

Does Uber competition reduce taxi drivers' income? Evidence from Brazil

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ABSTRACT

This article assesses the impact of Uber on the hourly wage of Brazilian taxi drivers. Information from the Continuous PNAD is used to build a longitudinal database that allows the estimation of these impacts through models in generalized differences in differences and in triple differences. The arrival of Uber is assessed in two moments: the first includes the cities of São Paulo, Rio de Janeiro, and Belo Horizonte, and the second, the cities of Goiânia, Recife, Curitiba, Salvador, and Fortaleza. The results indicate that Uber's arrival did not have a significant impact on the hourly wage of taxi drivers in Brazil. The article concludes that this evidence supports the idea that Uber does not take consumers of urban transport services from taxis, but only adds new consumers.

Keywords: Uber, Taxi, Longitudinal Data, Brazil

JEL Classification: O33, J23

1. Introduction

Although several studies show that net impacts on the labor market of sectors affected by new technologies are usually positive, i.e., an increase in the number of employees, there is a shared concern with its impact on the incumbent sector, particularly with the creation/elimination of employment. For example, Bessen (2015) shows that the number of banking sector employees increased despite the proliferation of Automatic Teller Machines (ATM), and Basker et al. (2015) show that the number of employees per gas station increased after the implementation of self-service pumps in the United States. Despite this evidence, resistance to changes by some of the workers in incumbent sectors is significant.

In this sense, the current expansion of technology companies associated with “Sharing Economy” has reignited the debate about the impact of innovations on the labor market. Although some have created so far non-existent markets, others have reached traditional sectors

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in the economy, such as car rentals (Getaround), the accommodation sector (Airbnb), and urban transport (Lyft and Uber). In general, these technology companies use applications capable of linking potential suppliers and consumers through georeferencing, thus reducing costs by facilitating the matching between supply and demand.

In contrast to these benefits, they are accused of taking employment and profit from traditional sectors, such as the hospitality and taxi sectors. The most common argument is that applications are in a gray area of tax regulation and legislation and would therefore have advantages that make competition unfair with these traditional sectors that are regulated and pay differentiated taxes. However, the impact of these applications goes beyond the labor market, since apparently it is not only the interest of a particular group of incumbent workers and companies that is under threat; there is also strong doubt about the state regulation concerning its costs and benefits, who will benefit or be disadvantaged with such a regulation, and its impact on the allocation of resources.

This debate, which has existed since the seminal contribution of Stigler (1971), is back in full force in the case of urban transport applications, where Uber is the pioneering company and the one with most prominence². Founded in 2010 in the city of San Francisco in the United States, today it operates in more than 70 countries reaching approximately 612 cities, with a total of more than 1.5 million drivers registered. Seven years after its beginning, the company is valued at US\$62.5 billion³. In Brazil, since its arrival in Rio de Janeiro in June 2014, Uber has already expanded business to 46 other cities and the latest information provided by the company shows that it already has more than 50 thousand drivers registered in the country⁴.

The worldwide acceptance of Uber described in detail by Hall and Krueger (2015), indicates that the regulation designed by Uber has lower social costs and appears to be more efficient than the state model, thus, their arrival into the market raises concerns for incumbent rivals, especially for taxi license owners. However, such concern seems to also affect taxi drivers, even those who do not own licenses. What is maybe not rational since they have earned the right to arbitrate, that is, to choose to work within the model that brings the highest income. Perhaps an explanation for this behavior is the misinformation the drivers are exposed to. As this

² Currently Uber has many competitors that offer a similar service, such as Lift, Cabify, Grab, Curd, among other local applications.

³ <https://www.nytimes.com/2015/12/04/business/dealbook/uber-nears-investment-at-a-62-5-billion-valuation.html>

⁴ Source: Uber. <https://newsroom.uber.com/brazil/fatos-e-dados-sobre-a-uber/>

is a fairly recent issue, few empirical studies have dealt with the impact of car ride applications on the taxi driver job market; as far as we know, there are only two studies that address this issue.

Berger et al. (2017) assessed the impacts of Uber on the fifty largest cities in the United States using aggregate data per city for jobs and taxi driver incomes. As control groups they used cities without Uber and workers of similar activities, such as truck drivers and vans. Using triple differences they found no evidence of employment reduction and found small reductions in the income of non-autonomous taxi drivers after Uber's arrival. One limitation of the work is the use of aggregate data, which implies the need to use many controls to try to mimic a random experiment, since the aggregate employment and income data by city are subject to a number of unobserved factors that change over time.

In Brazil, Esteves (2015a) used information from taxi applications with a greater insertion in the country (Easy taxi and 99taxis) to assess Uber's arrival into the cities of São Paulo, Rio de Janeiro, Belo Horizonte and Porto Alegre. As a control group, the author used cities of a similar size, and found that Uber did not initially affect the number of rides performed through the taxi applications. Esteves concluded that Uber probably met a pent-up demand and that Uber actually expanded the service consumer market. However, by using the number of rides per hour, the author fails to capture the effects of the increase in taxi fleets using the application. That is to say, the number of rides may have held up, but it does not mean the number of taxis that generated this number remained exactly the same in the assessed period.

In this sense, it is possible to affirm that the literature addressing the impact of Uber on the labor market of taxi drivers still has some gaps. This article aims to contribute to the literature by showing empirical evidence of these impacts in Brazil following the arrival of Uber in two moments. The first includes the cities of São Paulo, Rio de Janeiro and Belo Horizonte, and the second moment includes the cities of Goiânia, Recife, Curitiba, Salvador and Fortaleza. For this purpose, micro-data from the Continuous PNAD are used. This database allows the extraction of longitudinal information about the drivers, and from this, allows us to estimate models of differences in differences with controls for fixed effects (differences in generalized differences), and with controls for trend changes in other categories that are also potentially affected by Uber, such as bus drivers, van and motorcycle taxis drivers (triple differences). One of the advantages of this approach in relation to previous studies is that the use of driver

information allows the study to take Uber's arrival as a natural experiment. This is because drivers cannot select themselves to participate in the treatment and the choice of Uber is not related to the characteristics of these drivers.

In addition to this introduction, the article has four more sections. The next section discusses the urban transport by car regulation and introduce the idea of Uber as a private regulator. The third section looks at the data and methods used to identify the impact of Uber's arrival on the labor market of taxi drivers. The fourth section contains the results and a sequence of tests to assess their robustness. And at the end the main conclusions are presented, along with some ideas about the regulation of the urban transport service.

2. The competition to regulate urban transport services by car

Urban transport services by car (taxi) are regulated by the State for a number of reasons. One of these is that without the control of market entry there would be many taxis circulating and this would lead to, besides pollution and traffic congestion problems, a predatory competition that would lower the quality of service. In addition, free competition in the sector and the freedom to establish prices by the taxi drivers may lead to a price dispute that could make it impossible for the consumers to know what the real price is. This would thereby raise the search costs for a price that they would be willing to pay, or simply result in attrition due to bargaining the price to be charged for a considerable time⁵. Another reason for the regulation involves consumer safety issues. Consumers would like to have the guarantee that they are in a safe vehicle and guided by someone who is properly licensed and able to be identified in case any problem occurs.

Considering these "market failures" that can occur due to free competition in the sector, the most common regulation strategies involve entry control, licensing, mandatory insurance, and the establishment of fixed prices. Entry control aims to inhibit predatory competition, however, it assumes that the authority is able to determine the optimal number of cars and meet demand, while at the same time reducing traffic congestion and pollution problems. The licensing aims to guarantee minimum standards for the service being offered, such as the periodic requirement of driver training certification and vehicle quality certifications. Mandatory

⁵ This occurs in virtually every part of the world where taximeter use is not mandatory or is simply not used as a reference.

insurance aims to minimize problems that may arise in the case of accidents. Finally, fixed pricing in the form of fees aims to guarantee that the consumers have a clear definition of how much they will be charged for the service and the certainty that all taxis will charge the same price⁶. As well, this aims to guarantee the taxi owner a remuneration capable of ensuring the compliance of all the requirements established by the legislation and profitability cable of making the service economically viable and attractive.

However, these forms of regulations used around the world with minor variations are not immune to problems. Firstly the capacity of the State to establish the optimal number of cars licensed to offer the service and to supervise the standards established by the legislation is questioned. Monitoring costs are high and the supervisory discretionary power provided to a few public officials opens the possibility of some kind of regulatory capture by the regulated groups (STIGLER, 1971). Moreover, the high costs in the secondary market of licenses (sale and rental of vehicle registration plates) are a strong indication of income gains by a rent seeking⁷ group.

Regardless of the problems that emerge in any model of regulation that requires state supervision, the traditional regulation of taxi services generates other sorts of inefficiencies. For example, the current regulation gives discretionary power to the taxi driver to accept taxi rides. Thus, short taxi rides or those which simply do not interest the driver for some reason are rejected, and in the case of refusal, the consumers in certain situations may have no other transportation options. In addition, as service prices are fixed in terms of kilometers driven and/or stopping time, there is nothing to guarantee the consumer that the chosen route has less cost and/or time, when the driver is the one deciding which way to proceed.

Another very common problem is the lack of service at the times they are most in demand, such as on rainy days (Farber, 2014). Several authors have shown that the elasticity of the labor supply for taxi drivers is negative due to the existence a reference income (Camerer et al., 1997; Chou, 2002; Doran, 2004; Agarwal et al., 2015). Self-employed taxi drivers would work until reaching a daily and/or monthly pre-established income goal. For example, on rainy

⁶ In the case of Brazil, taximeter use is compulsory only in cities with more than 50,000 inhabitants, as provided by Law 12.468 of 2011. This Law, besides recognizing the profession of taxi driver, establishes criteria for exercising the activity, as well as rights and duties. See: http://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2011/Lei/L12468.htm

⁷ An expression created by Krueger (1974) and used to the present day to describe the idea that resource transfers are converted into social costs when individuals and firms spend resources and efforts to achieve it. In this case on screen, the resource spent is the license payment (license plate), which authorizes the driver to provide the taxi service and obtain gains with the market power obtained with the license.

days this goal may be reached faster, so they would choose to stop working earlier, and thus during the rest of the day there would be a shortage in the service offered. Aiming to solve these problems, several state authorities have tried to increase the supply of licensed vehicles; however, they ignore the fact that the problem is not the number of vehicles, but rather the incentives that the drivers are exposed to. For example, on rainy days higher costs are involved for self-employed drivers because of the risk of accidents, fuel expenses, and attrition due to driving in congested and, therefore, slower traffic. If the driver has already reached a particular goal or is able to produce the same income on another day with lower costs, the driver will do it and remove the vehicle from circulation on rainy days.

In turn, Uber, who calls itself a matching application and is often mistaken for being an urban transport vehicle company, is actually a private regulatory agency. Hall and Krueger (2015) show that the use of georeferenced information with the use of GPS installed in the consumers' and taxi drivers' smartphones, allows an increase in *matching* efficiency, thus reducing the transaction costs for both parties. For drivers, there is a decrease in the time and travel needed to attract clients, and for consumers there is a decrease in the cost of finding a vehicle, even though the use of applications requires a waiting time for consumers which in certain situations might be long.

However, the characteristics of the private regulator become more apparent when taking into account the rules that drivers and consumers are exposed to while using the application. For example, the problem of ride rejection that comes with state regulation is solved by Uber when the company does not inform the driver of the destination chosen by the consumer. The driver is aware of the destination only after accepting the ride. This ride may still be rejected, but the driver receives a negative rating from the company, which added to other rejections, will result in a penalty that normally involves the temporary suspension of access to the application. Therefore, incentives are created in order that no ride is refused and, although there are a few that can generate loss, for example, when a vehicle has to cover a long distance to do a short ride, the application seeks to minimize the chances of this happening by calling the closest driver. In addition, assuming that sudden losses may be possible, the application is able to generate ride average gains for drivers.

Nevertheless, these characteristics are currently common to applications used in door-to-door taxi services⁸. Not even the payment method via credit card is an Uber differential. Uber's main regulation differentials are their mechanism to determine prices and the use of a rating system. Uber's pricing system is quite similar to the taxi service regulated with established amounts per kilometers driven and stopping time, as well as a minimum amount for a ride. However, unlike the taxi service, Uber uses a dynamic pricing system known as Surge Pricing, established by a machine learning algorithm that uses big data to rate the quantity of consumers and drivers, available in a certain area and in a particular moment. A higher number of consumers in relation to the number of drivers available activates a multiplier in the price that discourages consumers and at the same time encourages drivers inactive at that moment to become available⁹. This tends to occur more frequently during dawn, especially on the weekends, and peak hours in big cities (HALL et al. 2015).

Thus, the pricing mechanism is a way of balancing the service's supply and demand without the common problems of shortage produced by state regulation. However, this mechanism alone does not guarantee reductions in waiting time or in service supply at those times when demand is very low. Thus, to maintain an uninterrupted service, Uber usually offers bonuses to drivers, reducing their commission in periods when the *surge pricing* is on, offering fixed payment amounts for a certain period of activation, or establishing the guarantee of minimum billing value in a certain period.

As previously highlighted, Uber's other relevant differential is its rating system, which assesses both drivers and passengers. With regard to the drivers, the rating of the rides involves several aspects ranging from the quality of the car to the care and safety of the ride. Drivers that are poorly rated (less than 4.6) are excluded from the application¹⁰. This implies that supervision is done without the need to have a state agent figure responsible for it, since each consumer is

⁸ Door-to-door taxi segment is one that works with telephone and/or application calls and the driver moves to the point of departure requested by the passenger. Currently the door-to-door taxi applications work with the same characteristics of Uber, that is, matching, georeferencing, and evaluation. However, they work only with licensed cars (taxis).

⁹ Hall and Nosko (2015) show that the absence of the surge pricing mechanism in New Year 2015 led the application not to complete about 75% of calls made in the period due to insufficient active drivers. According to the authors, in a scenario with fixed prices and supply (such as the taxi service under state regulation), when demand overcomes the supply, one has a considerable number of consumers willing to pay more for the service outside the market.

¹⁰ Although performance rating and exclusion also exists in taxi applications, the exclusion of the application does not prevent the driver and his car from driving, since one continues licensed to operate.

both a client and an Uber¹¹ prosecutor. This significantly reduces monitoring costs and is a much more efficient way of supervising because the evaluation criteria are based on the interests of consumers and not the interests of a state regulator or interest group, such as a provider of mandatory “refresher courses” for licensed drivers. For example, if a large number of consumers consider it necessary to have new vehicles made available by the application in a particular location, Uber may determine a shorter period of vehicle use, but if this is not considered necessary in other locations, the company can expand this period¹².

For these reasons, it is possible to see that Uber or any other similar application, are at first and foremost private public transport regulators, and being private, they aim for a profit that is obtained through a portion of what is charged in every ride (about 20% in the case of UberX). It is in Uber’s best interest to have as many rides, drivers, and satisfied customers¹³ as possible, that is, their survival in the market depends on an increase in welfare, something that does not necessarily occur with state regulatory agencies. It is undeniable that Uber has had some impact on the urban transport market, especially on car sales and taxi services, which until recently relied on the benefits of state regulation, such as having no competitors and, in cases of regulatory capture, having fees established quite above their marginal cost. In other words, the state regulation of car transport services has always been at the service of taxi license owners, as foreseen by Stigler’s (1971) Economic Regulation Theory.

On the other hand, drivers using the application services are able to offer similar or even better service at lower prices than those offered by taxis. This occurs because, among other reasons already discussed here, they do not have the costs of state regulation, such as having to pay for the issuance of licenses and their supervision. These lower prices allow the generation of welfare gains for the consumers in the form of consumer surplus, as shown in Cohen et al. (2016). The authors estimate that consumer surplus gains associated with UberX, Uber’s lowest

¹¹ In other words, this rating mechanism allows reducing the problems of moral hazard caused by hidden actions in the urban passenger transport service. Thus, the principal (regulator / Uber) receives information directly from its consumers and inhibits opportunistic actions on the part of the drivers (agents) excluding those that present an effort below the level established by the regulator.

¹² Currently the company demands in Brazil the maximum time of use of ten years. However in other cities in other countries it is possible to observe the requirement of a maximum of fifteen years. In addition, it is usually required vehicles with air conditioning, with four doors and windows working. For more details, see: <https://www.uber.com/pt-BR/drive/requirements>

¹³ It is important to note that the “regulation” enforced by applications is not immune to criticism. The most common refers to the lack of transparency in the criteria for selecting drivers and the absence of some form of insurance in case of an accident.

priced version, would have been \$6.8 billion in 2015 in the United States. In addition, the flexible working relationships established by Uber associated with the efficiency of the application to obtain customers and generate hourly earnings higher than those obtained by taxi drivers is able to increase the driver’s producer surplus (Chen et al., 2017).

3. Identification Strategy

The data used correspond to samples of taxi drivers who participated in the Continuous PNAD in two periods covering the entire national territory¹⁴. The first period is between the second quarter of 2014 and the first quarter of 2015. This period, as shown in Table 1, refers to the arrival of Uber in the cities of Rio de Janeiro, São Paulo, and Belo Horizonte. The second period is between the fourth quarter of 2015 and the third quarter of 2016, which includes the arrival of Uber in the cities of Goiânia, Recife, Curitiba, Salvador, and Fortaleza.

Table 1. Arrival of Uber per city in Brazil

City	Arrival
Rio de Janeiro	June 2014
São Paulo	August 2014
Belo Horizonte	December 2014
Brasília	February 2015
Porto Alegre	November 2015
Goiânia	January 2016
Recife	February 2016
Curitiba	March 2016
Salvador	April 2016
Fortaleza	April 2016

Source: Uber. <https://newsroom.uber.com/brazil/fatos-e-dados-sobre-a-uber/>

Note: Arrival in Campinas in January 2016 cannot be excluded from the control group on the long panel of second arrival.

Taxi drivers are identified by the Occupational Classification for Household Surveys (Brazilian “COD”) under code 8322, which refers to chauffeur and taxi drivers. As the occupational classification by the PNAD does not distinguish taxi drivers from the drivers of the applications, two identification criteria were chosen for the treated group (taxi drivers). The first criterion is to exclude the autonomous drivers, since after the arrival of the application, this is also the classification of Uber drivers. The second criterion is to consider only the drivers who

¹⁴ In each quarter, 211,344 permanent private households are investigated in approximately 16,000 census sectors, distributed in about 3,500 Brazilian municipalities.

have been working for more than a year, that is, before the application became part of the urban transport market.

The Continuous PNAD aims to monitor at least 20% of its sample for 5 interviews, i.e. 5 quarters. However, this purpose is not guaranteed for all activities. In the case of taxi drivers, information loss is much greater than that expected for the total sample. In this context, this study has chosen to work in each arrival of Uber with a short panel of three periods and a long panel with four periods. The first has a larger sample of drivers, but there is only one period before and another after Uber's arrival into some of the cities studied, while the second has a period before and two periods after the arrival into some of the cities, which allows us to evaluate the effects of Uber for at least six months from its arrival.

The choice of wage per hour as a study variable outcome is justified by the fact that the possible effects expected by Uber's arrival in the urban transport market involve both changes in income (wages) and the hours worked. For example, a possible effect of a reduction in the number of trips (rides) would be the need to work more hours (doing more rides) to maintain an income similar to the period prior to Uber. Otherwise, there would be a reduction in income. In both cases of increased hours and decreased income, there is a reduction in wages per hour. Thus, this variable is able to capture both effects, although their use does not allow them to be separated.

The strategy of identification consists of comparing two groups: a group that has had a specific change (treated) and another that has not (control). To identify the effects of Uber's arrival it is necessary that the exercise generates results as good as a random experiment, i.e. a natural experiment. In order to have a natural experiment it is important that the definition of who will be treated is random. In this case, the necessary conditions are that the treated group cannot choose whether they will be treated or not (self-selection), for example by moving to a place where the application started to work, and the choice of who will be treated (by Uber's arrival) cannot depend on characteristics that affect the taxi drivers' income.

It is not possible, however, to ensure that the arrival of Uber is random, i.e., independent of factors observed and non-observed which may influence the hourly income of taxi drivers. Both Esteves (2015a) and Berger et al. (2017) have drawn attention to the fact that the use of some controls is needed to give the study a random experimental nature. Esteves (2015a) used a fleet of private vehicles in circulation in the city as the control group, which according to the

author, is of fundamental importance for the Uber application's decision to participate in a particular city, since private cars could be potential rivals of applications. Hence, the greater the number of rivals, the greater would be the ability to capture the market through the supply of a substitute service. Alternatively, Berger et al. (2017) used unemployment rates, the portion of the population with higher education, the portion of the female population, and age groups that can be possibly correlated with both the arrival of Uber and the demand for taxi services. It should be noted that such studies used aggregate data and, therefore, need variables to control the effects of omission on the treatment impacts.

However, this study uses information from drivers and from Uber's decision to operate in a given city probably associated with fixed effects controlled in the estimated model. A short longitudinal database is used in which the need for controls decreases, since in the period of one year (four interviews), few of the characteristics likely to affect a drivers' income will change. In other words, there is no significant change in the controls indicated in the literature, such as the fleet of vehicles, age groups, the portion of population with a completed higher education, etc. In addition, the estimation with at least three periods has some advantages well known in the literature evaluating public policies (PISCHKE, 2005). The inclusion of the fixed time effect model allows controlling changes common to all drivers during the period evaluated, such as overall changes in the economy, seasonal effects, and business cycle fluctuations in Brazil. Of course, this does not exclude the possibility of omissions of changes occurring in the characteristics of drivers, such as the purchase of a new car; however, one year is a short period of time, so one should not expect significant changes in variables to be associated with the study.

Considering these aspects, the first strategy to identify the impact of Uber's arrival on the labor market of taxi drivers is a model of differences in generalized differences, given by:

$$w_{it} = \alpha_i + \delta_t + \beta Uber_{it} + \mu_{it} \quad (1)$$

Where w_{it} is the wage per hour of a driver i in the period t ; α_i are the fixed effects of drivers; δ_t are the time fixed effects and $Uber_{it}$ represents the study carried out in cities i from the period t as indicated in table 1. In turn, β represents the average effect of the study on the treated group. As this is a discrete study, the idea is to capture the extent of the effects of Uber but not its intensity because information regarding the evolution of the company's participation in the urban transport market is not available.

The estimations also include time trends per group (treated and control groups) to control potential differences in the trends among groups, and therefore, reduce concerns about the possibility that the impacts of Uber’s arrival are related to differences in the tendency among the groups (violating the condition of parallel trends) are reduced.

An important aspect of the identification strategy herein adopted is that it is assumed that changes in the local labor market are not caused by unobservable factors which vary in time and are correlated with Uber’s choice. For example, the growth in demand for taxis due to a sporting event, such as the FIFA World Cup. In this case, the effects on income could reflect changes that would have occurred even if Uber had not come to operate in the city. However, such changes would affect the urban transport sector as a whole, which includes the buses, vans, minibuses, as well as motorcycle taxis, since several cities included in the sample have the latter. This allows us to use these activities as a control group. Therefore, a more robust analysis is possible by adding one more dimension that not only allows us to assess the impacts of the application’s arrival on the labor market of these activities, but also to see whether the labor market of taxi drivers is more sensitive than the markets of other means of transport. Thus, a model with triple differences capable of controlling these changes is estimated by:

$$w_{ict} = \alpha_i + \delta_t + \beta_1(p_t h_i) + \beta_2(p_t d_i) + \beta_3 Uber_{it} + \mu_{it} \quad (2)$$

Where $p_t = 1$ when the period t occurs after treatment and is equal to zero otherwise, $d_i = 1$ when the driver is in a studied city and equal to zero otherwise, and $h_i = 1$ if the driver has a taxi and equal to zero otherwise. This triple differences model allows us to obtain the difference among the average income of drivers who work in cities where the application came into operation, and drivers who work in cities where the application is not used, as well as the changes in the average for drivers who do not drive taxis in the cities that received the application. The idea is to separate two effects: the effect of changes in the income of taxi drivers in the cities that do not have a relationship with the treatment, and the effect of changes in the income of drivers within the city in which the application has begun to operate and which has no relationship with the arrival of Uber. This allows, in addition to a more robust analysis, a detailed assessment of the impact of Uber on the income of taxi drivers.

In order to ensure a greater robustness of the results, a series of strategies are used. Changes in specification are carried out, weighted models are estimated by the PNAD weights,

and the hypothesis of parallel trends is verified by the estimation of a model with trends per group (cars x motorcycles and buses) and per treated and untreated groups, as suggested by Autor (2003).

4. Results

First, the results of the models using three periods only are shown in Table 2, which estimates the difference in differences, as well as the impacts of the first arrival (models 1-4) and the second arrival (models 5-8). Except for model 4, which used only drivers working in capital cities as the control group and the drivers who have worked for more than a year in this activity, which shows a negative impact on the income of around BRL\$ 2 per hour, statistically significant at 10% in the cities of São Paulo, Rio de Janeiro, and Belo Horizonte, the other models showed no significant coefficients.

Table 2: The effects of Uber’s arrival on the hourly income of taxi drivers in Brazil with three periods and double differences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Uber	-2.1087 (2.5927)	-1.5740 (1.1569)	-2.7298 (2.5926)	-2.0109* (1.1882)	0.1556 (0.8250)	-0.1744 (0.9443)	0.6396 (0.7980)	0.3019 (1.0709)
N	316	584	140	251	273	568	66	143
R ² intra	0.0130	0.0072	0.0178	0.0113	0.0265	0.0011	0.0449	0.0053
R ² between	0.0756	0.0362	0.0982	0.0450	0.0000	0.0005	0.534	0.0035
R ² total	0.0186	0.0049	0.0164	0.0076	0.0055	0.0006	0.0018	0.0025
Definition of taxi drivers	1	2	1	2	1	2	1	2
Control group	1	1	2	2	1	1	2	2
Arrival period	1	1	1	1	2	2	2	2

Notes: Entries are coefficients estimated by ordinary least squares. The dependent variable is income per hour. All the models have controls for individual and time fixed effects. Definition of taxi drivers 1: not self-employed. Definition of taxi drivers 2: working on the activity for more than a year. Control group 1: All the cities. Control group 2: Only State capitals. Arrival period 1: Rio de Janeiro, São Paulo, and Belo Horizonte. Arrival period 2: Goiânia, Recife, Curitiba, Salvador, and Fortaleza. Standard errors shown in brackets are robust to heteroskedasticity and adjusted for cluster per driver. *** p<0.01. ** p<0.05, * p<0.1.

When one more period is included, although there is a loss of some drivers’ information, there is also the benefit of having the impacts measured for one more period, enabling us to assess the medium-term impacts of Uber’s arrival. It should be remembered that the interviews are quarterly, therefore, two periods after the treatment is actually six months, which can be considered a reasonable time for consumers to get to know the application and its operation. This

aspect is important, particularly in relation to Uber's first arrival in Brazil in June 2014, as Uber did not have the awareness of the public it had the second time and currently has. In the second arrival, starting in January 2016, the application was already better known, so the treatment effect is expected to be more immediate.

Table 3 shows the results of all the treatment effects for the two periods and for different definitions of taxi driver identification and different control groups. The results again show that Uber's arrival has not generated effects significantly different from zero on the hourly income of taxi drivers. Comparing the results with Table 2 for the same specifications and control groups but with one less period, a signal change of some models is verified. Models (1), (2), and (6) cease to be negative and become positive, whereas model (4) ceases to be significant, and all of the coefficients become non-significant. In fact, the results indicate very small average impacts oscillating between R\$ -0,02 and R\$ 0,86. Therefore, it cannot be stated that Uber's arrival has generated some sort of loss to taxi drivers.

Table 3. The effects of Uber's arrival on the hourly income of taxi drivers in Brazil with four periods and double differences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Uber	0.4539 (0.6468)	0.0727 (0.6037)	-0.02752 (0.6851)	-0.0671 (0.7437)	0.4218 (0.7087)	0.8693 (1.3125)	0.5464 (0.7162)	0.4544 (1.3846)
N	173	315	76	137	143	294	34	67
R ² intra	0.0137	0.0061	0.0089	0.0020	0.0338	0.0027	0.1585	0.0180
R ² between	0.0306	0.0018	0.0099	0.0187	0.0284	0.0002	0.0005	0.0160
R ² total	0.0168	0.0023	0.0027	0.0001	0.0097	0.0004	0.0124	0.0026
Definition of taxi drivers	1	2	1	2	1	2	1	2
Control group	1	1	2	2	1	1	2	2
Arrival period	1	1	1	1	2	2	2	2

Notes: Entries are coefficients estimated by ordinary least squares. The dependent variable is income per hour. All the models have controls for individual and time fixed effects. Definition of taxi drivers 1: not self-employed. Definition of taxi drivers 2: working on the activity for more than a year. Control group 1: All the cities. Control group 2: Only State capitals. Arrival period 1: Rio de Janeiro, São Paulo, and Belo Horizonte. Arrival period 2: Goiânia, Recife, Curitiba, Salvador, and Fortaleza. Standard errors shown in brackets are robust to heteroskedasticity and adjusted for cluster per driver. *** p<0.01. ** p<0.05, * p<0.1.

However, as already discussed in the previous section, the impact on income, as estimated here in the models of difference in differences, could reflect changes that would occur even if Uber had not come into the city. Most probably, such changes would affect the sector of other means of passenger transport, like buses, vans, minibuses, and motorcycle taxis. This

situation allows us to use these activities as another control group, as well to estimate the income differences per hour of taxi drivers affected by the arrival of Uber, compared with drivers of other means of transport and drivers from cities where the application is not operating.

The results are divided per arrival into two tables: table 4 shows the results for Rio de Janeiro, São Paulo and Belo Horizonte, while table 5 presents the results for Goiânia, Recife, Curitiba, Salvador and Fortaleza. This time they include interactions between the treatment, taxi drivers, and the cities. The interaction $p_t * d_i$ captures the treatment effect on other means of transport, while the coefficient *Uber* captures the effect of Uber's arrival exclusively on the taxi drivers, so it is the coefficient of most interest in this study. The treatment effect on all treated groups, including taxi drivers and other means of transport, is obtained by the sum between the coefficient *Uber* and $p_t * d_i$.

Table 4. The effects of Uber's arrival on the hourly income of taxi drivers in Rio de Janeiro, São Paulo, and Belo Horizonte with four periods and triple differences.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Uber	0.2596 (0.3937)	0.0365 (0.7795)	-0.0424 (0.4328)	-0.5775 (0.8207)	0.0151 (0.4435)	-0.1861 (0.8090)	-0.2314 (0.925)	-0.5646 (0.9531)
pt*hi		-0.1618 (03396)		0.1190 (0.3794)		-0.0368 (0.4399)		-0.0047 (0.6056)
pt*di		0.4343 (0.6400)		0.5380 (0.6666)		-0.3423 (0.7027)		0.4365 (0.7266)
N	574	574	716	716	186	186	247	247
R ² intra	0.0100	0.0106	0.0067	0.0069	0.0047	0.0055	0.0033	0.0038
R ² between	0.0073	0.0066	0.0052	0.0006	0.0011	0.0037	0.0446	0.0212
R ² total	0.0046	0.0052	0.0014	0.0035	0.0006	0.0024	0.0042	0.0023
Definition of taxi drivers	1	1	2	2	1	1	2	2
Control group	1	1	1	1	2	2	2	2

Notes: Entries are coefficients estimated by ordinary least squares. The dependent variable is income per hour. All the models have controls for individual and time fixed effects. Definition of taxi drivers 1: not self-employed. Definition of taxi drivers 2: working on the activity for more than a year. Control group 1: All the cities. Control group 2: Only State capitals. Standard errors shown in brackets are robust to heteroskedasticity and adjusted for cluster per driver. *** p<0.01. ** p<0.05, * p<0.1.

However, for these treatment effects to have internal validity, that is, so that one can infer about causality, it is important not to violate the condition of parallel trends, which means that the treatment effect cannot reflect differences in the trend before the treatment occurs¹⁵. In order

¹⁵ However, it must be clear that the groups are allowed to have level differences in the dependent variable but not in their trends.

to test the possibility of parallel trends, Autor (2003) suggested the estimation of a model with interactions between the control groups and the treatment in the lags, and in the periods after the treatment (leads). The hypothesis that there is no difference in the trends is answered if it is not possible to reject the null hypothesis that the coefficients in this interaction are equal to zero. These results can be seen in Table A.1 of the Appendix. In all of the estimated models with different control groups, these coefficients are equal to zero. This allows us to interpret the results found here as being in fact the treatment effects.

Table 5. The effects of Uber’s arrival on the hourly income of taxi drivers in Goiânia, Recife, Curitiba, Salvador, and Fortaleza with four periods and triple differences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Uber	0.9919 (0.6935)	-0.0020 (0.9786)	1.2516 (1.1073)	0.6233 (1.3192)	0.7926 (0.7013)	0.2136 (1.0670)	1.0822 (1.1449)	1.5207 (1.5712)
pt*hi		0.7687 (0.5012)		0.4896 (0.5742)		0.4675 (0.9033)		-0.7321 (1.2147)
pt*di		0.5988 (0.7062)		0.4270 (0.6942)		0.3845 (0.7780)		-0.1141 (0.7654)
N	545	545	698	698	112	112	145	145
R ² intra	0.0140	0.0154	0.0045	0.0050	0.0542	0.0559	0.0123	0.0146
R ² between	0.0092	0.0153	0.0001	0.0194	0.0161	0.0085	0.0040	0.0038
R ² total	0.0060	0.0096	0.0021	0.0111	0.0166	0.0157	0.0075	0.0003
Definition of taxi drivers	1	1	2	2	1	1	2	2
Control group	1	1	1	1	2	2	2	2

Notes: Entries are coefficients estimated by ordinary least squares. The dependent variable is income per hour. All the models have controls for individual and time fixed effects. Definition of taxi drivers 1: not self-employed. Definition of taxi drivers 2: working on the activity for more than a year. Control group 1: All the cities. Control group 2: Only State capitals. Standard errors shown in brackets are robust to heteroskedasticity and adjusted for cluster per driver. *** p<0.01. ** p<0.05, * p<0.1.

Initially, it is possible that the results show the importance of controlling the interactions, since in some cases there are coefficient signal changes, and this indicates strong evidence of bias due to the omission of relevant variables. However, in spite of this, all coefficients are non-significant statistically in all estimated models for all of the treated parties (taxi drivers, others, and all of them together) in both arrival periods of the application in Brazil. Thus, there is strong evidence that Uber’s arrival did not have an actual effect on the income of the workers of the passenger transport sector in Brazil, particularly the taxi drivers. Additionally, to guarantee the robustness of such a result, table A.2 of the appendix shows the estimation of models in triple differences with another specification, using the logarithm of hourly income and with the weights provided by PNAD, which considerably increased the number of observations. Still,

even when another specification and almost one million observations were used, the results remain the same: there is no effect.

A possible explanation for these results is that the service offered by Uber attends a distinct profile of consumer. The taxi market can be divided into three segments (ESTEVEES, 2015b): (i) the segment of taxi stands, known in international literature as taxi rank; (ii) the street segment, known as hailing; and (iii) the pre-booking segment, also known as taxi-booking or phone booking. At first sight, it would appear that applications can replace taxis in all segments, although the third segment (pre-booking) was the one most affected by Uber. However, the sample of taxi drivers used in this study does not allow for distinguishing the driver's working segment. Therefore, these results can only reflect a sample composed mainly of drivers of the first and second segments.

Another explanation is the partial equilibrium of the service market. As in all segments, the service regulation imposes supply restrictions; taxi service prices are not determined by supply and demand competitive mechanisms, but are defined in the form of fares, which are usually well above marginal costs. Thus, prices above the competitive equilibrium reduce the number of potential consumers. In this sense, a rival with an analogous service and lower prices would enable its use by a higher number of consumers. This is probably the group of consumers of Uber services. As the company does not have the costs of state regulation, has lower transaction costs, and is able to efficiently manage its prices through its Surge Pricing mechanism, which seeks to establish prices close to the equilibrium between supply and demand. This conclusion is similar to Esteves' (2015a), who affirmed that it is not possible to rule out the possibility that the entry of Uber into the Brazilian urban transport market has been characterized, almost exclusively, by the expansion and diversification of this market, which means it has met a repressed demand that was not attended by the service provided by taxi drivers up until then. In other words, the application would work almost exclusively with "new" customers¹⁶.

¹⁶ This group of potential consumers certainly is not small in Brazil. The data from PNAD 2014 indicates that 74.03% of the Brazilian population had used their smartphone to access internet in that year. More than a half of users (57.97%) are concentrated between 18 and 39 years old, which means, even though it is assumed that people with advanced age have problems with handling the application, there is a reasonable number of potential consumers of this type of transport service. Therefore, it is not likely that absence of effects following Uber's arrival on taxi drivers' income is due to low access of internet via smartphone in Brazil.

Finally, it is possible to elicit an explanation based on the dissuasive powers imposed by legislation. From this point of view, the absence of effects on the labor market of taxi drivers would be explained by the fact that the Uber has created an illegal market for passengers¹⁷. In Brazil, the regulations regarding public transportation by car can be classified, at least, as controversial. The Federal Constitution in Article 22 provides the competence for the Union to legislate on national transportation policies. At the same time, the Federal Law 12.468/2011 establishes that “it is the exclusive activity of professional taxi drivers to utilize their own or third-party vehicles for remunerated public passenger transport”. Therefore, it establishes the monopoly of public passenger transport by car to taxi drivers. However, the Federal Law 12.587/2012, which established the guidelines for the National Policy on Urban Mobility, does not provide the public transport by car. That is, Uber operates in a gray area of legislation. For this reason, under the pressure of interest groups, some cities started to legislate on the matter, imposing a set of local rules for application-aided transport service. However, the two periods considered in this study are not affected by any of these rules, since the only city with this sort of legislation is São Paulo, which regulates the service provided by the application through decree 58.981/16, promulgated in May 2016, almost two years after the arrival of Uber in the city. In regard to the other cities evaluated in this study, until now none of them have had a legislation that allows the operation of an application-aided transport service. Ultimately, this possible illegality generates insecurity for both drivers and potential consumers, and can be part of the explanation for Uber’s lack of impact on the Brazilian taxi driver labor market.

4. Conclusions

This study examined the impact of Uber on the labor market of urban passenger transportation services in Brazil. Considering the results obtained for two periods of arrival with different control groups, different specifications, and estimations of differences obtained in a double or triple way, this arrival was not found to change the Brazilian taxi drivers’ hourly income. The results corroborate with the existing literature (ESTEVEZ, 2015a; BERGER et al.,

¹⁷ In Brazil, regulations regarding public car transport are controversial. The Federal Constitution in Article 22 provides for the competence of the Union to legislate on national transport policy. At the same time that Federal Law 12.468/2011 establishes that “it is the private activity of taxi drivers to use their own or third-party vehicles for charged public passenger transportation.” Therefore, it establishes the monopoly of the activity of transport of passengers by car for taxi driver.

2017) that the impact of Uber on the employment and income of taxi drivers is very small and even non-existent in many cases. Nevertheless, there was and still is a lot of resistance to the application by taxi drivers, enterprises and license owners, and state authorities.

The resistance by taxi drivers does not make much sense in theory and was not expected a priori, because they can arbitrate and choose between working in a taxi with or without an application or even more than one application. It cannot be ignored that drivers are indirectly affected by the Uber rating system and its criteria to exclude bad drivers. This system has created an expectation of good service that did not exist before due to lack of competition and efficient monitoring mechanisms by the state regulators¹⁸. In turn, resistance by the incumbent companies and license owners is expected. Considering that they have privileges and market power protected by the law, it is natural that they would use all possible resources to stop any competitors and other potential “rent seekers” and to keep their economic income in a “rent protection” type behavior (TULLOCK, 1967; KRUEGER, 1974). On the other hand, governmental authorities responsible for the regulation of passenger transport services by car, are self-interested politicians and bureaucrats who act as legislators in order to facilitate the matching of supply and demand (STIGLER, 1971). They would establish the regulation so as to maximize votes and political campaign funding without taking social interests into consideration (PELTZMAN, 1976). Without state regulation, they have nothing to sell or ways to benefit.

Therefore, it seems this is another case in which state intervention into the economy leads to the creation of rent-seeking by a group that is not interested in giving up their regulated and established privileges. Yet, applications that replace the state regulation of public transport by car not only significantly reduce the social costs of regulation, but also generate welfare benefits from the competition and consequently a reduction in price. There is already empirical evidence of both an increase in customers’ and drivers’ well-being. Thus, the arrival of Uber brought transparency to the social costs of regulation, particularly for the customers who are the ones most negatively affected. For Becker (1983), regulation generates social costs (dead-weight) to the point that the jeopardized groups start to place pressure in order to change the regulation. This seems to be the case because apparently Uber relies on the political support of its consumers

¹⁸ Leibenstein (1966) suggests that the imperfections of the market allow the incumbent suppliers not to seek for the best efficiency and profits, and they tend to accommodate, in a lenient way, to a certain level of inefficiency because of the lack in competitive pressure.

to make its operation legal. This is because private regulation established by Uber presents undeniable advantages compared to the state regulation of transport services by car.

In private regulation, technology provides significant reductions in the cost of monitoring/control, which in the public sector is done by public agents that can be captured by the regulated groups. On the other hand, the supervision of the application is carried out by customers that can only be “captured” when they provide a good service. Another advantage of the private regulation imposed by the applications is that they have some similar characteristics to a contestable market¹⁹, such as those proposed by Baumol (1982). Although the implementation of all new technologies involves sunk costs in terms of knowledge investments, the fact that there is no need for a large volume of asset investment, such as cars, results in low arrival costs in the sector. This encourages leading monopolistic competitor enterprises like Uber to keep improving their praxis, innovating and especially encouraging them to perform in similar conditions to a competitive market. In contrast, the state regulation makes taxi companies operate in a similar way to monopoly-like conditions. Furthermore, the application shows an efficient way of changing the prices in order to balance supply and demand. This would not be possible in the state regulation model, since it deals with only two types of prices defined by peak and off-peak times, which apparently are not enough to generate the needed income so the taxi drivers can offer an uninterrupted service and/or in an amount high enough to meet the demand, especially in the rush hour in big cities. The current state regulation model used in most countries generates supply shortages, either because of the insufficient number of issued licenses, or because of the incentives generated so that drivers do not work when they are most needed.

Having said that, this study shows more evidence that taxi drivers have not been negatively affected by the arrival of the application. Moreover, the results obtained in this study support the idea that Uber has spread the market to new customers and, thus, the taxi services were able to keep their share of the transportation market. This could be a sign that the taxi services will continue to exist, mainly in the taxi stands segment. On the other hand, this also indicates that there are high social costs in the current regulation model, and a large number of potential customers are excluded from the market.

Finally, it is worth highlighting that this study and consequently its conclusions are limited. The most relevant limitation concerns its external validity. Although models of

¹⁹ See Martin (2000) for a review of the theory of contestable markets and their limitations of application.

difference in differences may have good internal validity, i.e., we can infer their causality effects on the treatment of the referred groups, the same does not occur with their external validity. In other words, the estimated effects in this study may be different in other countries or cities. Besides, an increase in periods in the future shall indicate that the effects of Uber arrival occur in a significant way and distinct magnitude in different periods. So, it is important that new studies are carried out, preferably with longitudinal information about rides, taxi drivers, where they work, and, of course, information of Uber itself. Thus, it will be possible to evaluate its impacts in a more detailed and complete way, considering that this study had restrictions regarding information and, therefore, conclusions are limited to the available information.

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Appendix

Table A.1. Parallel trends tests

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
t_1 *Uber	-0.0202 (0.4721)	0.3812 (0.6101)	0.4113 (0.5658)	0.3080 (0.6344)	0.0545 (0.5633)	0.2041 (0.6199)	0.7205 (0.7179)	0.2348 (0.7250)
t_1 *Taxi	-0.0687 (0.4093)	-0.5649 (0.4755)	-0.5698 (0.5175)	-0.3437 (0.5316)	-0.0705 (0.4667)	-0.5777 (0.5314)	-0.9957 (0.9082)	-0.3119 (0.6964)
n	574	716	186	247	509	624	121	155
Definition of taxi drivers	1	2	1	2	1	2	1	2
Control group	1	1	2	2	1	1	2	2
Arrival period	1	1	1	1	2	2	2	2

Notes: Entries are coefficients estimated by ordinary least squares. The dependent variable is income per hour. All the models have controls for individual and time fixed effects. Definition of taxi drivers 1: not self-employed. Definition of taxi drivers 2: working on the activity for more than a year. Control group 1: All the cities. Control group 2: Only State capitals. Arrival period 1: Rio de Janeiro, São Paulo, and Belo Horizonte. Arrival period 2: Goiânia, Recife, Curitiba, Salvador, and Fortaleza. Standard errors shown in brackets are robust to heteroskedasticity and adjusted for cluster per driver. *** $p < 0.01$. ** $p < 0.05$, * $p < 0.1$.

Table A.2. Effects of Uber's arrival on hourly income logarithms and on hourly income of taxi drivers in Brazil with weight, four periods and triple differences

Variável dependente: logaritmo do salário por hora								
Uber	-0.1565 (0.1193)	0.0354 (0.1130)	-0.0007 (0.1304)	0.0731 (0.1237)	0.0566 (0.1263)	0.0123 (0.1236)	0.1458 (0.1501)	0.0902 (0.1399)
n	574	716	186	247	509	624	121	155
R ² intra	0.0386	0.0349	0.0387	0.0276	0.0434	0.0393	0.0465	0.0341
R ² between	0.0171	0.0061	0.0175	0.0144	0.0039	0.0017	0.0071	0.0002
R ² total	0.0162	0.0023	0.0126	0.0010	0.0091	0.0036	0.0065	0.0010
Variável dependente: salário por hora (w)								
Uber	0.8165 (0.9115)	0.3966 (0.9859)	0.5036 (0.9616)	0.2594 (0.9679)	0.8705 (0.8967)	0.0490 (1.0474)	1.2442 (1.0640)	0.5818 (1.0955)
n*t	860.632	1.133.699	260.069	379.670	727.855	936.217	127.292	182.188
R ² intra	0.0169	0.0178	0.0409	0.0205	0.0162	0.0224	0.0446	0.0304
R ² between	0.0257	0.0001	0.0430	0.0047	0.0069	0.0097	0.0093	0.0003
R ² total	0.0171	0.0005	0.0208	0.0031	0.0068	0.0011	0.0107	0.0011
Definition of taxi drivers	1	2	1	2	1	2	1	2
Control group	1	1	2	2	1	1	2	2
Arrival	1	1	1	1	2	2	2	2

period

Notes: Entries are coefficients estimated by ordinary least squares. The dependent variable is income per hour and the logarithm of income per hour. All the models have controls for individual and time fixed effects. Definition of taxi drivers 1: not self-employed. Definition of taxi drivers 2: working on the activity for more than a year. Control group 1: All the cities. Control group 2: Only State capitals. Arrival period 1: Rio de Janeiro, São Paulo, and Belo Horizonte. Arrival period 2: Goiânia, Recife, Curitiba, Salvador, and Fortaleza. Standard errors shown in brackets are robust to heteroskedasticity and adjusted for cluster per driver. *** $p < 0.01$. ** $p < 0.05$, * $p < 0.1$.