
Mazda MX-30	33,990 EUR	–	25,990 EUR	76.46%	20,250 EUR
KIA e-SOUL	34,490 EUR	–	26,490 EUR	76.80%	20,742 EUR
KIA e-NIRO	35,290 EUR	–	27,290 EUR	77.33%	21,408 EUR
Hyundai Ioniq Electric	35,990 EUR	2000 EUR	27,490 EUR	76.38%	21,575 EUR
Hyundai KONA Electric	35,890 EUR	2000 EUR	27,890 EUR	77.71%	21,908 EUR
Volkswagen ID.3	36,110 EUR	1500 EUR	26,110 EUR	72.31%	22,092 EUR
BMW i3	39,700 EUR	–	31,700 EUR	79.85%	25,083 EUR
Škoda Enyaq iV	39,490 EUR	–	31,990 EUR	81.01%	25,325 EUR
DS3 Crossback E-Tense	39,990 EUR	–	31,990 EUR	79.99%	25,325 EUR
Volkswagen ID.4	42,660 EUR	3000 EUR	34,660 EUR	81.25%	27,550 EUR
Tesla Model 3 *	40,990 EUR	–	32,990 EUR	80.48%	32,990 EUR

* Without VAT.

It is clear from Table 9 that the prices are relatively high even with a subsidy of EUR 8000. In addition, the vehicle used for passenger transportation must be large enough for the passengers and their luggage. A taxi company could become uncompetitive with the acquisition of BEVs because when comparing the cheapest liquefied petroleum gas (LPG) cars and those BEVs, the price difference can be more than 100%. As a result, it is necessary to favor the use of BEV or HEV taxis in cities through additional benefits.

4.5. Results Comparison

This article describes the specific situation (case study) in Slovakia. However, a formal comparison of results is possible. For example, this study proved that the number of taxi vehicles registered in Bratislava (the capital of Slovakia) increased from 1858 (2017) to 4355 (2020). Another study [47] from Johannesburg in Africa focused on Uber and Bolt services. In 2013, there were no more than 500 drivers in this city. In 2019, there were more than 6000 drivers. Although the units are different (drivers/vehicles), we can say that one driver usually uses one car in such services. The authors of [48] focused on a dataset of 29,434 taxi drivers in Taiwan. The results indicate that Uber reduced regular taxi drivers'

service revenue by approximately 12 percent in the initial year and 18 percent in the third year of entry of Uber. Their results show that Uber reduced regular taxi drivers' service revenue by approximately 12 percent in the initial year and 18 percent in the third year of entry of Uber. Other numerical comparisons are difficult. Most studies focus on the user side—demand, modeling, behavior, or economics. However, this article points to increased interest in the taxi business (quantified by the number of vehicles and licenses issued).

5. Conclusions

In this article, we have concluded that the change in legislation, combined with new platforms in the field of taxi services, significantly contributes to the interest in establishing new companies doing business in this area. The Slovak government started regulating taxi services quickly. It brought about new regulations that prevent the provision of unauthorized taxi services. This change helped existing taxi companies, but the passengers were unsatisfied with the short-term service outage and price increase. On the other hand, in all surveyed regions, there was a significant annual increase in the number of taxi services and registered vehicles.

From a mathematical point of view, we identified in the article that the most significant variable that correlates with the number of taxis and taxi vehicles is the number of inhabitants of the regional city. We can explain this very simply. Citizens of the regional center used the taxi service the most. The taxi service via application in other smaller cities and towns is unavailable or is available only occasionally.

In the last part, we pointed out the environmental issue of a change in legislation. The taxi vehicle has no restrictions on age and mileage anymore. Our theoretical part of the analysis shows the possibility of using electric taxi vehicles. Thanks to the short travel distance and operation in the city, BEVs are appropriate for this purpose. However, there is a problem with their high acquisition costs. This article mainly describes the Bolt platform. Its principle is that the application sets the fare itself. It does not consider the real expenses of a taxi company. There is no possibility of establishing the own price (for example, due to an environmentally friendly vehicle fleet). Overall, the combination of unregulated cost inputs and, conversely, fully regulated prices in the application are unsuitable for this business environment. However, the application provided benefits for passengers and residents of large cities—a more affordable, faster, and more transparent online taxi service.

It is important to mention that the taxi service can also affect the demand for public passenger transport. This impact can be negative if we take taxi transport as a substitution service for public passenger transport. Conversely, a taxi service can be complementary to public transport if people use it as a first-/last-mile transport [49,50].

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