Effects of Taxi Market Deregulation: Evidence from a Natural Experiment

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Abstract

We analyse the effects of deregulation of the Finnish taxi market using a difference-in-difference framework. We estimate the causal impacts of deregulation on consumers, taxi firms, and taxi drivers. Our key finding is that the offered fares have increased on average by 7% in large municipalities and by 15% in small and medium municipalities. However, the variation in the offered fares is significant and consumers tend to choose lower fares when available. Large municipalities saw an increase in the number of taxi firms post-deregulation, which is reflected in lower average revenue, lower number of employees per firm, and a decrease in average profits. The amount of taxi firms in small and medium regions has not changed, but profits have declined despite the increase in prices. We develop a theoretical model to explain this contradictory result.

JEL: C54, D47, L11, L43, L98, R48

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1 Introduction

Decisions concerning regulation are of utmost importance for ensuring the proper functioning and efficiency of markets. From an economic standpoint, regulation is justified when correcting for market failures, but if not done correctly it may distort the market even further. Sometimes the administrative costs and distortions can even exceed the benefits obtained from regulation.

The early successes with deregulating various industries in 1970s in the United States have lead to a trend towards deregulation in industrialised countries. Deregulation has been seen to increase efficiency, reduce costs, and thus stimulate economic growth. On the other hand, deregulation is not the panacea; various deregulatory policies have resulted in adverse effects. For example, rail privatisation in the UK in 1990s increased prices and reduced passenger numbers, with no positive effects on innovation. Similarly, deregulation of the Swedish taxi sector has been found to reduce security and increase fares. There exists no clear consensus as to how deregulation effects different industries.

Although deregulation has been a contentious issue in policy debates for decades, the economic literature on the effects of full economic deregulation (i.e. removing both quantity and price regulation simultaneously) is fairly narrow. We fill this gap by analysing the causal effects of deregulation of the taxi market in the context of Finland. Before 2018, the taxi market in Finland was characterised by strict quantity and fare regulations: licence numbers were decided at the municipality level and fares controlled by a country-wide price ceiling. Both of these restrictions were removed.

We take advantage of a natural experiment arising from one of the 19 regions of Finland not implementing the deregulatory legislation. This allows us to estimate the effects of the policy change using a difference-in-differences approach. We estimate the effects of taxi market deregulation on offered fares and various characteristics of taxi firms and taxi drivers. We then build a model to explain the regional differences in the empirical findings with respect to population density of a region.

We find that taxi market deregulation has on average increased offered fares by 7% in large municipalities, and by 14 and 15% in medium and small regions, respectively. The variation in offered prices is substantial - in large municipalities variation is large within a region, whereas in smaller regions the variation comes mainly from variation between the regions. Based on secondary data from the Finnish Transport and Communications Agency, consumers in large municipalities tend to choose taxi trips priced at the lower end of the distribution.

Large municipalities saw an increase in the number of taxi firms post-deregulation, which is reflected in lower average revenue, lower number of employees per firm, and a decrease in average profits. The amount of taxi firms in small and medium regions has however not changed, but profits have declined despite the increase in prices.

The theoretical model shows that two factors can explain the different post-deregulation paths taken by larger and smaller regions: the economies of scale in matching drivers to riders and larger regions having more competition between dispatch centres. Irrespective of whether the dispatch centre market is competitive or monopolistic, the model predicts lower equilibrium prices in larger regions. The outcome – while surprising and contradictory to standard market models – is due to the economies of scale in matching. The differences in taxi firm entry, on the other hand, can be attributed to the different levels of dispatch centre competition. Moreover, publicly funded trips form a large part of the market in smaller regions, which may explain the lack of entry by taxi firms. The prices for these publicly funded trips have post-regulation been determined in a competitive procurement process, which has resulted in lower prices than before.

The article is organised as follows. We begin by reviewing the prior literature on deregulation and taxi markets in Section 1.1. We then provide a contextual background on the Finnish taxi market in Section 2. Section 3 discusses our methodology and describes the data. We then present the empirical results in Section 4, and build a theoretical model that explains the empirical findings in Section 5. Section 6 concludes.

1.1 Literature

Most of the earlier literature concerning deregulation draws from the literature on regulation. The traditional theory of economic regulation is that it serves public interest by correcting some market failure and hence improves social welfare - government intervention is justified if markets "fail" to meet the ideal of perfect competition. This theory has been criticised for relying heavily on the assumption that regulators are equipped with perfect information, and aim to maximise social welfare. Government regulation is seen as efficient, and can be implemented without substantial costs: somewhat paradoxically the information costs and transaction costs that cause the market failure are not present within regulation (Posner, 1974). Later literature has contradicted this notion by arguing that governments use flawed information as the basis of their regulatory decisions (Sappington and Stiglitz, 1987). The empirical research on the efficiency of regulation has confirmed this concern (for an overview of the literature, see Joskow and Rose (1989)).

Theoretical research concludes that markets are deregulated when the cost of regulation exceeds costs stemming from deregulating and the remaining market failure. A trend towards deregulation began in the United States in 1980s, with substantial deregulation in transportation, communications, financial, and energy sectors (Winston, 1998). Winston (1993) reviews some of the literature concerning these early experiments with deregulation, finding that in general economists have succeeded in predicting the effects of deregulation, such as lower prices and increased variation in prices. Deregulation has improved service quality through enhancing technological development. Profits and employee wages have in general declined after deregulation. However, variation in wages has in some cases increased, which could be explained by the wage moving closer to the marginal product, similarly to prices moving closer to marginal costs, and thus the market moving closer to the competitive equilbirium.

Taxis are among the most extensively regulated transportation modes in industrialised countries. This extensive regulation has been justified by imperfect competition. For an industry to be competitive, a large number of firms must face a large number of customers at a given time and place. In the cruising taxi market, this is rarely the case. One of the earliest models of the taxi market by Douglas (1972) portrays how the equilibrium price in the market is inefficient, and the efficient price minimises output. He argues that in deregulated cruising taxi market, there will be upward pressure on the price. Same conclusion is reached by Shreiber (1975), who argues that the cruising market is special in that the consumer meets one taxi at a time, and cannot therefore shop around. This "temporary monopoly" results in higher prices than in a competitive equilibrium.[1] Similarly, through building a simple model Cairns and Liston-Heyes (1996) conclude that in absence of price regulation there exists no equilibrium in a taxi market. Hence free entry and pricing may not be optimal.

However, most of economic taxi market literature supports at least some extent of deregulation (Moore and Balaker, 2006). De Vany (1975) considers a similar model to Douglas (1972) and tests it in multiple market configurations. He argues that restricted entry implies reduced consumer surplus. Through assessing taxi market restrictions in four UK cities, Beesley (1973) argues in favour of relaxing entry restrictions. By comparing costs and benefits of regulation, he argues that restrictions may impose more costs than benefits. In a similar vein, Beesley and Glaister (1983) argue that although there is a rationale behind regulation, regulators act based on limited information which generally results in inefficient regulations. Frankena and Pautler (1986) argue that there is no rationale for most entry regulations in the taxi market, although some fare and safety regulations may be justified.

The earliest models have been criticised for being unrealistic due to for example their primary focus being on the cruising market (see Williams (1980) and Shreiber (1975)). Taxi markets are characterised by fragmentation, and can roughly be divided into three market segments: the taxi rank, cruising, and dispatch market.[2] It seems obvious that the types of market failures in different market segments can differ, which is why some countries have introduced two-tier systems where different regulations are in place for different market segments (Aarhaug and Skollerud, 2014). Schaller (2007) notes that entry regulation in taxi market may lead to very different results in cab stand/street

[1] With the same logic, we could argue that there exists a temporary monopsony in a situation where a taxi driver and a consumer meet, but it is argued that taxi rides are a type of a credence good, and information asymmetry benefits the supplier.

[2] A fourth segment of the market is contract rides. For example in Finland, taxi rides compensated by social insurance form a large part of the market. We leave these types of rides outside of our analysis. For the effects of deregulation and subsequent procurement on taxi rides reimbursed by the Social Insurance Institution of Finland (Kela), see Ahomäki et al. (2023).

hail and dispatch market: whereas entry regulation may be justified in cruising market, regulation in the dispatch market may lead to deficiencies in taxicab availability.

Partly due to the support economic literature gives to deregulation, various countries have experimented with relaxing taxi market regulation. Because of successes in deregulation in other transportation, such as railroad, intercity bus and airline industries, some US cities extended deregulation into the taxi market as well. Teal and Berglund (1987) argue that deregulation has not achieved the objectives set for it: prices have generally increased and service quality has not improved. Gärling et al. (1995) analyse the short-term effects (8 months) of deregulation of taxi markets in Sweden, coming to fairly similar results as Teal and Berglund (1987). A more recent study by Marell and Westin (2002) extends the analysis to a longer time span, and finds some positive effects with respect to competition and productivity in rural areas of Sweden. The taxi market reform in Finland has gained quite a bit of attention in the recent years, and work in progress by Harju et al. (Mimeo) aims to evaluate the effects of taxi market deregulation on tax avoidance in the taxi industry.

The differential effects in urban and rural areas is highlighted in other empirical research as well. Gaunt (1995) studies effects of taxi deregulation in New Zealand, and finds that despite increase in entry and reduction in prices of taxi trips in major cities, there were only minor entry increases and price reductions in medium, and minor reductions in entry and increases in prices in small cities. It is not obvious that the intensity of competition increases automatically with deregulation, which may explain the different effects in rural and urban areas, as well as differences in different sectors of the taxi market (such as street hail vs. dispatch). Morrison (1997) comes to a similar conclusion, arguing that especially consumers in large cities have benefited from better availability and lower prices after deregulation.

The aforementioned countries have imposed "full" deregulation, as in deregulation of both entry and prices. Various countries have conducted policies focused on deregulating one part of the market. For example in Ireland entry restrictions were removed, whilst price regulations were kept in place. Barrett (2010) finds that entry deregulation has increased output and reduced consumer waiting times in the long run. In the Netherlands entry was similarly freed, and fixed prices were replaced with maximum pricing. The effects seem to be fairly similar to the Irish case: Bakker (2007) concludes that the size of taxi fleet grew substantially after deregulation. Maximum prices were initially supposed to be removed after an adjustment period, but because the prices increased substantially faster than the CPI, the maximum prices were kept in place.

A crucial limitation in the reliability of the literature, as already noted by Winston in 1993, is the absence of a counterfactual approach, and thus the inability to determine whether changes in an industry after deregulation are caused by regulatory change or other factors. Later literature, both theoretical and empirical has not been successful in overcoming this limitation. This study addresses this shortcoming.

2 Taxi markets in Finland

The Act on Transport Services (320/2017) entered into force on the 1st of July 2018, bringing about a multitude of changes into the taxi market. Before the reform, the Finnish taxi market was heavily regulated: quantity, prices, and quality were all strictly controlled.[3] The new Act sought to enhance competition and innovation by significantly lowering entry and quality controls and allowing free pricing.

Before the reform each municipality was assigned a fixed number of taxi licences. The number was confirmed annually by the regional Centre for Economic Development, Transport, and the Environment (ELY-Centre). In order to obtain a taxi licence, individuals had to meet specific criteria concerning clean criminal records, good health, and a completed taxi driver's exam. The licences were also linked to a specific vehicle. Because the licence quota was municipality-specific, taxis were only allowed to serve customers in the municipality in which they obtained their licence. If a taxi ride ended in another municipality, the taxi had to immediately return to its own municipality afterwards. The dispatch centres were required to provide services round the clock to ensure the availability of taxis in all geographical regions and at all times.

Deregulation implied that the municipality specific quotas on licences were abolished, meaning that practically anyone who meets the criteria for taxi driver's licence is able to obtain one. The licence is now nationwide instead of being tied to a single area. However, the company must still report a primary operating area. The licence is no longer connected to a specific vehicle, but only to the operator. At the same time, the requirements on clean criminal records were tightened in the Act[4].

Before the reform, taxi fares were controlled by an annually confirmed price ceiling. It was possible to charge less, but because of the strict entry controls and therefore a lack of competition, the maximum prices were de facto prevailing prices in the market.

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[3] Repealed Taxi Transport Act 217/2007

[4] The current requirements for obtaining a taxi driving licence can be found from `https://www.traficom.fi/en/services/taxi-driving-licence`

From July 2018 pricing has been free, although the law still requires pricing principles to be transparent and easily available to the consumer.

Some regulatory measures have been (re-)introduced after 2018. Since 2021, taxi operators have been required to operate as a company and consequently obtain a VAT number. In addition to the taxi driver's exam, an entrepreneurship exam was made a prerequisite for obtaining a licence. If the price of the trip is not fixed, it must be based on time and distance and calculated using a taximeter. A price of an example trip must be available for the consumer (10km + 15min) in order to allow for an easier comparison of prices.

In 2018 the total turnover of the Finnish taxi market was a little above a billion euros. During 2017, taxi trips comprised 1.2 % of passengers and 1.2 % of kilometres in total transportation. The most common type of taxi trip is a trip home or to some other location on a night out. The Finnish taxi market is characterised by a large share of publicly financed trips, which make up around 40 % of the industry turnover (Traficom, 2020). In rural areas, this figure is even higher. The Social Insurance Institution of Finland (Kela) is the largest public financier of taxi services, and it reimburses taxi trips to a health care provider in the case of illness, pregnancy, childbirth, or rehabilitation. After the reform, Kela has selected regional dispatch centers through public procurement Ahomäki et al. (2023). It is important to note the high proportion of publicly financed trips since it can affect the behaviour of taxi firms and cause the effects of deregulation to differ from the predicted (Marell and Westin, 2002).

3 Methodology and Data

We evaluate the causal impacts of taxi market deregulation utilising a legal reform that took place in 2018 in all other regions of Finland besides Åland. Åland is an autonomous island region located between Finland and Sweden, and although it is part of Finland, it enjoys considerable independence in setting some of its own regulations. Prior to the reform, Åland followed the national taxi regulation. While preparing the deregulatory legislation, the Finnish Ministry of Communication and Transportation forgot to inform the provincial government of Åland about the upcoming changes. When Åland was informed about the matter, they considered the preparation time too short and made the decision to remain under the old legislation. Therefore, the fact that Åland was left outside the deregulatory reform was fairly random, making it a reasonable candidate for a control group.

The pre-treatment period consists of years 2013 - 2017, during which no other taxi market reforms took place. The post-treatment period consists of years 2018 - 2019.[5] Most of our variables of interest are either annual (firm variables) or depict the situation in the end of a specific year (employee variables). Year 2018 is included in the treatment group since we expect the effects of the deregulation to be observable even at the yearly level.

Our primary goal is to estimate the effects of deregulation in sub-regions similar to Åland. We assess similarity based on area, geographical similarities, population and its density, as well as the presence of an airport and a central hospital. We identified 25 candidate regions that form our main treatment group. Our secondary goal is to expand this analysis into large cities with larger and more complex (post-treatment) taxi markets. We include five large municipalities in this treatment group. Since Åland has followed the same price-setting rules that were present at a national level prior to the reform, we are able to study the effects on offered prices regardless of regions' similarity

[5] In 2020, the Covid-19 pandemic significantly altered the market conditions. It does not seem feasible to assume that the pandemic affected markets in Åland and mainland Finland in the same way. Hence we limit our firm and employee level analysis to years before the pandemic.

to Åland. The complete list of the sub-regions and their characteristics is shown in Tables A.1 and A.2 in the Appendix.

We divide our analysis into three parts. First, we evaluate the effects of deregulation on offered consumer fares. These offered fares are obtained by searching for taxi trips through mobile applications. Second, we evaluate how profitability has changed for firms and their employees after deregulation. We estimate changes in firms' profits and costs as well as employee wages. We also examine other employee characteristics such as experience, whether they are born abroad, and part-time employment. Third, in section 5 of the paper, we study the mechanisms through which deregulation affected taxi markets in different regions by developing a model which considers population size and density as a key difference between regions.

The main regression used to estimate the firm and employee effects is the standard difference-in-differences equation

$$y_{imt} = \alpha + \beta P_t + \gamma T_m + \delta P_t \times T_m + \lambda_m + \theta_t + \psi X_i + \epsilon_{imt} \tag{1}$$

where P_t indicates post-treatment period, T_m indicates sub-region that received treatment, λ_m represents region fixed effects, θ_t time fixed effects, and X_{imt} contains controls for firms' age.

For the estimates of price effects we use a regression similar to the one depicted in Equation 1, but with the difference that we only observe two time periods: regulated maximum prices before the deregulation, and offered prices four years after the deregulation in 2022. Price regressions also include additional controls for trip distance and whether a dispatch centre operates solely through a mobile application.

To be able to interpret the difference-in-differences estimates as causal, we need to ensure that we can confidently assume the control group to represent a counterfactual for the treatment group. This parallel trends assumption implies that we have to be able to assume that Åland would have continued on the same trajectory as mainland Finland in absence of the deregulatory reform. We evaluate the validity of this assumption by visual inspection as well as statistical tests standard to the literature.

The parallel trends assumption seems to hold fairly well visually: as shown in Figures A.1, A.2 and A.3, the pre-trends for our outcome variables evolve similarly.[6] This indicates that prior nationwide shocks affected all regions under the same legislation in similar ways.

Following Autor (2003), we further evaluate the feasibility of the parallel trends assumption by estimating the following regression

$$y_{imt} = \alpha + \gamma T_m + \sum_{t=2014}^{2019} \delta_t (Y_t \times T_m) + \sum_{t=2014}^{2019} \beta_t Y_t + X_{imt} + \epsilon_{imt}$$

where Y_t represent binary variables corresponding to years from 2014 to 2019. The coefficient of interest is thus δ_t, which represents the additional difference in the outcome variable by year stemming from being located in mainland Finland (treatment group). This should not deviate from zero in the pre-treatment years. We plot the coefficients and the corresponding 95 % confidence intervals against time. The results are shown in Figures A.4 and A.5. Reassuringly, these are not significantly different from zero for most of the outcome variables and treatment groups.

We have also acknowledged the concerns about potential spillover effects between treated units (SUTVA). The primary concern in our study is whether treated regions react to treatment in other regions and whether treated regions have spillover effects on the control group. The reform abolished operating regions, and although taxis must have a primary operating region, they are now free to operate anywhere in Finland apart from Åland. This could raise a concern with respect to regional spillover effects. We argue that these spillover effects are unlikely since taxi markets tend to be fairly local. Our regions incorporate significant geographic areas around population centers, which in turn are quite far apart from each other due to Finland being sparsely populated. Spillovers into the control group are unlikely, since Åland is a separate geographic entity

[6] We also use fare of the taxi trip as an outcome variable, but the pre-treatment trends are identical since maximum fares were imposed on a national level.

as it is an island, and the taxi driver's licence obtained in Mainland Finland cannot be used to offer taxi trips in Åland and vice versa.

We assume the treatment to be equal in all similarly sized regions, since quantity regulation was based on a region's size and the maximum fares were decided on a national level. Due to possible differences in the way quantity regulation was set, there is a reason to believe that differently sized regions might have had different treatment. Also, based on previous literature, there seems to be solid evidence that the region size is a confounding variable when examining the effects of taxi deregulation. We address this by presenting our results separately for small, medium, and large regions.

3.1 Data

Firm and employee-level data are obtained from Statistics Finland. The time period we examine is years 2013 to 2019. Firm data includes information from financial statements including revenue, profit and costs. The data also contains information on firm's age, size, and its employees.[7] At the employee level, we observe socio-demographic characteristics such as age, education, and ethnicity, and work-related characteristics such as wages and employment history. Descriptive statistics for the firm-level data aggregated at a treatment group level are shown in Table A.3. Instead of licence holders we utilise data on individuals who work in the taxi transportation sector, since not everyone who has obtained a taxi licence is actually working in this sector.[8]

As we use data on individuals who work in the taxi transportation sector, the data includes dispatch centres. This is not our entity of interest, and thus we have made the assumption that if the most common position in a firm is a taxi driver, the firm is a taxi transportation firm. However, if the most common position is something else, such as

[7]Statistics Finland collects information on an individual's employer for the longest employment period of a year as well as the employer at the last day of the year. Therefore, a single employee may have at most two employers per year in our data. Therefore, it is likely that we underestimate the number of employees per firm, especially after reform, when working part-time became significantly easier.

[8]The issue with using licence information is that the licences were easy to obtain by simply notifying the government. This meant that some individuals obtained the licence as an option without proper plans to ever drive a taxi. This argument is supported by a survey conducted by the FCCA on taxi licence holders.

an office worker, the firm is assumed to be a dispatch centre, and thus dropped from our data.

To study consumer effects, we manually collected post-treatment prices and times-to-arrival for 5 690 taxi trips in 18 small and mid-sized sub-regions during April of 2022. The trips collected were approximately 5, 15, and 25km in distance and they either started or ended in a regional centre, such as an airport, a regional hospital or the city centre. We expanded the data during June and July 2022 by collecting prices and waiting times for those five large municipalities with ride-hailing platforms such as Uber, Yango, and Bolt present in the market.[9] Based on firm revenue, and not including dispatch centers, these five municipalities make up 88% of the studied taxi markets. The expanded data contains fares and times-to-arrival for 15 171 taxi trips over the distances of 1, 2, 3, 4, 5, 7.5, 10, 12.5, 15 and 20 kilometres. We include trips that take place within the city centres, between city centres and the suburbs, and within the suburbs.

During both of the collection periods, we collected identical data from the control group Åland. Due to having only one dispatch centre with a phone application, we obtain one price and waiting time observation per query. Therefore, the control group data consist of 482 trips collected in April 2022 and 758 trips collected in June and July 2022. However, since these are regulated fares, they can be generalised to other taxi firms in Åland regardless of the method of ordering.

It should be noted that there were no pandemic-related restrictions in place during any of our collection periods in any of the regions studied. However, there was an increase in regulated fares in Åland on June 1st 2022. The local taxi company immediately increased its fares to meet the new regulated limit. Åland was planning higher regulated fares already in March, which together with relatively slow process of writing and updating legislation, speaks in favor of focusing on the updated fares in our analysis. We provide our results using both new and old regulated fares, and our main results are not significantly affected by which prices are used.

[9]These larger cities are Helsinki, Espoo, and Vantaa in the capital region, as well as Tampere and Turku.

Table 1: Descriptive statistics on queries

	Large regions	Medium regions	Small regions	Åland
Observations	3,068.20	389.20	256.86	1,240.00
	(847.53)	(316.27)	(125.18)	
Obs. per query	7.22	2.43	1.45	1.02
	(5.82)	(1.70)	(0.81)	(0.15)
Number of dispatch centres	13.80	5.10	4.14	1.00
	(3.19)	(1.73)	(1.77)	
5km fare	19.38	23.45	23.50	18.33
	(4.94)	(7.78)	(8.05)	(1.40)
5km time to arrival	8.18	7.89	7.95	4.73
	(5.08)	(5.66)	(6.90)	(2.24)

Notes: Table presents the regional averages categorised by region size, with standard deviation in parentheses. Control group Åland consist of only one region and thus has no variation in region-level variables. Number of dispatch centres portrays the number of dispatch centres or ride-hailing platforms that we used in data collection, and is therefore the number of dispatch centres with mobile applications.

In order to obtain the fares for trips before deregulation, we exploit the knowledge that all taxi firms priced their services at the regulated upper limit. We also know the exact prices and the pricing formula used.[10] Since we know the distance and duration of each collected taxi trip, we are able to calculate the pre-treatment fares for each trip.[11] These fares vary depending on the time of the day, since there were different maximum starting fees for daytime, evening, or weekend trips. The price can also vary based on the amount of traffic on the roads, since if the taxi was moving slow it could charge a time based fee. We take both of these concerns into consideration.

To ensure that the calculated prices accurately reflect the fare before the deregulation, we compare the collected data from Åland, our control group, to the calculated fares using prices set by the current regulation.[12]

[10] Government Decree on maximum fares charged from customers for taxi transport services (403/2017, 570/2016, 796/2015, 470/2014, 460/2013)

[11] Pre-reform regulated fares were different depending on whether the ride was for 1-2 or 3-4 passengers. Post-reform dispatch centres usually set fares for 1-4 or 5-8 passengers. Our estimates act as a lower bound since we assume 1-2 passengers when calculating pre-reform fares and collecting control group observations.

[12] Åland continues to use the same formula for setting maximum prices that was used prior to deregulation in all of Finland. Furthermore, in publicly financed trips covered based on social sickness insurance

The results are presented in Table A.4. The observed fares are very similar to the calculated ones. The minor differences can be explained by the fact that the application used in Åland only gives price quotes in integers, thus the prices may actually vary by some cents. Furthermore, prior to deregulation as well as under the current regulatory framework of Åland, taxis are allowed to use the waiting price instead of the distance-based price whenever the taxi is moving sufficiently slow, for example due to traffic congestion. This may consequently explain some of the difference, since we use only the distance of the trip in our fare calculation. These minor differences should not affect the differences-in-differences estimates since the error is identical in both treatment and control group and, more importantly, the pre-treatment difference in fares is equal to zero.

there are still maximum prices, which are almost identical to maximum taxi trip prices (Government decree 406/2022, only available in Finnish).

4 Empirical analysis

4.1 Consumers

We begin by analysing the effects of deregulation on offered prices. The main estimation results presented in Table 2 show the change in average offered taxi fares caused by the treatment.

Table 2: DiD estimates on offered fares

	(1) All regions	(2) Large municipalities	(3) Medium sub-regions	(4) Small sub-regions
Treatment	0.040***	0.034***	0.043***	0.032***
	(0.004)	(0.003)	(0.003)	(0.003)
Post	0.151***	0.151***	0.151***	0.151***
	(0.000)	(0.005)	(0.005)	(0.005)
Treatment x Post	0.092***	0.071***	0.153***	0.139***
	(0.024)	(0.005)	(0.006)	(0.006)
Control at baseline	2.074***	2.042***	2.122***	2.082***
	(0.011)	(0.004)	(0.005)	(0.006)
Observations	43579	32198	9300	5113
Time Fixed Effects	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: Table presents differences-in-differences estimates of treatment impact on offered fares (logarithmic). Pre-treatment fares are calculated for each trip using 2017 regulated fares. Time fixed effects include both time-of-day and day-of-week. Region fixed effects are at sub-region level. Standard errors are clustered at regional level and are presented in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Our difference-in-differences estimates show statistically and economically significant increases in average offered fares in all regions. Average offered fares have increased 14% and 15% in small and medium sized sub-regions, respectively. In large municipalities, offered fares have increased on average by 7%.

Before deregulation, offered and realised fares were essentially the same because of the price ceiling. Since prices are allowed to diverge post-regulation, it is important to not only examine the averages but also evaluate whole spread of options available for the consumer.

Figure 1 plots the observed fares for different distances in both the treatment and control groups, as well as the pre-reform regulated fares for the respective distances.[13]

In all different sized regions the observed offered fares are on both sides of the control group fares. In large municipalities, offered fares lie on both sides of the pre-reform fares, which means that it is possible for a consumer to obtain a taxi trip for cheaper even in nominal terms than before deregulation.

In small and medium-sized sub-regions this variation in fares comes mainly from variation *between* different regions - the estimated increase in average offered price varies between 0.02 and 0.22. The region-specific regression results are presented in the Appendix Table A.5. In large municipalities however, the variation in offered fares *within* the region is substantial, meaning that consumers can choose cheaper rides if they wish to.

Observations from realised fares confirm our findings. The Finnish Transport and Communications Agency (Traficom) has been collecting data on all taxi trips since April 2022.[14] Similarly to our findings, the variation in realised fares is substantial, particularly in larger municipalities. Traficom's data shows that the realised fares in large municipalities have on average decreased after the deregulatory reform. Especially in the capital region, consumers seem to pick taxi rides that are on the lower end of the fare distribution and thus below the pre-reform regulated fares.

In Traficom's data we observe how consumers from other regions than Uusimaa (the region that contains the capital region) choose taxi rides from the upper end of the distribution. This can be explained by our finding that in smaller regions the variation comes primarily from variation between the regions, which implies that consumers do not have much choice. Furthermore, prices have on average increased significantly in

[13]The fare spread is also visible when looking at the list prices of the dispatch centres. We show in Figure A.6 that the list prices are mostly correlated with the observed prices, meaning that similar price spread would be observed also when ordering a taxi without using the mobile applications. List prices were collected from firms' websites during June 2022. Some firms, e.g. Uber, do not have list prices available. Other firms, e.g. Yango, state that dynamic pricing will be applied during high demand.

[14]Price monitoring of taxi services, `https://tieto.traficom.fi/en/statistics/price-monitoring-taxi-services`

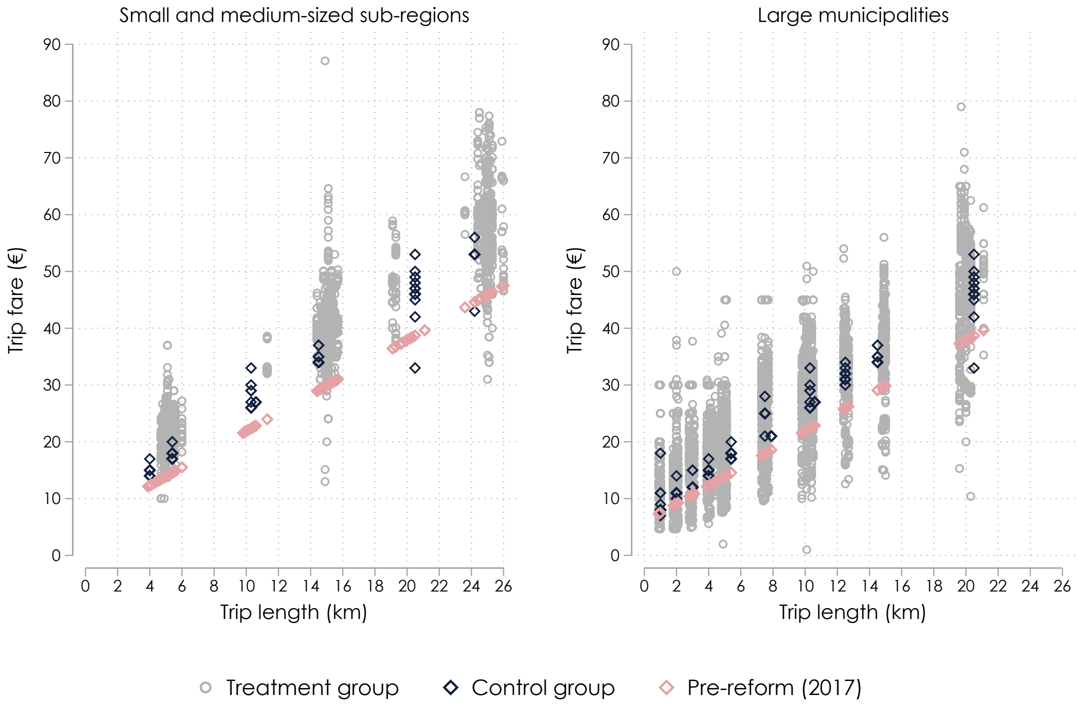

Figure 1: Observed taxicab fares during business hours (weekdays and Saturdays)
Notes: Figures present all observed fares sorted by trip length. Control group observation collected in June and July are used. Pre-reform fares are calculated using regulated fares from 2017.

most smaller regions. Thus consumers are benefiting from the deregulation mainly in large regions where there is competition between firms.

To better understand why certain regions have lower prices we estimate the correlation between observed variables and the fares. We see in Table 3 that app-only dispatch services offer on average cheaper rides in larger municipalities. This is also evident from Traficom's price monitoring where the distribution of realised fares of trips booked through applications is skewed to the left, meaning that consumers tend to choose the cheaper rides. This could be explained by the fact that applications allow for fairly low effort comparison of fares. Furthermore, in large municipalities there are more substitutes for taxi rides, such as public transportation, which may imply that consumers have more price elastic demand when it comes to taxi rides. If the offered fares are very high, consumers may choose to use another mode of transportation instead. In smaller and more remote areas this may not be possible, and the taxi firm has more bargaining power.

Table 3: Descriptive regressions on logarithms of fares

	(1) All regions	(2) Small regions	(3) Medium regions	(4) Large municipalities
Number of dispatch centers in region	-0.017^{**}	-0.047^{***}	-0.013^{**}	-0.020^{***}
	(0.005)	(0.004)	(0.004)	(0.000)
Trip length (km)	0.063^{***}	0.052^{***}	0.050^{***}	0.070^{***}
	(0.003)	(0.002)	(0.001)	(0.002)
App-only dispatch	-0.376^{***}	0.101^{***}	-0.110^{*}	-0.404^{*}
	(0.081)	(0.008)	(0.035)	(0.093)
Outside business hours	0.067^{***}	0.083	0.076^{*}	0.062^{*}
	(0.012)	(0.039)	(0.026)	(0.015)
Friday or Saturday	0.007	0.011	0.010	0.012
	(0.004)	(0.007)	(0.006)	(0.007)
Peak demand	−0.004	0.030	0.012	−0.011
	(0.007)	(0.037)	(0.020)	(0.006)
Pickup at city	-0.037^{**}	0.018	−0.008	−0.030
	(0.012)	(0.020)	(0.012)	(0.016)
Constant	2.750^{***}	3.057^{***}	2.961^{***}	2.857^{***}
	(0.044)	(0.046)	(0.028)	(0.029)
Observations	22101	1798	3892	15171
Region Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*

Notes: Dependent variable in all regressions is log(fare). App-only dispatch refers to dispatch centers which only operate through mobile applications. Peak demand is an interaction term of *Outside business hours* and *Friday or Saturday.* Pickup at city is a dummy variable that gets value 0 if pickup location is in a suburb and 1 if close to a city center. Standard errors are clustered at regional level and are presented in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Another explanation for the regional differences in the effects of deregulation on fares is market concentration. As seen in earlier studies, such as Buri et al. (2022), the effect deregulation has on fares depends heavily on the amount of competition that forms within the industry. Table 3 shows how the number of dispatch centres within a region is negatively correlated with offered fares. The size of the coefficient is larger in small regions where the absolute amount of dispatch centers is also lower. This makes sense since we would expect a more significant impact on competition when moving from 2 to 3 dispatch centres than when moving from 10 to 11.

We explore the mechanism through which the policy reform affected different regions further in section 5.

4.2 Taxi markets, firms and employees

We begin the analysis by visually inspecting market level variables. Figure A.1 depicts the evolution of these variables by region size. The development of industry revenue has been fairly stable in all sub-groups, and only in large municipalities the aggregate revenue seems to slightly increase after the reform. The aggregate number of taxi drivers in the market has been gradually reducing in all regions pre-reform. In large and medium regions the trend has changed after, and number of drivers has begun to increase. Number of firms has similarly been declining in all regions, but in large municipalities there is a sharp increase after the deregulation.

Deregulation has not led to any significant changes in average revenue in small sub-regions, as can be observed from Table A.7. In medium sub-regions the average revenue has increased by around 5.6%. The average number of employees in medium sub-regions has increased, which may imply higher degree of market concentration (Table A.8). In small-regions this effect is not statistically significant.

On the contrary, in large municipalities, average revenue has decreased by approximately 6%. This could be explained by the fact that there has been an increase in the number of firms after the reform. Since this has not been accompanied by a sufficiently large increase in demand and industry revenue, revenue per firm has reduced (see Figure A.1). Furthermore, as seen from Table A.8, the average number of employees per firm has a negative sign, although this is not statistically significant. Deregulation has likely led to a smaller average firm size in large municipalities.

The difference-in-differences estimates for profit as a percentage of firm revenue can be seen in Table A.9. Profit has decreased in small and large regions, and although the sign is also negative for medium sub-regions, this estimate is not statistically significant. Overall it can be argued that deregulation has decreased the profitability of the taxi sector.

Total costs as a percentage of revenue have increased in all regions (Table A.10). The increase is the most substantial in large municipalities, about 14%. Some of this increase in small and medium regions can be explained by the increase in fuel costs as seen in Table A.11. Since average revenue has not changed in small regions, it might be that taxis are idle more often than before. On the employee level, we find that income has decreased in small and medium regions by 5 and 10 %, respectively (Table A.12). The estimate for large municipalities is not statistically significant.

By estimating changes in the industry experience of taxi drivers (Table A.13) we find that the average experience has decreased in medium and large municipalities. These estimates are lower bounds for the actual effect, since we were able to observe the employee experience only starting from year 2008 and hence the experience is truncated at 5 years. The effect can be explained mainly by new firms entering the market post reform.

4.3 Other impacts of deregulation

The analysis has so far focused on observable and quantifiable impacts of the reform such as prices and firm profits. In reality, the taxi market has evolved also in other ways following the reform. These cannot necessarily be categorised as changes caused by the deregulation, but we argue that the increased competition enabled by the change could have, for example, increased the pace at which the market adapted new technologies.

For different consumers the market has become either more obscure or more transparent depending on how you hail a taxi. Consumers who use mobile applications to order a taxi have significantly more information available than they had before the reform. Nowadays most applications provide consumer with exact fare, travel time and time-to-arrival of the taxi, while some also provide the name, photo and consumer ratings of the driver as well as the model and brand of the car that will be arriving.

However, for consumers who hail a taxi or pick one at random at a taxi rank, the situation has worsened. Under the prior regulation both the price and the quality of the taxi was pre-determined regardless of where the consumer entered a taxi. Nowadays, both quality and price can vary significantly between otherwise similar looking cars, and while taxis are required to display the prices clearly in the window of the car, comparing the prices can require significant effort from the consumer.

5 Theoretical Framework

We consider a static, steady-state model of ride-hailing in homogeneous space à la Castillo et al. (2022). While Castillo et al. (2022) study surge pricing by a platform, we adapt the model to analyse the persistent differences between local markets of unequal population sizes, both pre- and post-deregulation.

5.1 Model of a Local Taxi Market

Consider the trip demand as $D(p,T) = ar(p)g(T)$, where a is the number of potential riders, $g(T) \in [0,1]$ is the fraction of riders willing to wait for the average pickup time T, and $r(p) \in [0,1]$ is the fraction of riders willing to pay the price p for a trip. Thus, $D(p,T)$ is the number of trips requested in a given area and unit of time. Specifically, assuming that $g(T) = (1+T)^{-1}$ will be convenient for obtaining a closed-form solution to the model.

Assumption 1. *Trip demand is* $D(p,T) = ar(p)(1+T)^{-1}$, *where* $r(p)$ *differentiable and decreasing in* p $(r' < 0)$, $r(0) = 1$, *and* $r(p) = 0, \forall p \geq \bar{p}$, *where* $\bar{p}$ *is sufficiently large.*

Hence, the pool of potential riders is finite, lower prices and waiting times result in more trip requests, and nobody is willing to pay or wait infinitely. Furthermore, by treating a independently of p and T we make the simplifying assumption that the taxi riders' preferences with respect to the waiting time and their willingness to pay are identical across different local markets within the same period of time. To account for the varying population densities across the local taxi markets, we assume that they have an identical geographical size but different population sizes and, therefore, different numbers of potential riders.[15] As such, the aim of the analysis is to demonstrate that variations in a alone can explain a large share of the regional differences both pre- and post-deregulation.

[15] Equivalently, one could standardize the population size and vary the geographical size of the market. However, it is more natural to think that the market and the drivers' area of operation are mainly limited by distance.

Let N be the total number of taxis in the area during the given time period. If Q is the equilibrium number of trips, t is the average duration of the trip with the rider, T is the average time to reach the rider, and I is the number of idle taxis, the total density of the taxis in steady state is given by the identity

$$N = I + tQ + TQ. \tag{2}$$

That is, taxis are in one of three different states: idle, on their way to a pickup, or driving a passenger. The idle taxis as well as the potential riders are assumed to be identically distributed across the space.

Notice that T is both the average waiting time for the rider as well as the time spent by the driver en route. We assume that the platforms match the trip request to the closest idle taxi. The matching technology is reflected by $T(I)$, which is decreasing in I. That is, the average waiting time is shorter the more idle taxis there are. If the potential riders and idle taxis are uniformly distributed over n-dimensional Euclidean space and the taxis drive in a straight line at a constant speed, then $T(I) = I^{-\frac{1}{n}}$ (Castillo et al., 2022).

For the purposes of the model, it is convenient to define the inverse function $I(T)$, which exists by the monotonicity of $T(I)$. By isolating Q in (2) and substituting $I(T)$, we obtain the trip supply

$$S(T, N) = \frac{N - I(T)}{t + T}. \tag{3}$$

We make the following assumption regarding the functional form of the trip supply.

Assumption 2. *Trip supply is* $S(T, N) = (N - T^{-1})(1 + T)^{-1}$ *if* $N - T^{-1} > 0$ *and 0 otherwise.*

Note that $S(T, N)$ is increasing in N, and first increasing and then decreasing in T.[16] By standardising the average trip duration to $t = 1$ and reducing the matching function to its simplest spatial form, $I(T) = T^{-1}$, i.e. a straight line, allows us to obtain

[16]This last property is what creates the possibility of a bad equilibrium (a “wild goose chase”) studied by Castillo et al. (2022).

a convenient closed-form solution to the market equilibrium. While the existence of an equilibrium can be proved with less structure as in Castillo et al. (2022), the second-order partial derivatives of an implicit function, which we need for the analysis, are tedious and would nevertheless require additional assumptions to sign.

For the purpose of defining the profits of taxi firms and platforms, let $\tau \in [0,1]$ denote the share of the price collected by the platform. All taxis are assumed to have the same costs. For simplicity, the taxi firms' profits are considered at the level of a single taxi:

$$\pi = [(1-\tau)p - c(1+T)]q - F, \tag{4}$$

where $q \equiv Q/N$ denotes the number of trips per taxi and $c < \bar{p}$.

In (4), c is a constant unit cost of driving, which is multiplied by the average trip length $t + T$ (where we again assume that $t = 1$), and F is a fixed cost. The fixed cost includes the driver's wage, the rental cost of the vehicle, and any other charges that are independent of whether the taxi is driving or idle. While t is considered exogenous, $c(t + T)$ is also increasing in T, which is endogenous. Driving to the passenger is not directly compensated and yet costs more fuel (and, possibly, incurs higher insurance costs).

Proposition 1. *The equilibrium number of trips (Q) and average waiting time (T) are given by*

$$Q(p,N) = \begin{cases} \frac{ar(p)(N-ar(p))}{N-ar(p)+1} & \textit{if } N > ar(p) \textit{ and } \pi \geq 0 \\ 0 & \textit{otherwise} \end{cases}, \tag{5}$$

$$T(p,N) = \begin{cases} \frac{1}{N-ar(p)} & \textit{if } N > ar(p) \textit{ and } \pi \geq 0 \\ +\infty & \textit{otherwise} \end{cases}. \tag{6}$$

Proof. Set

$$D(p,T) = \frac{ar(p)}{1+T} = \frac{N-1/T}{1+T} = S(p,T). \tag{7}$$

By solving (7) for T, we obtain (5). Then, substitute (5) in $D(p, T)$ and denote this by $Q(p, N)$ to obtain (6).

For $D(p, T)$ and $S(p, T)$ to intersect in the positive region of T and Q, it is required that $N > ar(p)$. Otherwise, the market does not exist, $Q = 0$, and the waiting time is infinite, $T = +\infty$. Furthermore, the profit per taxi needs to be non-negative, $\pi \geq 0$, in any interior equilibrium, which depends also on τ, c and F. □

5.2 Pre-Deregulation Equilibrium

Before 2018, fares as well as entry to the Finnish taxi market were regulated. The regulator set price ceilings periodically and, effectively, these were charged throughout the country. The number of licences were not set by an explicit rule. Instead, they were at the discretion of local authorities. Nevertheless, there were approximately 2 licences per 1,000 inhabitants across the country. Therefore, in terms of the model, the pre-deregulation era can be modelled as a situation in which local taxi markets of varying number of potential riders a had the same price p and the same relative number of taxis n such that $N = an$.

Proposition 2. *Consider p and $N = an$ such that an interior equilibrium, $Q(p, N) > 0$, exists. Then*

$$\frac{\partial Q}{\partial a} > 0, \frac{\partial q}{\partial a} > 0, \frac{\partial T}{\partial a} < 0 \text{ and } \frac{\partial \pi}{\partial a} > 0.$$

Proof. Substitute $an = N$ in (5) and (6) to obtain

$$Q(a, p, n) = \frac{a^2 r(p)(n - r(p))}{an - ar(p) + 1}, \tag{8}$$

$$q(a, p, n) = \frac{Q(p, n)}{an} = \frac{ar(p)(n - r(p))}{(an - ar(p) + 1)n}, \tag{9}$$

and

$$T(a, p, n) = \frac{1}{a(n - r(p))}. \tag{10}$$

Differentiating (8),(9) and (10) with respect to a yields

$$\frac{\partial Q}{\partial a} = \frac{ar(p)(n-r(p))(an-ar(p)+2)}{(an-ar(p)+1)^2} > 0, \frac{\partial q}{\partial a} = \frac{r(p)(n-r(p))}{(an-ar(p)+1)^2 n} > 0$$

and

$$\frac{\partial T}{\partial a} = -\frac{n-ar(p)}{a^2(n-ar(p))^2} < 0.$$

Finally, substitute (8) and (10) in (4) to obtain

$$\pi(p,n) = \frac{(1-\tau)par(p)(n-r(p))}{(an-ar(p)+1)n} - \frac{cr(p)}{n} - F. \tag{11}$$

Differentiating (11) with respect to a yields

$$\frac{\partial \pi}{\partial a} = \frac{(1-\tau)pr(p)(n-r(p))}{(an-ar(p)+1)^2 n} > 0.$$

□

We see that more populous regions enjoy a greater number of trips and lower waiting times. The latter effect brings an additional benefit by enabling the taxis to complete more trips. That is, considering Q as a function of a, there are increasing returns to scale:

$$Q(ak,p,n) = \frac{a^2k^2r(p)(n-r(p))}{k(an-ar(p))+1} > kQ(a,p,n), \forall k > 1.$$

Due to these economies of scale and proportionally set number of licences, driving a taxi becomes more profitable in local markets that have a greater population. This is also verified by the pre-deregulation data. This feature of the market also contributes to the fact that the private taxi market is smaller than the publicly funded taxi market in areas of lower population levels (and/or longer distances).

Note that

$$\frac{\partial Q}{\partial p} = \frac{\left(r(p)^2\,a - 2\,(na+1)\,r(p) + a\,n^2 + n\right) r' a^2}{\left(an - ar(p) + 1\right)^2} \leq 0 \leftrightarrow p \geq \hat{p},$$

where $\hat{p}$ is defined by

$$r(\hat{p}) = \frac{na - \sqrt{na+1} + 1}{a}.$$

That is, if $p < \hat{p}$, the market is in a wild-goose-chase (WGC) equilibrium (Castillo et al., 2022), where a higher price would both increase the number of rides and decrease the waiting time. Given the pre-deregulation constraint of having the same p and n for all local markets of varying a, it is possible that some local markets get stuck in a "perpetual" WGC equilibrium even if the choice of p and n is second-best socially optimal.

5.3 Post-Deregulation Equilibrium

The deregulation abolished the price ceilings and restrictions on the number of licences. This also changed the position of the local dispatch centers. Pre-deregulation, the dispatch centres were largely owned by the local taxi firms and usually paid no dividends. As such, their dispatch fee, τp, was set by cost-recovery basis. Post-deregulation, however, they may have obtained pricing power towards both the riders and drivers. Among drivers there were new entrants that were not shareholders of the dispatch center.

For simplicity, we consider two opposite dispatch center market structures: a monopoly and competitive industry. This will be sufficient for the purpose of gaining an insight of the effects of deregulation and the role of varying market sizes. Modelling a dispatch center oligopoly, in contrast, would require much additional structure with respect to competition on both sides of the market and the entry of dispatch centers as well as restrictive assumptions regarding multi- or single homing of riders and drivers.

Irrespective of the dispatch center market structure, the post-deregulation driver industry can be considered competitive. As such, the number of taxis depends on the free-entry condition, $\pi = 0$.[17]

While the dispatch centers faced competition, especially in the more populous areas, for simplicity we consider the problem of a monopoly dispatch center. This will give

[17]Ignoring the integer issue is less of a problem in this context since taxis can (and some do) operate part time.

us an idea of the pricing pressure and how it varies geographically when unhindered by competition. As such, the problem of the dispatch center is to maximise the aggregate revenue, τpQ, such that $\pi = 0$. However, by substituting the constraint into the objective function, we see that the center's problem becomes

$$\max_{p,N} \Pi = pQ - c(1+T)Q - NF. \tag{12}$$

Through p and τ, the dispatch center is able to control the entry of drivers. Thus, its problem is equivalent to choosing p and N to maximise the aggregate profit and then use τ to transfer it from the taxis. Again, we substitute $an = N$ in (12) to analyse the relative number of taxis.

The post-deregulation markets are assumed to be isolated, which implies that irrespective of the dispatch center market structure there will be no WGC equilibria with $p > \hat{p}$.[18] Similarly, no rider is willing to pay more than $\bar{p}$. Likewise, we can set a upper bound for N, say,

$$a(\bar{p} - c) - \bar{N}F = 0 \leftrightarrow \bar{N} = \frac{a(\bar{p} - c)}{F}.$$

Since the domains $p \in [\hat{p}, \bar{p}]$ and $N \in [0, \bar{N}]$ are non-empty and compact, by the Bolzano–Weierstrass theorem a maximum exists for the two continuous objective functions, which will be analysed shortly.

To guarantee the uniqueness of the solutions and to facilitate the comparative statics analyses, we make the following assumption.

Assumption 3. *The Hessian of the aggregate profit,*

$$\mathbf{H}(\mathcal{F}(p,n)), \text{ where } \mathcal{F}(p,n) \equiv pQ(p,n) - c(1+T(p,n))Q(p,n) - anF,$$

is negative definite. Furthermore, $\mathcal{F}(p,n) > 0, \exists p, n > 0$.

[18] Of course, it is possible that there are temporary WGC equilibria due to supply or demand shocks in the absence of dynamic pricing.

Proposition 3. *Let p^* and n^* denote the unique maximising point of* (12)*. Then,*

$$\frac{\partial p^*}{\partial a} < 0 \text{ and } \frac{\partial n^*}{\partial a} < 0.$$

Proof. Let $\mathcal{F}_i$ and $\mathcal{F}_{ij}$ denote first- and second-order partial derivatives of (12) with respect to variables i and j, where $i, j \in \{p, n, a\}$.

By Assumption (3), the first-order conditions,

$$\mathcal{F}_p = \frac{\left(p\left(n^2a + n + ar(p)^2 - 2\,(na+1)\,r(p)\right) r' + r(p)\,(n - r(p))\,(na - ar(p) + 1)\right) a^2}{(na - ar(p) + 1)^2}$$

$$-car' = 0$$

and

$$\mathcal{F}_n = \frac{p\,a^2 r(p)}{(na - ar(p) + 1)^2} - aF = 0,$$

define the unique maximising point p^* and n^*.

By Cramer's rule,

$$\frac{\partial p^*}{\partial a} = \frac{\begin{vmatrix} -\mathcal{F}_{pa} & \mathcal{F}_{pn} \\ -\mathcal{F}_{na} & \mathcal{F}_{nn} \end{vmatrix}}{D} \tag{13}$$

and

$$\frac{\partial n^*}{\partial a} = \frac{\begin{vmatrix} \mathcal{F}_{pp} & -\mathcal{F}_{pa} \\ \mathcal{F}_{pn} & -\mathcal{F}_{na} \end{vmatrix}}{D}, \tag{14}$$

where

$$D = \begin{vmatrix} \mathcal{F}_{pp} & \mathcal{F}_{pn} \\ \mathcal{F}_{pn} & \mathcal{F}_{nn} \end{vmatrix} > 0$$

by Assumption (3). Thus, (13) and (14) have the same sign as their numerators.

Solve $\mathcal{F}_p = 0$ for c and substitute in $\mathcal{F}_{pa}$ to obtain

$$\mathcal{F}_{pa} = \frac{\left(p\left(n^2a + n - (na+2)\,r(p)\right) r' + r(p)\,(n - r(p))\,(na - ar(p) + 1)\right) a}{(na - ar(p) + 1)^3}. \tag{15}$$

Similarly, solve $\mathcal{F}_n = 0$ for F and substitute in $\mathcal{F}_{na}$ to obtain

$$\mathcal{F}_{na} = -\frac{(na - ar(p) - 1)\, r(p)\, pa}{(na - ar(p) + 1)^3}. \tag{16}$$

Using (15) and (16), the numerator of (13) simplifies to

$$-\mathcal{F}_{pa}\mathcal{F}_{nn} + \mathcal{F}_{na}\mathcal{F}_{pn} = \frac{p\, a^3 r(p)\, (r'p + r(p))}{(ar(p) - na - 1)^4} < 0,$$

where the negative sign is implied by

$$\mathcal{F}_p + car' < 0, \leftrightarrow$$

$$p\left(n^2 a + n + ar(p)^2 - 2\,(na+1)\, r(p)\right) r' + r(p)\,(n - r(p))\,(na - ar(p) + 1) < 0,$$

where

$$n^2 a + n + ar(p)^2 - 2\,(na+1)\, r(p) < (n - r(p))\,(na - ar(p) + 1)\,,$$

and from which we can derive that $pr' + r(p) < 0$.

[TO BE COMPLETED]

□

The intuition behind the result is as follows. A higher number of potential riders creates an incentive to increase the price as well as the number of taxis. However, due to the economies of scale, the decrease in the marginal costs outweighs the increase in marginal revenue. Thus, it becomes optimal to have a higher number of taxis but lower prices in more populous areas. Conversely, in sparsely populated areas the main incentive is to increase rider prices rather than the number of taxis.

In order to assess whether the inter-regional differences in the post-deregulation prices and the number of taxis are due to market power or general characteristics of the taxi market, we compare the monopoly dispatch center to a competitive market. Perfect competition and free entry should lead to an outcome where the aggregate profits are zero: $\Pi = 0$. However, the outcome is not uniquely determined as there are infinitely many combinations of p and n that satisfy the zero profit condition. This originates from the fact that there are likewise different combinations of p and T that equate market demand and supply. It is interesting to consider that a competitive taxi markets may have the tendency to lead to a multitude of different outcomes. In any case, the theoretical indeterminacy remains without additional assumptions regarding the pricing strategies, which itself are non-standard in the competitive market framework.

To set aside the issue of indeterminacy, we focus on "maximum entry equilibrium", where the maximum number of taxis enter that the market can bear. Both riders and divers are assumed to multihome and the competition between the dispatch centers drives also their profits to zero and $\tau = 0$. Formally, the maximum entry equilibrium is a solution to

$$\max_{p,n} an \text{ s.t. } \mathcal{F}(p,n) = 0. \tag{17}$$

Proposition 4. *Let p' and n' denote the unique maximising point of* (17)*. Then,*

$$\frac{\partial p'}{\partial a} < 0 \textit{ and } \frac{\partial n'}{\partial a} > 0.$$

Proof. The Lagrangian of (17) is

$$L = na + \lambda \mathcal{F}(p,n). \tag{18}$$

By Assumption (3), the only critical point of $\mathcal{F}(p,n)$ is far away from the boundary of the constraint set. Hence, the constraint qualification will be satisfied at any candidate for a solution. Since $\mathcal{F}(p,n)$ is strictly concave by Assumption (3), (18) (as a sum of concave and strictly concave functions) is also strictly concave and the first-order conditions,

$$L_n = a + \lambda \mathcal{F}_n = 0, \tag{19}$$

$$L_p = \lambda \mathcal{F}_p = 0, \tag{20}$$

$$L_\lambda = \mathcal{F}(p,n) = 0, \tag{21}$$

yield a unique global maximum. Furthermore, it is necessary that $\mathcal{F}_n < 0$ for the constraint to be active.

By combining (19), (20) and (21), we have two equations that define the optimal p' and n':

$$\mathcal{F}_p = 0, \tag{22}$$

$$\mathcal{F}(p, n) = 0. \tag{23}$$

By Cramer's rule,

$$\frac{\partial p^*}{\partial a} = \frac{\begin{vmatrix} -\mathcal{F}_{pa} & \mathcal{F}_{pn} \\ -\mathcal{F}_a & \mathcal{F}_n \end{vmatrix}}{E} \tag{24}$$

and

$$\frac{\partial n^*}{\partial a} = \frac{\begin{vmatrix} \mathcal{F}_{pp} & -\mathcal{F}_{pa} \\ \mathcal{F}_p & -\mathcal{F}_a \end{vmatrix}}{E}, \tag{25}$$

where

$$E = \begin{vmatrix} \mathcal{F}_{pp} & \mathcal{F}_{pn} \\ \mathcal{F}_p & \mathcal{F}_n \end{vmatrix} = \mathcal{F}_{pp}\mathcal{F}_n > 0$$

by strict concavity of $\mathcal{F}(p, n)$, (22) and $\mathcal{F}_n < 0$. Thus, (24) and (25) have the same sign as their numerators.

Solve $\mathcal{F}_p = 0$ for c and substitute in $\mathcal{F}_{pa}$ to obtain

$$\mathcal{F}_{pa} = \frac{\left(p\left(n^2a + n - (na+2)\,r(p)\right)r' + r(p)\,(n - r(p))\,(na - ar(p) + 1)\right)a}{(na - ar(p) + 1)^3}. \tag{26}$$

Since

$$\mathcal{F}_p + r'ac =$$

$$\frac{\left(p\left(n^2a + n + ar(p)^2 - (2na+2)\,r(p)\right)r' + r(p)\,(n - r(p))\,(na - ar(p) + 1)\right)a^2}{(na - ar(p) + 1)^2} < 0$$

and

$$n^2 a + n - (na + 2)\, r(p) > n^2 a + n + ar(p)^2 - (2na + 2)\, r(p) \leftrightarrow r(p)\, a\, (n - r(p)) > 0,$$

also $\mathcal{F}_{pa} < 0$.

Solve $\mathcal{F}(p, n) = 0$ for F and substitute in $\mathcal{F}_a$ to obtain

$$\mathcal{F}_a = \frac{par(p)\,(n - r(p))}{(na - ar(p) + 1)^2} > 0$$

Note that

$$\mathcal{F}_{pn} = \frac{a^2\,(p\,(na + ar(p) + 1)\, r' + r(p)\,(na - ar(p) + 1))}{(na - ar(p) + 1)^3} < 0,$$

since

$$na + ar(p) + 1 > na - ar(p) + 1$$

and, as shown in the proof of Proposition 3, $pr' + r(p) < 0$.

Given that $\mathcal{F}_n < 0, \mathcal{F}_{pa} < 0, \mathcal{F}_a > 0$ and $\mathcal{F}_{pn} < 0$, the numerator of (24) is negative:

$$-\mathcal{F}_n \mathcal{F}_{pa} + \mathcal{F}_a \mathcal{F}_{pn} < 0.$$

Finally, since $\mathcal{F}_p = 0, \mathcal{F}_a > 0$ and $\mathcal{F}_{pp} < 0$, the numerator of (25) is positive:

$$-\mathcal{F}_a \mathcal{F}_{pp} > 0.$$

□

We see from Propositions 3 and 4 that both market structures exhibit a negative relationship between the equilibrium price and population size. While market power obviously affects the price level, we see that –irrespective of it – the model predicts that the post-deregulation prices will diverge and become relatively higher in smaller regions. This is due to the scale economies that are an inherent feature of the matching technology in the taxi market.

On the other hand, market power rather than the matching technology seems to be responsible for the regional differences in market entry and non-entry, since Propositions 3 and 4 diverge in this respect. Larger regions saw an increase and smaller regions saw no change in the number of taxis post-deregulation. The first outcome is consistent with the model if the larger regions are (relatively more) competitive. The second outcome, together with the fact that the prices increased in the smaller regions, is consistent with the model if the smaller regions are (relatively more) non-competitive. Indeed, we see from the data that the number of dispatch centers increases with the population size. Although we will not proceed to consider dispatch center entry, the level of dispatch center competition may also be attributed to the varying population sizes and distances.

Besides market power, the lack of entry in smaller regions despite the increase in the consumer prices may also be explained by other factors outside the model. Publicly funded taxi trips to hospitals etc. play a large role in the Finnish taxi market and, in particular, in the smaller regions where the privately funded market is even smaller due to the scale economies. Following the deregulation of the taxi market, there was now public procurement of publicly funded trips. These procurement rounds lead to a significant decrease in the fares and incomes gained from these trips. As such, this may have further decreased the incentive to enter the driver market in the smaller regions since there are not enough customers in the private market for firms to choose not to participate in the publicly funded market.

Another change caused by the deregulation was that idle taxis were now free to wait wherever they wanted. Speculatively, this may have lead to dis-coordination and worse distribution of idle taxis, where individual drivers conglomerated too heavily in the central places but ended up driving longer to their eventual place of pick-up. The increased fuel costs in the data support this possibility.

Another empirical observation from the post-deregulation market is that there is much more price dispersion in the larger regions. Naturally, this is less likely in the smaller regions, simply due to the small number of rival dispatch centres. However, we conjecture that in larger regions with multiple dispatch centres there may exist asymmetric equilibria, where the dispatch centres choose different price points and average waiting times. This would require that the riders are multihoming but the drivers are not, which is in fact not uncommon in these places. Nevertheless, extending the model towards this direction is beyond the scope of this paper.

6 Conclusion

Deregulation has been a contentious issue for decades. There exists a body of literature, both theoretical and empirical, discussing the effects of deregulating taxi markets, but no clear consensus has been reached. We examine the effects of taxi market deregulation by taking advantage of a natural experiment.

Our empirical results indicate that taxi markets of different size have evolved very differently following deregulation. The offered fares have on average increased by 7% in large municipalities and by around 15% in small and medium-sized sub-regions. Variation in offered prices is significant, especially in large municipalities. There is evidence that the realised fares in some large municipalities have, in fact, decreased, which would imply that consumers are choosing cheaper rides.

The result that fares have increased relatively more in small regions is fairly consistent with the previous literature (for example, Marell and Westin (2002) and Gaunt (1995)). This could be explained by a multitude of factors: we observe that fares are correlated with, for example, the number of dispatch centres within the area. Moreover, our theoretical analysis shows that when deregulation allows prices to diverge this outcome would happen whether the dispatch centre market is competitive or monopolistic. The outcome – while surprising and contradictory to standard market models – is due to the economies of scale in matching. Furthermore, the level of dispatch center competition can explain why there has been taxi firm entry into large but not medium-size or small regions.

This is in line with our employee-level findings, where we find that in small- and medium-sized regions the taxi driver income has decreased, whereas in large municipalities the change is not statistically significant. Empirically estimating the effects of deregulation on dispatch centres and thus understanding this part of the market would naturally be the next step in analysing this finding, although this is left for future research since our data do not allow for this kind of examination.

We find that dispatch centres that operate solely through mobile applications offer a cheaper service than their more traditional counterparts. This is in line with previous findings in the literature, such as ride-hailing platforms being a more efficient taxi operators (i.e. they boast a higher capacity utilisation rate) than traditional firms (Cramer and Krueger, 2016). It could furthermore be argued that applications reduce search frictions and transaction costs, therefore increasing efficiency. However, consumers may end up paying for lower fares with a longer time-to-arrival.

We find that the experience of the employees in the taxi sector has decreased in the medium and large regions, which implies that there have been new inexperienced employees entering the market. Future research could assess taxi driver background even further, and it may be especially interesting to evaluate how deregulation has affected employment, namely whether new entrants have previously been employed. This would allow us to better understand the welfare impacts of the reform even further.

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Online appendix

A Tables

Table A.1: Sub-group division

Control	Treatment				
Åland	**Small sub-regions**	Municipalities	**Medium sub-regions**	Municipalities	**Large municipalities**
Eckerö	Pietarsaari	*Kruunupyy, Luoto, Pedersöre, Pietarsaari, Uusikaarlepyy*	Hämeenlinna	*Hattula, Hämeenlinna, Janakkala*	*Helsinki*
Finström	Kokkola	*Kokkola, Kannus*	Kouvola	*Kouvola*	*Espoo*
Geta	Vakka-Suomi	*Kustavi, Laitila, Pyhäranta, Taivassalo, Uusikapunki, Vehmaa*	Lappeenranta	*Lappeenranta, Lemi, Luumäki, Savitaipale, Taipalsaari*	*Vantaa*
Hammarland	Turunmaa	*Kemiönsaari, Parainen*	Kuopio	*Kuopio, Siilinjärvi*	*Tampere*
Jomala	Raasepori	*Hanko, Inkoo, Raasepori*	Joensuu	*Heinävesi, Ilomantsi, Joensuu, Juuka, Kontiolahti, Liperi, Outokumpu, Polvijärvi*	*Turku*
Lemland	Mikkeli	*Hirvensalmi, Kangasniemi, Mikkeli, Mäntyharju, Pertunmaa, Puumala*	Rovaniemi	*Rovaniemi, Ranua*	
Lumparland	Kemi-Tornio	*Kemi, Keminmaa, Simo, Tervola, Tornio*	Pori	*Harjavalta, Huittinen, Kokemäki, Merikarvia, Nakkila, Pomarkku, Pori, Ulvila*	
Mariehamn	Suupohja	*Kaskinen, Kristiinankaupunki, Närpiö*	Vaasa	*Kalajoki, Laihia, Maalahti, Mustasaari, Vaasa, Vöyri*	
Saltvik	Raahe	*Pyhäjoki, Raahe, Siikajoki*	Jyväskylä	*Hankasalmi, Jyväskylä, Laukaa, Muurame, Petäjävesi, Toivakka, Uurainen*	
Sund	Loviisa	*Lapinjärvi, Loviisa*	Oulu	*Hailuoto, Kempele, Liminka, Lumijoki, Muhos, Oulu, Tyrnävä*	
	Porvoo	*Askola, Myrskylä, Porvoo, Pukkila*			
	Pieksämäki	*Juva, Pieksämäki*			
	Kotka-Hamina	*Hamina, Kotka, Miehikkälä, Pyhtää, Vironlahti*			
	Imatra	*Imatra, Parikkala, Rautjärvi, Ruokolahti*			
	Forssa	*Forssa, Humppila, Jokioinen, Tammela, Ypäjä*			

Notes: List of regions in control and treatment groups. We compare Åland to small and medium sub-regions as well as large municipalities.

Table A.2: Control and treatment region characteristics by region size

	Control	Treatment		
	Åland	Small sub-regions	Medium sub-regions	Large municipalities
Population	27 716	45 551	143 022	317 282
	(0.0)	(18494.0)	(54074.8)	(187797.0)
Population density (pop/km^2)	27.2	21.5	33.2	1223.6
	(0.0)	(11.6)	(13.3)	(1026.7)
Median income (€)	25 751	21 245	21 514	23 725
	(1923.5)	(1494.4)	(1964.6)	(2650.0)
Area (km^2)	5866.4	4240.4	7132.9	496.0
	(0.0)	(1763.1)	(3282.3)	(216.8)
of which land (%)	17.4	60.4	73.0	68.9
	(0.0)	(0.189)	(0.158)	(0.260)
Industry revenue (*/100 000*)	96.6	568.4	2440	21800
	(0.00)	(591.0)	(2520)	(18500)
Number of sub-regions	1	15	10	5
Number of municipalities	10	56	49	5

Notes: Population, population density, area, and average number of taxi firms are the means of a sub-region. Population density is calculated by dividing population by the land area of the region. Median income represents the mean of municipality level median income.

Table A.3: Firm characteristics by region size

	Small sub-regions	Medium sub-regions	Large municipalities	Åland
Number of firms	65.221	164.929	656.710	51.000
	(25.401)	(59.144)	(344.006)	(0.000)
Firm age	16.135	15.319	11.204	9.417
	(10.320)	(10.692)	(11.330)	(7.569)
Revenue	126921.237	148145.659	128887.152	96452.333
	(138224.031)	(291985.774)	(284634.903)	(90235.310)
Profit as a percentage of revenue	0.292	0.260	0.298	0.321
	(0.228)	(0.512)	(1.614)	(0.211)
Employees	1.496	1.891	1.502	0.941
	(1.752)	(4.485)	(4.213)	(1.142)
Experience in years	6.993	6.830	6.076	5.792
	(2.905)	(3.087)	(3.326)	(2.828)
Observations	443	831	1196	24

Notes: Number of firms is a regional variable. Firm age, revenue, profit, employee count and experience are firm-level variables, which are averaged at a regional level.

Table A.4: Difference between observed and calculated fares

	Real	Calculated	Real - Calculated
1km	8.32	8.61	-0.29
	(1.53)	(0.00)	(0.22)
2km	11.02	10.62	0.40
	(0.47)	(0.00)	(0.07)
3km	12.12	12.63	-0.51
	(0.59)	(0.00)	(0.08)
4km	14.64	14.64	0.00
	(0.60)	(0.00)	(0.08)
5km	17.58	17.45	0.13
	(0.61)	(0.00)	(0.09)
7.5km	22.94	22.08	0.85
	(2.13)	(0.41)	(0.36)
10km	26.89	27.60	-0.71
	(1.25)	(0.30)	(0.19)
12.5km	31.58	31.72	-0.14
	(0.70)	(0.00)	(0.10)
15km	34.20	35.74	-1.54
	(0.64)	(0.00)	(0.09)
20km	46.14	47.80	-1.66
	(2.39)	(0.00)	(0.34)
25km	52.71	55.24	-2.53
	(2.16)	(0.00)	(0.44)

Notes: Table presents the difference between observed and calculated fares in Åland. Calculated fares do not include waiting fees, which are applicable whenever a taxi is driving slower (e.g. due to traffic congestion). The calculated fares include additional fuel fare added in June following a sharp increase in fuel prices.

Table A.5: DiD estimates on offered fares, by region

	(1) Espoo	(2) Helsinki	(3) Hämeenlinna	(4) Joensuu	(5) Jyväskylä	(6) Kemi-Tornio	(7) Kokkola	(8) Kouvola	(9) Kuopio	(10) Lappeenranta	(11) Mikkeli	(12) Oulu	(13) Pori	(14) Raahe	(15) Raasepori	(16) Rovaniemi	(17) Tampere	(18) Turku	(19) Turunmaa	(20) Vaasa	(21) Vakka-Suomi	(22) Vantaa
Treatment	0.048***	0.047***	0.031***	0.031***	0.037***	0.017***	0.025***	0.019*	0.037***	0.040***	0.028***	0.015***	0.033***	0.033***	0.044***	0.029***	0.028***	0.016***	0.015***	0.032***	0.022***	0.038***
	(0.003)	(0.003)	(0.007)	(0.004)	(0.003)	(0.003)	(0.006)	(0.009)	(0.004)	(0.005)	(0.004)	(0.004)	(0.003)	(0.005)	(0.007)	(0.003)	(0.003)	(0.003)	(0.004)	(0.009)	(0.003)	(0.003)
Post	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***	0.151***
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Treatment x Post	0.020**	0.103***	0.208***	0.083***	0.133***	0.169***	0.068***	0.005	0.092***	0.155***	0.102***	0.158***	0.171***	0.217***	0.095***	0.202***	0.123***	0.147***	0.129***	0.107***	0.130***	-0.013*
	(0.006)	(0.007)	(0.016)	(0.011)	(0.009)	(0.008)	(0.011)	(0.016)	(0.009)	(0.012)	(0.009)	(0.008)	(0.006)	(0.011)	(0.025)	(0.006)	(0.007)	(0.005)	(0.007)	(0.017)	(0.007)	(0.006)
Control at baseline	2.047***	2.035***	1.990***	2.016***	2.027***	2.022***	1.991***	1.986***	2.022***	2.002***	2.009***	2.028***	2.022***	2.012***	1.994***	2.070***	2.039***	1.995***	2.003***	1.989***	2.023***	2.037***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
Observations	7772	9362	1748	2144	2462	2226	1734	1628	2446	1836	1988	2634	2518	1989	1742	3756	4874	7626	2102	1772	2428	8288
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Table presents differences-in-differences estimates of treatment impact on offered fares for each sub-region. Pre-treatment fares are calculated for each trip using 2017 regulated fares. Time fixed effects include both time-of-day and day-of-week. Robuster standard errors (hc3) are presented in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.6: Availability of taxi firms by region

Region	Mean	Median	Min	Max
Åland	1.00	1.00	1.00	1.00
Espoo	0.57	0.77	0.01	1.00
Helsinki	0.64	0.77	0.02	1.00
Hämeenlinna	0.29	0.09	0.03	0.94
Joensuu	0.89	0.89	0.84	0.94
Jyväskylä	0.36	0.29	0.00	0.96
Kemi-Tornio	0.58	0.76	0.02	0.97
Kokkola	0.52	0.52	0.07	0.97
Kouvola	0.42	0.16	0.09	1.00
Kuopio	0.37	0.32	0.01	0.89
Lappeenranta	0.60	0.69	0.18	0.92
Mikkeli	0.44	0.30	0.01	1.00
Oulu	0.35	0.20	0.15	1.00
Pori	0.64	0.67	0.24	0.99
Raahe	1.00	1.00	1.00	1.00
Raasepori	0.62	0.62	0.62	0.63
Rovaniemi	0.56	0.53	0.01	0.90
Tampere	0.52	0.56	0.08	1.00
Turku	0.77	0.85	0.36	1.00
Turunmaa	0.48	0.44	0.16	0.87
Vaasa	0.35	0.11	0.07	0.86
Vakka-Suomi	0.78	0.73	0.61	0.99
Vantaa	0.56	0.55	0.02	1.00

Notes: Table presents taxi availability for each region. Availability is measured for each dispatch center and represents the share of queries when dispatch center had available taxis. It does not take time-to-arrival into account.

Table A.7: Revenue

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	2047.023	59956.342**	52964.441***
	(4225.947)	(17777.092)	(810.115)
Post	27898.176***	21977.121***	23214.604*
	(3533.036)	(1952.691)	(5767.806)
Treatment x Post	2538.766	10634.547*	-6704.333*
	(3818.515)	(4195.530)	(2011.200)
Control at baseline	277882.103	1903070.785	110346.740***
	(143422.020)	(1144951.220)	(6527.124)
Observations	5373	9350	11535
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 1, where the dependent variable is a firm's revenue.

Table A.8: Employees

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	0.003	0.820***	1.014***
	(0.058)	(0.126)	(0.051)
Post	0.012	-0.055	-0.072
	(0.048)	(0.033)	(0.160)
Treatment x Post	0.027	0.195*	-0.185
	(0.051)	(0.069)	(0.074)
Control at baseline	3.416	9.160	1.464***
	(1.672)	(5.224)	(0.178)
Observations	5373	9350	11535
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 1, where the dependent variable is a firm's number of employees.

Table A.9: Profit as a percentage of revenue

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	0.025***	0.057***	0.039***
	(0.005)	(0.005)	(0.004)
Post	0.045**	0.024	0.006
	(0.012)	(0.027)	(0.021)
Treatment x Post	-0.057***	-0.056	-0.114*
	(0.011)	(0.026)	(0.038)
Control at baseline	0.019	0.036	0.010
	(0.047)	(0.073)	(0.008)
Observations	5362	9322	11490
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 1, where the dependent variable is a firm's profit as a percentage of their revenue.

Table A.10: Costs as a percentage of revenue

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	-0.009*	-0.061***	-0.085***
	(0.004)	(0.005)	(0.001)
Post	0.012*	-0.006	0.049**
	(0.005)	(0.019)	(0.010)
Treatment x Post	0.016*	0.055*	0.055**
	(0.007)	(0.018)	(0.013)
Control at baseline	0.375***	0.608*	0.399***
	(0.052)	(0.197)	(0.004)
Observations	5361	9323	11490
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 1, where the dependent variable is total costs as a percentage revenue.

Table A.11: Fuel costs as a percentage of revenue

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	0.020***	0.018***	-0.005
	(0.001)	(0.002)	(0.002)
Post	-0.008*	-0.012*	-0.014***
	(0.004)	(0.004)	(0.001)
Treatment x Post	0.017***	0.016***	0.006
	(0.003)	(0.002)	(0.003)
Control at baseline	0.060	0.309	0.017***
	(0.033)	(0.145)	(0.002)
Observations	5360	9318	11486
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 1, where the dependent variable is fuel costs as a percentage of revenue.

Table A.12: Income

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	3980.817***	708.059	2805.086***
	(463.679)	(416.227)	(244.189)
Post	2210.796**	1686.260***	1473.727**
	(664.027)	(298.129)	(271.813)
Treatment x Post	-1674.586*	-3599.719***	-1351.449
	(609.165)	(479.704)	(632.587)
Control at baseline	30894.742***	35142.207***	30662.335***
	(1854.419)	(2682.278)	(367.722)
Observations	8952	17499	26095
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 1, where the dependent variable is taxi driver income.

Table A.13: Experience in the taxi sector in years

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	0.375***	0.241***	0.441***
	(0.035)	(0.044)	(0.042)
Post	0.247***	0.126**	0.140*
	(0.052)	(0.037)	(0.039)
Treatment x Post	-0.059	-0.292***	-0.084*
	(0.056)	(0.049)	(0.031)
Control at baseline	3.714***	3.510***	4.378***
	(0.193)	(0.200)	(0.040)
Observations	9137	17674	26288
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 1, where the dependent variable is taxi driver's experience in years.

B Figures

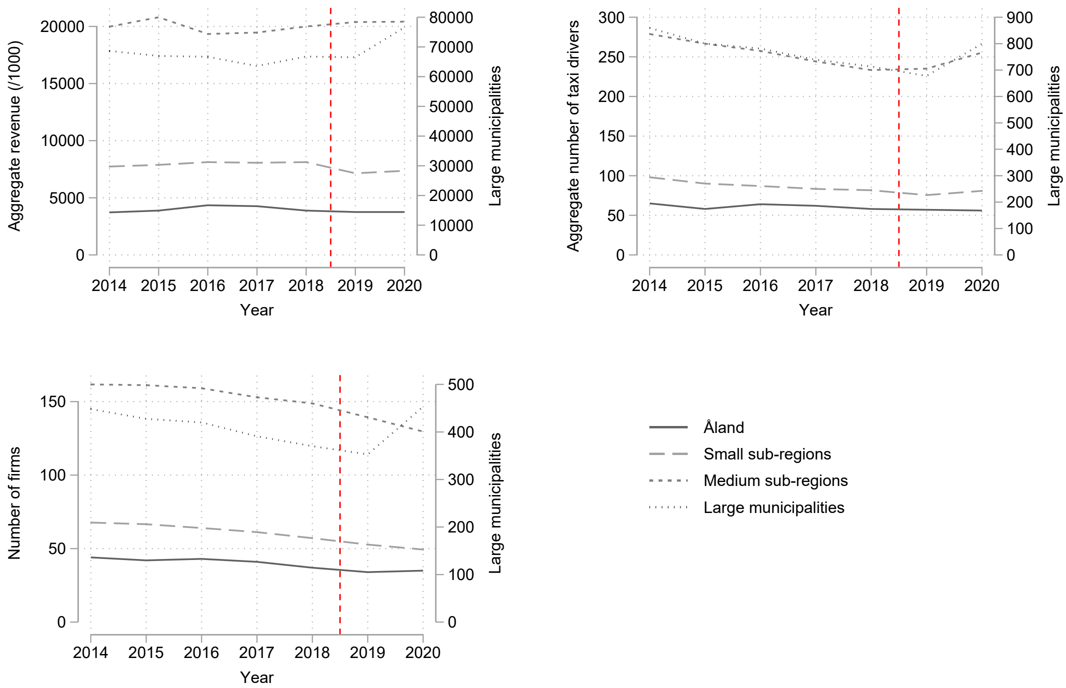

Figure A.1: Evolution of market level variables

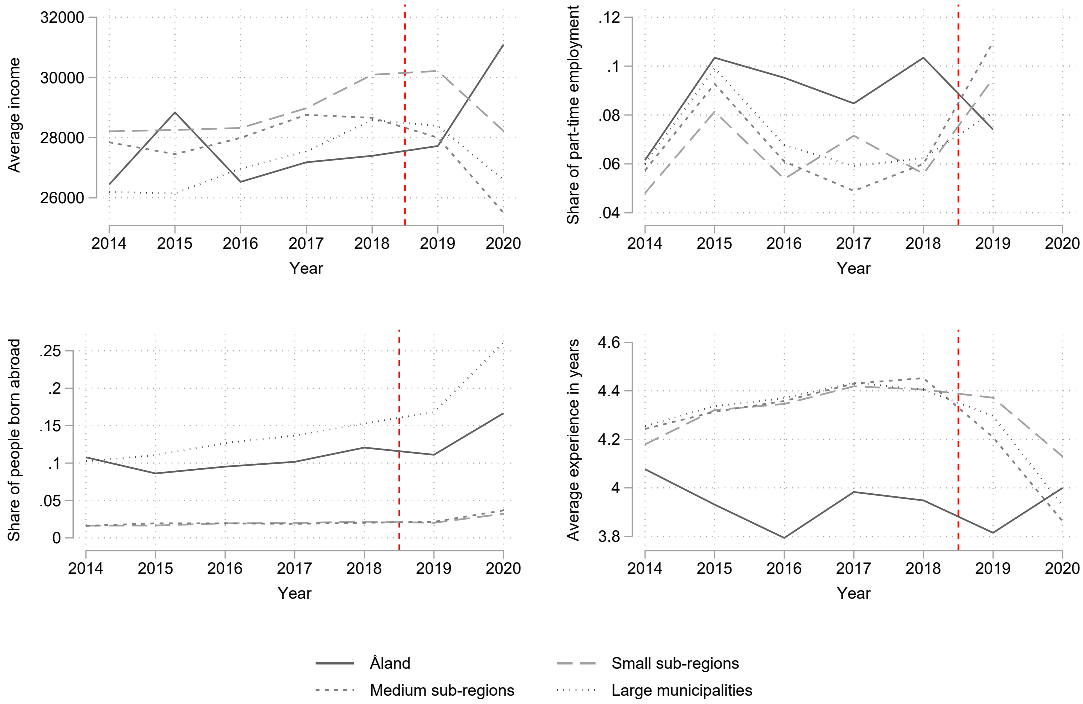

Figure A.2: Evolution of employee level variables

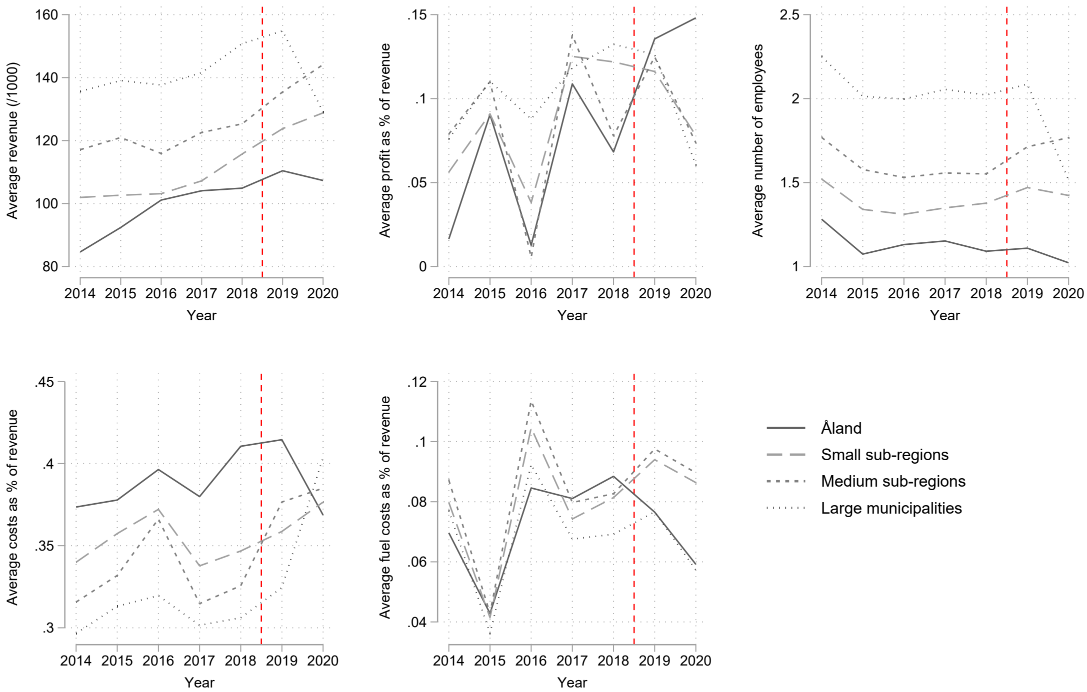

Figure A.3: Evolution of firm level variables

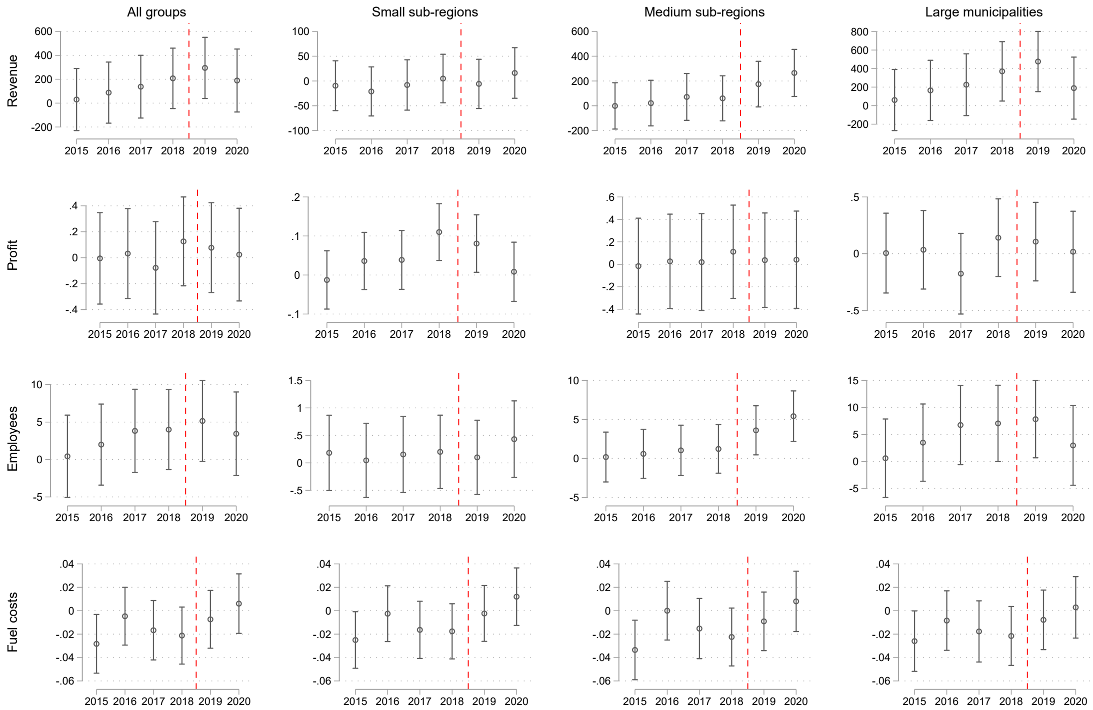

Figure A.4: Testing of parallel trends assumption for firms

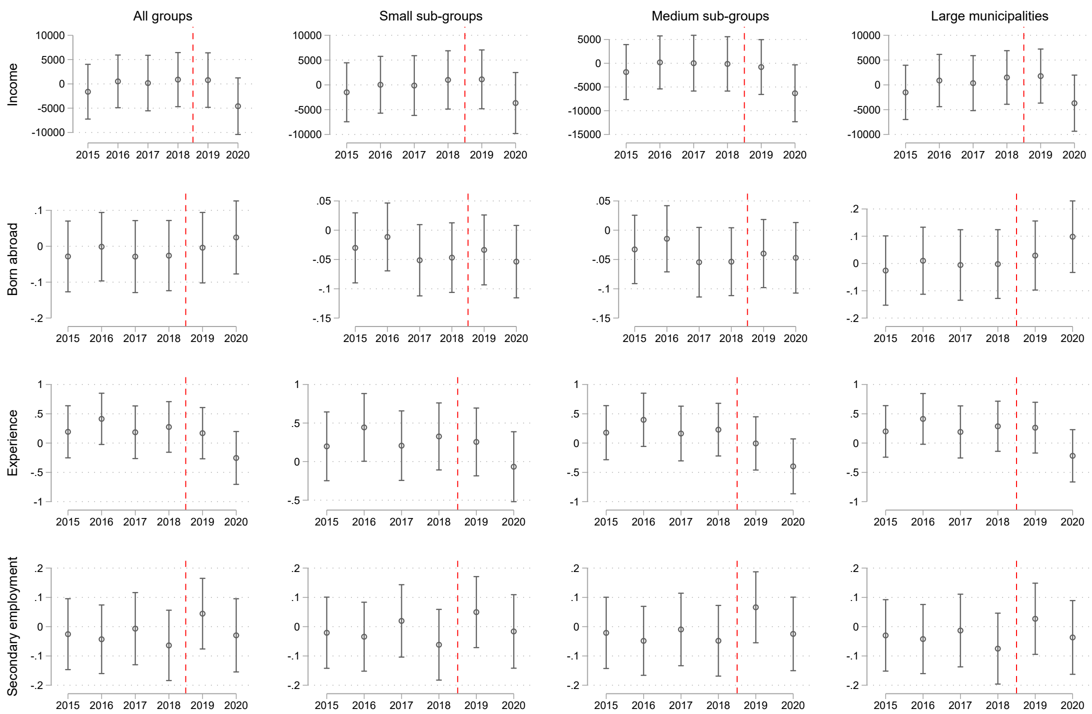

Figure A.5: Testing of parallel trends assumption for employees

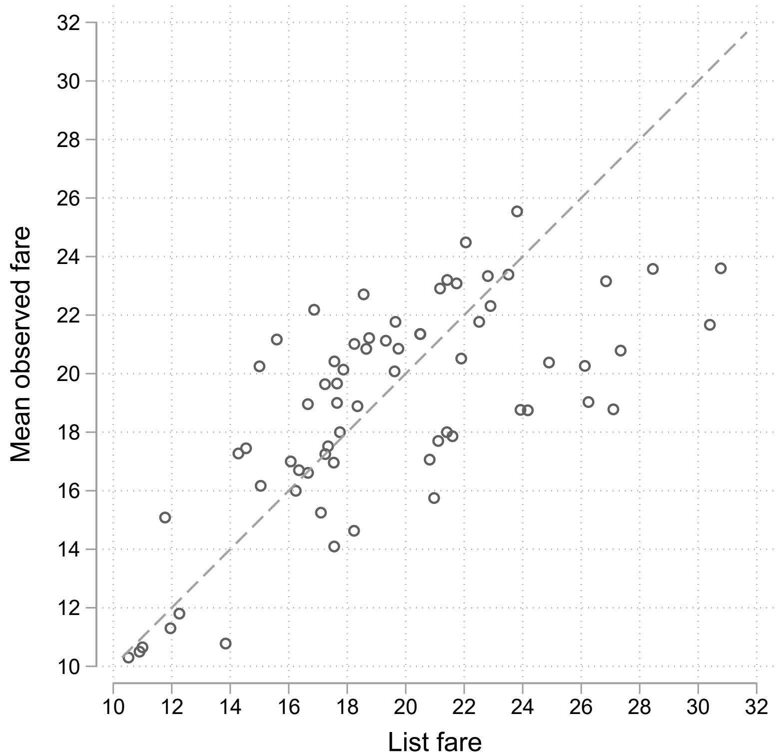

Figure A.6: Correlation between observed fares and fares calculated using list prices, 5km trips

Notes: Each observation is a pair of an average observed 5km fare and list fare for each dispatch center in our data.

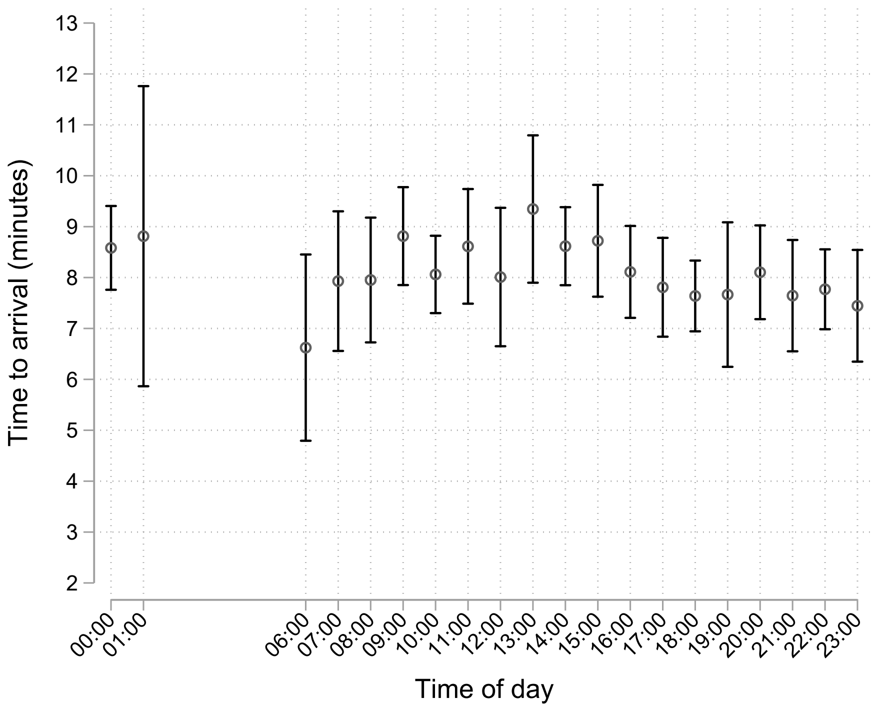

Figure A.7: Marginal means of time to arrival

Notes: Marginal means are estimated by regressing time to arrival on time of day dummy variables as well as the set of controls used for example Table 3

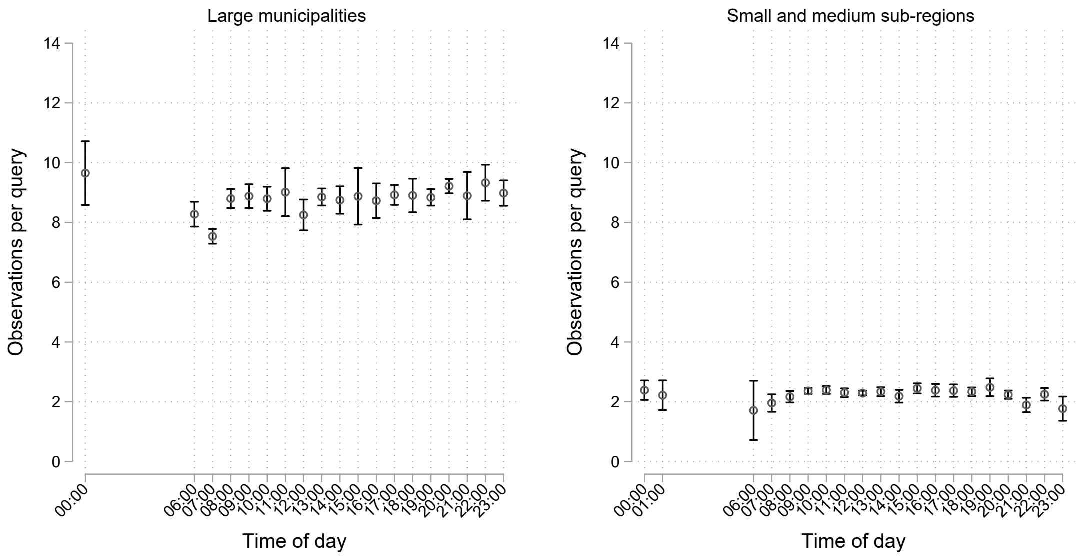

Figure A.8: Marginal means of number of observations per query

Notes: Marginal means are estimated by regressing distinct observations per query time of day dummy variables as well as the set of controls used for example in Table 3

C Availability of taxis

We collected data on the availability and time-to-arrival (TTA) of taxis. Unlike fares, we do not have data on TTA from the pre-treatment period. However, there exists evidence that there were serious shortages of taxis during hours of high-demand, especially in large cities.[19] Hence, our main objective is to examine availability and whether it changes at different times of the day and week. We also assess whether the observable variables seem to correlate with TTA.

The dependent variable in the first four regressions (1) - (4) in Table A.14 is time-to-arrival. We find that ordering a taxi in a city or urban centre is correlated with a significantly shorter time to arrival. This makes sense since there tend to be more taxis around where services are located. This is in line with estimate for *distance to a taxi rank* being significantly and positively correlated with TTA. This might indicate that taxis are still on call at the stations. Distance to taxi rank is only available for large municipalities.

When looking at large municipalities, we also find a significant difference between dispatch centres that only allow ordering through their applications (i.e., they do not wait at the taxi ranks) and other taxi firms. The time-to-arrival seems to be on average 1.5 minutes higher for app-only firms. Interestingly, fare seems to significantly correlate with TTA only in medium regions where higher fare means lower TTA. The fact that this is not the case in large municipalities is surprising, but could result in part from app-only dispatch centres that capture this effect, since their services are significantly cheaper, as shown in Table 3.

Finally, peak demand hours are correlated with approximately 30 second faster average time to arrival when focusing on large municipalities. We further study how time of day correlates with TTA by looking at the estimated marginal means of time-to-arrival by time of day presented in Figure A.7. We find that, if anything, there seems to be slightly shorter average time to arrival during peak hours (that is, around the time

[19]There are numerous news articles from the regulated period reporting about long queues at taxi ranks (e.g. https://yle.fi/uutiset/3-6162938 (in Finnish)).

Table A.14: Descriptive regressions on time-to-arrival

	Time to arrival				Minimum time to arrival per query			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All regions	Small regions	Medium regions	Large municipalities	All regions	Small regions	Medium regions	Large municipalities
Pickup at city	-4.846***	-6.004**	-6.200***	-3.100**	-4.579***	-6.160**	-5.642***	-1.406**
	(0.621)	(1.118)	(0.745)	(0.585)	(0.567)	(1.060)	(0.837)	(0.264)
Outside business hours	0.049	1.439	0.953	-0.044	-0.034	1.351*	0.723	0.106
	(0.235)	(0.826)	(0.627)	(0.222)	(0.475)	(0.505)	(0.885)	(0.058)
Friday or saturday	0.901***	0.674	0.091	0.862**	0.386	1.040	-0.093	0.111
	(0.194)	(0.827)	(0.147)	(0.169)	(0.287)	(0.975)	(0.230)	(0.061)
Peak demand	-1.567***	-0.427	-0.370	-1.323*	-0.657	-0.700	-0.155	-0.758**
	(0.341)	(1.072)	(0.944)	(0.332)	(0.663)	(1.373)	(1.161)	(0.118)
Number of firms per region	0.060	2.834***	1.276***	0.302***	-0.037	2.378***	0.743***	-0.010
	(0.115)	(0.275)	(0.125)	(0.018)	(0.151)	(0.101)	(0.095)	(0.014)
Trip length (km)	0.143	0.645	0.548**	-0.157	0.301	0.572**	0.214	-0.055
	(0.142)	(0.321)	(0.156)	(0.064)	(0.149)	(0.118)	(0.119)	(0.056)
Trip length squared	0.002	-0.017*	-0.004	0.006*	-0.005	-0.016*	-0.003	0.005
	(0.004)	(0.005)	(0.003)	(0.001)	(0.004)	(0.005)	(0.004)	(0.004)
App-only dispatch	0.611	-1.258	-1.262	1.432**				
	(0.336)	(0.656)	(1.049)	(0.283)				
Fare	-0.038	-0.037	-0.172*	0.042				
	(0.032)	(0.119)	(0.066)	(0.031)				
Distance from rank to pickup				0.848***				0.848**
				(0.073)				(0.133)
Constant	9.909***	-9.426**	3.813	5.151***	6.709***	-8.554***	3.029*	3.571***
	(1.883)	(2.088)	(2.033)	(0.530)	(1.712)	(0.967)	(1.070)	(0.309)
Observations	19592	1798	3892	12353	5411	1134	1597	1426
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable in regressions (1) - (4) is time-to-arrival and in (5) - (8) it is the shortest time-to-arrival in each query. App-only dispatch refers to dispatch centers which only operate through mobile applications. Peak demand is an interaction term of *Outside business hours* and *Friday or Saturday*. Pickup at city is a dummy variable that gets value 0 if pickup location is in a suburb and 1 if close to a city center. Distance from rank to pickup is only available for large municipalities which have public information on the locations of taxi ranks. Standard errors are clustered at regional level and are presented in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

restaurants close), indicating that supply responds to demand peaks. Furthermore the number of available cars does not differ between different times of day (Figure A.8)