Effects of Taxi Market Deregulation: Evidence from a Natural Experiment

Jan Jääskeläinen* Samuli Leppälä* Anni Väättänen*

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Abstract

We study the causal effects of the complete deregulation of the Finnish taxi market, where entry restrictions and national fare ceilings were simultaneously abolished in 2018. Using a regional policy discontinuity and combining fare data with administrative firm and worker-level registers, we estimate the impact of deregulation on prices, market structure, and driver outcomes. Posted fares increased and became substantially more dispersed, but consumers choose lower-priced providers when available. Entry expanded sharply in large regions, reducing average firm revenue and profitability. In contrast, small and medium-sized regions experienced fare increases without meaningful entry, and firm profits declined despite higher prices. To interpret these heterogeneous effects, we develop a model of taxi markets with economies of scale in matching and platform competition.

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*Finnish Competition and Consumer Authority, Lintulahdenkuja 2, P.O. 5, 00531, Helsinki, Finland, firstname.lastname@kkv.fi

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1 Introduction

1.1 Background

Deregulation has been a central policy tool in industrialized economies since the late 1970s. Early reforms in U.S. transportation, telecommunications, and energy markets suggested that removing entry and price controls could increase efficiency, lower prices, and stimulate innovation (Winston, 1993, 1998). These experiences fueled broader deregulatory reforms worldwide. Yet deregulation is not universally welfare-improving. For example, in Sweden's taxi market the removal of regulatory constraints has led to price increases and safety concerns (Gärling et al., 1995) . The effects of deregulation are therefore dependent on industry characteristics and the institutional context.

Despite decades of policy debates, credible causal evidence on full economic deregulation (simultaneous removal of entry and price controls) remains limited. Much of the empirical literature examines partial reforms (e.g., entry deregulation with price caps retained) or lacks a clear counterfactual. This paper studies the causal effects of full deregulation of the Finnish taxi market, where both quantity restrictions and nationwide fare ceilings were abolished simultaneously in 2018.

Prior to the reform, the Finnish taxi market was tightly regulated. Entry was restricted through municipality-level licence quotas and the fares were determined by a nationwide maximum pricing formula. The 2018 reform removed both restrictions at once. We exploit a natural experiment arising from Åland, one of Finland's 19 regions, which did not implement the deregulation. This setting allows us to estimate causal effects using a difference-in-differences framework.

We combine three data sources: (i) manually collected offered fares from taxi applications, (ii) realized transaction-level fare data from the Finnish Transport and Communications Agency, and (iii) firm- and employee-level register data from Statistics Finland. We estimate the effects of deregulation on prices, price dispersion, firm structure, profitability, and driver outcomes. To interpret regional heterogeneity in the data, we develop a theoretical model emphasising economies of scale in matching and competition between dispatch platforms.

We find significant regional heterogeneity. In large regions, deregulation substantially increased entry. The average revenue and profitability of the firm declined and the number of employees per firm decreased, consistent with market fragmentation. Price dispersion increased significantly. Although average offered fares increased, realised fares in large regions are concentrated at the lower end of the price distribution, indicating that consumers choose lower-priced providers when search frictions are reduced. Accordingly, realised fares in large regions decreased by around 28 percent.

In contrast, small and medium-sized regions experienced realised fare increases of 4-23 percent, with little change in entry. Profits declined despite higher prices, and driver income fell. These patterns suggest that deregulation did not generate sufficient competitive pressure in thin markets to offset higher costs or coordination losses.

Our theoretical framework rationalises these findings through two mechanisms: (i) the economies of scale in matching drivers to riders and (ii) larger regions having more competition between dispatch centres. Regardless of whether the dispatch centre market is competitive or monopolistic, the model predicts lower equilibrium fares in larger regions with greater potential demand. 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. In addition, publicly funded trips form a large part of the market in smaller regions, which can contribute to the lack of entry by taxi firms. Post-deregulation, the fares for these publicly funded trips have been determined in a competitive procurement process, which has resulted in lower fares than before.

The Finnish case highlights a broader policy challenge. Optimal regulation in taxi markets likely differs between regions due to variation in population density and matching frictions. A uniform national policy may therefore produce heterogeneous welfare effects. We precisely document such a divergence.

This paper contributes to at least two strands of literature. First, it provides causal evidence for complete deregulation in a transportation market. Second, it adds to the broader literature on regulation by showing that the effects of deregulation depend critically on local market conditions.

The remainder of the paper proceeds as follows. Section 1.2 reviews the related literature. Section 2 describes the institutional setting. Section 3 outlines the empirical strategy and data. Section 4 presents the empirical results. Section 5 develops the theoretical model. Section 6 discusses welfare implications. Section 7 concludes.

1.2 Literature

Early work on deregulation builds on the traditional theory of regulation, which holds that regulation improves social welfare by correcting market failures. Government intervention is therefore justified when markets fail to achieve perfect competition. However, this view assumes regulators possess perfect information and act solely to maximise social welfare. While markets are seen as subject to information and transaction costs, regulation itself is assumed to operate without such frictions — a paradox highlighted by 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). Empirical research on the efficiency of regulation has confirmed this concern.[1]

Deregulation is warranted when regulatory costs exceed the combined costs of deregulation and any remaining market failures. A trend toward deregulation began in the United States in the late 1970s, with substantial deregulation in the transportation, communications, financial, and energy sectors (Winston, 1998). Reviewing the literature on these early deregulation initiatives, (Winston, 1993) finds that economists largely predicted outcomes correctly: lower fares, greater price dispersion, and technological improvements. Profits and wages generally declined, though wage dispersion sometimes increased. These changes are consistent with

[1]For an overview of the literature, see Joskow and Rose (1989).

prices and wages moving closer to marginal cost and marginal product, and thus a movement towards the competitive equilibrium.

Taxis are among the most widely regulated transportation modes in industrialised countries, often justified by concerns about imperfect competition (Cairns and Liston-Heyes, 1996). Competitive markets require many firms and consumers interacting simultaneously, a condition rarely met in the cruising segment. One of the first models of the taxi market by Douglas (1972) portrays how the equilibrium fare in the market is inefficient. He argues that in the deregulated cruising taxi market, there will be upward pressure on the fares. Shreiber (1975),reaches a similar conclusion, noting that consumers typically encounter one taxi at a time and cannot easily compare prices. This 'temporary monopoly" can generate fares above competitive levels. [2] Similarly, Cairns and Liston-Heyes (1996) set up a simple model and concludes that in the absence of fare regulation there exists no equilibrium in a taxi market, suggesting that free entry and pricing may not be optimal.

Despite early concerns, much of the subsequent literature supports some degree of deregulation (Moore and Balaker, 2006). De Vany (1975) considers a model similar to Douglas (1972) and determines equilibrium output in different regulatory frameworks such as a franchised monopoly, the medallion system, and under free entry. He argues that restricted entry implies reduced consumer surplus. Through assessing taxi market restrictions in four UK cities, Beesley (1973) concludes that entry restrictions often impose costs exceeding their benefits, and Beesley and Glaister (1983) argue that regulators, operating under limited information, may implement inefficient policies. Similarly, Frankena and Pautler (1986) argue there is no rationale for most entry controls, though certain safety and fare regulations may be justified.

Early models have been criticised for focusing almost exclusively on the cruising segment (Williams, 1980; Shreiber, 1975). In practice, taxi markets are fragmented into taxi ranks,

[2] 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.

street hailing (cruising), and dispatch services.[3] Market failures likely differ across these segments, leading some countries to adopt two-tier regulatory systems (Aarhaug and Skollerud, 2014). Schaller (2007) notes that entry regulation in the cab stand/street hail market may be justified, but regulation in the dispatch market may lead to deficiencies in taxicab availability. The emergence of ride-hailing platforms adds another dimension to the discussion. The attractive feature of these platforms is that they reduce matching frictions and have higher capacity utilisation rates than traditional taxis (Cramer and Krueger, 2016). However, as Fréchette et al. (2019) argue, segmentation between traditional taxis and these platforms may reduce market thickness and consequently worsen matching frictions.

Encouraged by supportive economic evidence and prior successes in other transport industries, several countries have deregulated taxi markets. However, outcomes have been mixed. Teal and Berglund (1987) argue that deregulation has not achieved the objectives set for it: fares have generally increased and service quality has not improved. Gärling et al. (1995) document similar short-term results in Sweden, while Marell and Westin (2002) identify longer-term gains in competition and productivity in rural areas of Sweden. The reform of the taxi market in Finland has gained a lot of attention in recent years, and ongoing research by Harju et al. (2023) aims to evaluate the effects of deregulation of the taxi market on tax avoidance in the taxi industry.

Empirical evidence also highlights the heterogeneity in effects of deregulation between urban and rural areas.Gaunt (1995) shows that deregulation in New Zealand increased entry and reduced fares in major cities, while effects were modest or reversed in smaller cities. It is not obvious that competition intensifies automatically with deregulation, which helps explain differences across regions and market segments Morrison (1997) comes to a similar conclusion, findings that consumers in larger cities benefit more from deregulation in terms of availability and lower fares.

[3]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. (2024).

The aforementioned countries have imposed a “full” deregulation, i.e. deregulated both entry and fares while others have adopted policies focused on deregulating one aspect of the market. For example, in Ireland, entry restrictions were removed whilst fare regulations were kept in place, resulting in increased output and reduced waiting times (Barrett, 2010). In the Netherlands, entry was similarly liberalised, and fixed fares were replaced with maximum pricing. Bakker (2007) finds that the size of the taxi fleet grew substantially after deregulation. The maximum fares were initially meant to be removed after an adjustment period, but as the fares increased substantially faster than the CPI, the maximum fares were kept in place.

Two limitations characterise much of this literature. First, many studies lack credible counterfactuals, making it difficult to separate the effects of deregulation from broader market trends. Second, most analyses treat taxi markets as homogeneous, despite the existence of substantial regional differences. This paper addresses both by exploiting a regional policy discontinuity to identify causal effects and by modelling heterogeneous treatment effects across markets of varying thickness. The Finnish reform therefore provides a setting to study how full deregulation interacts with economies of scale in matching and platform competition in a geographically heterogeneous market.

2 Institutional Setting: Taxi Markets in Finland

2.1 Pre-Reform Regulation

Taxi markets in Finland were tightly regulated for decades. Quantity restrictions were introduced in 1937 and remained in place until 2018. The primary stated objectives were passenger safety and the guarantee of service availability in rural areas and during low-demand periods.

Prior to deregulation, three features defined the regulatory regime.

Entry restrictions. Each municipality was assigned a fixed number of taxi licenses, determined annually by regional authorities. Licenses were tied to a specific municipality and vehicle. Operators were required to meet criteria related to criminal background, health, and professional certification. Because license quotas were binding, entry was effectively capped, limiting competition and creating scarcity rents.

Geographic segmentation reinforced these restrictions. Taxis were only permitted to operate within their licensed municipality. If a ride ended outside that municipality, the driver was required to return immediately. This prevented cross-regional competition among taxi operators and thus further reduced competitive pressure.

Price regulation. Fares were subject to a nationwide maximum pricing formula updated annually. Although operators were legally allowed to charge less, binding entry restrictions and limited competition meant that the regulated maximum fare became the de facto market price across the country.

Service obligations. Dispatch centers were required to provide 24-hour service to ensure availability in all regions. This cross-subsidization mechanism was intended to support rural coverage.

The regulatory framework was uniform nationwide despite substantial heterogeneity in population density and demand conditions. As a result, densely populated urban markets and sparsely populated rural regions operated under identical rules.

Several studies consider environmental issues and congestion as important factors when discussing regulation in taxi market (Schaller, 2021). However, in Finland, these have not been seen as relevant issues in the context of taxi regulation, perhaps due there being low amount of traffic even within cities.

2.2 The 2018 Reform

The Act on Transport Services (320/2017), effective July 1, 2018, fundamentally altered the market. The reform was part of a wider transportation policy that aimed to increase competition and facilitate digitalisation. The key changes, which occurred simultaneously, were the following:

Removal of licence quotas, Entry restrictions were abolished. Any operator meeting statutory criteria could obtain a license.

Nationwide operating rights. Licenses were no longer tied to a specific municipality.

Free pricing. The national fare ceiling was removed, allowing operators to set prices freely.

Reduced quality regulation. Entry and operational requirements were simplified, although background checks were tightened.

Some regulatory elements aimed at increasing quality were reintroduced after 2018, most significantly the requirement that operators register as companies, obtain VAT numbers, and pass licensing exams.[4] However, these no measures regarding entry caps or price ceilings have been reinstated .

2.3 Market Structure and Publicly Financed Trips

The Finnish taxi market is relatively small but economically significant, with annual turnover exceeding one billion euros at the time of reform. A defining feature of the market is the high share of publicly funded rides, which account for approximately 40 % of industry revenue (Traficom, 2020). In rural areas, this share is even greater.

Publicly financed trips primarily consist of transportation to healthcare providers, reimbursed through the national social insurance system. After deregulation, these services were procured through competitive tenders at the regional level. Consequently, the price of publicly funded trips is determined through procurement contracts rather than by the market (Ahomäki et al., 2024).

The large role of publicly financed rides has important economic implications. In regions where such trips constitute a significant share of demand, firms may rely less on competitive pricing in the private market. This may weaken entry incentives and dampen the competitive effects of deregulation, particularly in sparsely populated areas. (Marell and Westin, 2002).

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

2.4 Technological Change and Platform Entry

The reform coincided with the expansion of digital ride-hailing platforms. Before 2018, some platform-based operators attempted to enter the market, but faced legal barriers due to licencing requirements. The removal of entry caps and geographic restrictions allowed full-scale platform competition in urban areas.

Digital platforms reduce search friction by allowing consumers to view prices, estimated arrival times, and driver information before booking. This technological change is therefore complementary to deregulation. However, platform entry has been concentrated in large urban regions, reinforcing geographic heterogeneity in competitive pressure.

3 Empirical approach and Data

3.1 Empirical approach

We identify the causal effects of taxi market deregulation using a regional policy discontinuity generated by Finland's 2018 reform. The reform simultaneously removed entry restrictions and national fare ceilings in all mainland regions. The autonomous region of Åland did not implement the reform and retained the pre-existing regulatory regime. This institutional difference provides a natural control group.

Åland is part of Finland but has legislative autonomy in selected policy domains. Because implementation of the reform required regional legislative approval, Åland chose not to adopt the new framework during the reform period. Before 2018, taxi regulation in Åland was identical to mainland Finland. The pre-reform institutional environment was therefore common across all regions.

Our empirical analysis proceeds in three parts. First, we estimate the effects of deregulation on offered and realised fares. Second, we examine the results at the firm and employee-levels, including revenue, profits, costs, employment, wages, and experience. Third, we develop a theoretical framework that explains why deregulation may generate heterogeneous effects across regions of different size and demand density.

To estimate the effects on realised and offered fares, we employ the following difference-in-differences specification:

$$ln(y_{irt}) = \alpha + \beta P_t + \gamma T_r + \delta(P_t \times T_r) + \lambda_r + \theta_t + \psi X'_{jrt} + \varepsilon_{jrt}, \tag{1}$$

where y_{jrt} denotes the fare for trip j in region r at time t. The indicator P_t equals one in the post-deregulation period and zero otherwise, while T_r equals one for regions exposed to deregulation and zero for the control region. Our coefficient of interest is δ, which measures the average change in fares in treated regions after deregulation relative to the contemporaneous change in the control region. Under the parallel trends assumption, δ identifies the causal effect of deregulation on fares.

The specification includes region fixed effects, λ_r, which absorb time-invariant differences across regions, and time fixed effects, θ_t, which control for common temporal shocks. The time fixed effects account for weekday effects and time-of-day variation. The vector X'_{jrt} contains trip-level control variables, including trip distance and the booking method (street hail or rank, dispatch center, or mobile application).

Pre-treatment prices are calculated by using the regulated maximum fares in 2017. For realised fares, we calculate a counterfactual price for each realised post-treatment trip by utilising the maximum fare schedule in Åland. For offered post-deregulation prices we simply use the collected data on offered prices both in the treatment and in the control group.

Standard errors are clustered at the region level. The model is estimated separately for small, medium-sised, and large regions. This stratification is motivated by institutional design: pre-reform license quotas were set proportionally to regional population, implying that deregulation represented different effective shocks depending on market size.

For firm and worker-level outcomes, we similarly estimate standard difference-in-differences model of the following form:

$$y_{irt} = \alpha + \beta P_t + \gamma T_r + \delta(P_t \times T_r) + \lambda_r + \theta_t + \psi X_{irt} + \varepsilon_{irt}, \tag{2}$$

where P_t indicates post-treatment period, T_r indicates region r that received treatment, λ_r represents region fixed effects, θ_t time fixed effects, and X_{it} contains controls for firm i's age. We estimate the coefficients separately for small, medium, and large regions.

Identification is based on the assumption that, without deregulation, the outcomes of mainland Finland and Åland would have followed parallel trends. Prior to deregulation, fares were set at the national level, and Åland continues to use the same method and cost index to determine prices. For firm- and employee-level variables, we evaluate the parallel trends assumption using two approaches.

First, graphical evidence shows similar pre-reform trends in revenue, employment, and firm counts across treatment and control regions. These are shown in Figures B.1, B.2 and B.3 in the Online Appendix.

Second, we estimate event-study specifications following Autor (2003):

$$y_{irt} = \alpha + \gamma T_r + \sum_{t=2014}^{2022} \delta_t (Y_t \times T_r) + \sum_{t=2014}^{2022} \beta_t Y_t + \psi X_{it} + \varepsilon_{irt}, \tag{3}$$

where Y_s are year indicator variables for 2014–2022, T_r is a treatment group indicator (1 for mainland Finland, 0 for Åland), and X_{it} includes same controls as in Equation 2. The coefficient of interest is δ_t, which represents the additional difference in the outcome variable by year due to 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 pre-reform interaction coefficients are statistically indistinguishable from zero across most outcomes. We do not detect systematic differential pre-trends, supporting the parallel trends assumption. The results are shown in Figures B.4 and B.5 in the Online Appendix.

A potential concern for identification is cross-regional spillovers. The reform removed geographic operating restrictions within mainland Finland, raising the possibility of entry reallocations across treated regions. However, spillovers into the control group are highly unlikely.

Taxi markets are inherently local due to high transport costs and geographically concentrated demand. Åland is geographically separated from mainland Finland, and taxi licenses issued in mainland Finland cannot be used in Åland and vice versa. As a result, firms and drivers cannot arbitrage regulatory differences across regions. We therefore consider violations of the stable unit treatment value assumption (SUTVA) unlikely.

Although deregulation formally applied uniformly across mainland regions, its effective intensity varied. Entry restrictions were calibrated to local population levels, and demand density differs substantially across regions. Consequently, the removal of entry and price controls represents a larger competitive shock in some markets than in others.

To account for this, we present results separately for small, medium-sized, and large regions. This approach allows the treatment effect to vary with local market size rather than imposing homogeneous effects.

3.2 Data

Our analysis combines three complementary data sources: (i) manually collected offered fares from taxi applications, (ii) realised transaction-level fare data from the Finnish Transport and Communications Agency, and (iii) firm- and employee-level register data from Statistics Finland. Together, these data allow us to examine pricing, market structure, and labour market effects of taxi market deregulation.

Offered fare data

We collect post-treatment offered fares by submitting taxi ride queries through mobile applications. In April 2022, we manually collected fares and times-to-arrival for 5,690 taxi trips in 18 small and medium-sized regions. Trips were approximately 5, 15, and 25 kilometres in length and either originated from or terminated in a regional centre (e.g., airport, regional hospital, or city centre).

We expanded the data collection during June–July 2022 to include the five largest regions where ride-hailing platforms (Uber, Yango, and Bolt) operate.[5] These five regions account for approximately 88% of total firm revenue in the taxi markets studied (excluding dispatch centres). In the expanded sample, we collect fares and waiting times for 15,171 trips of 1, 2, 3, 4, 5, 7.5, 10, 12.5, 15, and 20 kilometres. Trips include routes within city centres, between city centres and suburbs, and within suburban areas.

During both collection periods, we simultaneously collected identical data from Åland, which serves as our control group. Åland has one dispatch centre with a mobile application, yielding one fare and waiting-time observation per query. The control sample consists of 482 trips (April 2022) and 758 trips (June–July 2022). Because taxi fares in Åland remain regulated, observed fares can be generalised across firms regardless of booking method.

No pandemic-related restrictions were in place in any region during the data collection periods.

Table 1 presents descriptive statistics on these queries by region size. As expected, both the number of offers per query and the number of dispatch centres increase with market size. Average 5 km fares are similar in small and medium regions but somewhat lower in large regions. Interestingly, price dispersion is also lower in large regions despite the presence of significantly more dispatch centres, suggesting intensified competitive pressure in large regions with thicker markets.

Realised fare data

To complement offered fare data, we use realised fare data provided to us by the Finnish Transport and Communications Agency (Traficom) on the realised prices of taxi trips in Finland from

[5] Helsinki, Espoo, and Vantaa (capital region), Tampere, and Turku.

Table 1: Descriptive statistics on queries

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

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.

April 2022 up until the end of 2022.[6]. These data contain transaction-level information on completed taxi rides, including the duration and time of the trip, as well as the final price charged to customers. Unlike fare quotes obtained from applications, realised fares reflect actual payments and, therefore, incorporate any deviations between quoted and paid prices. We furthermore use data from the Social Insurance Institution of Finland (Kela) on publicly reimbursed taxi trips, in order to identify and drop public trips from the data.

The realised fare data allow us to assess whether offered fares are informative about actual transaction prices and which offered fares are actually chosen by consumers. We restrict the sample by excluding observations with implausible values (defined as prices exceeding €100 per kilometer), trips that can be matched to publicly reimbursed journeys recorded by Kela, and observations outside the geographic areas included in our analysis. The resulting dataset comprises slightly more than 5.1 million taxi trips. Of these, approximately 3.9 million occurred in large regions, 879,000 in medium-sized regions, and 348,000 in small regions.

[6]Traficom has been collecting data on all taxi trips since April 2022. See Traficom's *Price monitoring of taxi services*, `https://tieto.traficom.fi/en/statistics/price-monitoring-taxi-services`

Constructed pre-reform fares

Our price analysis differs from a standard difference-in-differences design because we do not observe micro-level trip data from the pre-reform period. Instead, we construct counterfactual pre-treatment fares for each observed post-treatment trip.

Prior to deregulation, all taxi firms priced at the regulated maximum fare. The pricing formula and fare schedule were specified in government decrees.[7] Since we observe trip distance and duration for every collected query, we can compute the fare that would have applied under the pre-reform regulation.[8]

We validate this approach using the autonomous region of Åland, which continues to apply the same maximum-fare formula that was used in mainland Finland prior to deregulation. Comparing observed fares in Åland with our calculated fares reveals only minor discrepancies (see Online Appendix Table A.4). These small differences arise because (i) the local taxi application rounds fares to integers, and (ii) taxis may apply time-based charges when travelling slowly due to for example traffic congestion. Since these measurement differences apply equally in treatment and control regions, they do not bias our difference-in-differences estimates.

The pricing information from Åland also allows us to construct post-treatment control prices. Because our realised fare data cover only mainland Finland, we use Åland's government decrees[9] to calculate the counterfactual for each post-treatment realised fare.

In summary, for offered fares, we calculate all pre-treatment prices. For realised fares, we construct pre-treatment prices for all regions and post-treatment control prices for Åland. This approach enables us to estimate price effects despite the absence of micro-level pre-reform transaction data.

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

[8] Pre-reform fares differed for 1-2 versus 3–4 passengers. Post-reform dispatch centres typically set fares for 1-4 or 5-8 passengers. Our estimates use the 1-2 passenger schedule, implying that our price effects should be interpreted as lower bounds.

[9] Åland regional government decision on taxi fares in Åland 2022/33 & 2021/156

Firm- and employee-level register data

Firm- and employee-level data are obtained from Statistics Finland and cover years 2013–2022. The pre-treatment period is 2013–2017 and the post-treatment period 2018–2022. Since deregulation took place mid-2018, we treat 2018 as a post-reform year; excluding 2018 does not affect our results. We omit 2020–2021 from the main specifications due to COVID-19 disruptions, which might have affected Åland and mainland Finland differently.

Firm-level data are based on financial statements and include revenue, costs, profits, firm age, size, and employment. Due to register limitations, we observe at most two employers per employee per year, which likely leads us to underestimate the number of employees per firm—particularly after deregulation, when part-time work became more common.

Employee-level data contain socio-demographic characteristics (age, education, ethnicity) and labour market variables (wages, employment history). Rather than focusing on licence holders, we examine individuals working in the taxi transportation sector, as many licence holders do not actively operate in the market. This distinction is important because taxi licences became relatively easy to obtain after deregulation, and licence counts therefore overstate active market participation.

Descriptive statistics for firm-level outcomes aggregated by treatment status are presented in the Online Appendix (Table A.3).

4 Empirical analysis

4.1 Consumers

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

Our difference-in-differences estimates show statistically and economically significant increases in average offered fares in all regions. Average offered fares have increased 13% and

Table 2: DiD estimates on offered fares

	(1) Small regions	(2) Medium regions	(3) Large regions
Treatment	0.000	0.001	0.034***
	(0.002)	(0.002)	(0.003)
Post	0.162***	0.162***	0.151***
	(0.003)	(0.003)	(0.005)
Treatment × Post	0.128***	0.141***	0.071***
	(0.004)	(0.004)	(0.005)
Control at baseline	2.224***	2.234***	2.039***
	(0.007)	(0.005)	(0.004)
Observations	4,107	8,294	31,858
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: Table presents differences-in-differences estimates of treatment effects 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. Standard errors clustered at regional level are presented in parentheses. The control group for small and medium regions is the same (same trip lenghts and thus prices), which explains the same post-coefficients. The significant positive treatment-coefficient for large regions can be explained by the fact that there are small, less than one km differences in trip lengths. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

14% in small and medium-sized regions, respectively. In large regions, offered fares have increased by 7% on average.

Before deregulation, there was no difference between or variation within offered and realised fares. Post-regulation offered fares vary and not all offered fares are realised. Hence, it is important not only to examine the averages, but also to evaluate the spread of options available for the consumers, as well as which of the options the consumers eventually choose.

The fare variation is significant in all regions, but the source of variation varies.[10] In small and medium-sized regions, the variation in offered fares comes mainly from variation *between*

[10]The full offered fare spread as well as the pre-reform regulated fares for the respective lengths can be seen in Figure B.6. A similar pattern is observed in the list fares of the dispatch centres. We show in Figure B.7 that the list fares are correlated with the observed fares, meaning that similar fare spread would also be observed when ordering a taxi without using the mobile applications. List fares were collected from firms' websites during June 2022. Some firms, e.g. Uber, do not have list fares available. Other firms, e.g. Yango, state that dynamic pricing will be applied during high demand.

different regions. In large regions, the variation in offered fares *within* the region is substantial, meaning that consumers can choose cheaper rides if they wish.

We next examine realised fares using transaction-level data from the national transport authority, which records the final price paid for completed taxi trips. We compute the median and interquartile range of realised fares for the same 24 regions used in the offered-fare analysis, grouped into large, medium-sized, and small regions.

Figure 1 plots the median and interquartile range of both offered and realised fares in the deregulated regions, along with the median fare in the control region where regulation remained in place. In large regions, realised fares exhibit substantial dispersion, as indicated by a wide interquartile range across all trip lengths. Notably, the median realised fare lies at the lower end of the offered-fare distribution. This pattern suggests that although prices vary widely, consumers in large markets tend to select lower-priced options. In this sense, consumers appear to benefit from the increased price dispersion following deregulation.

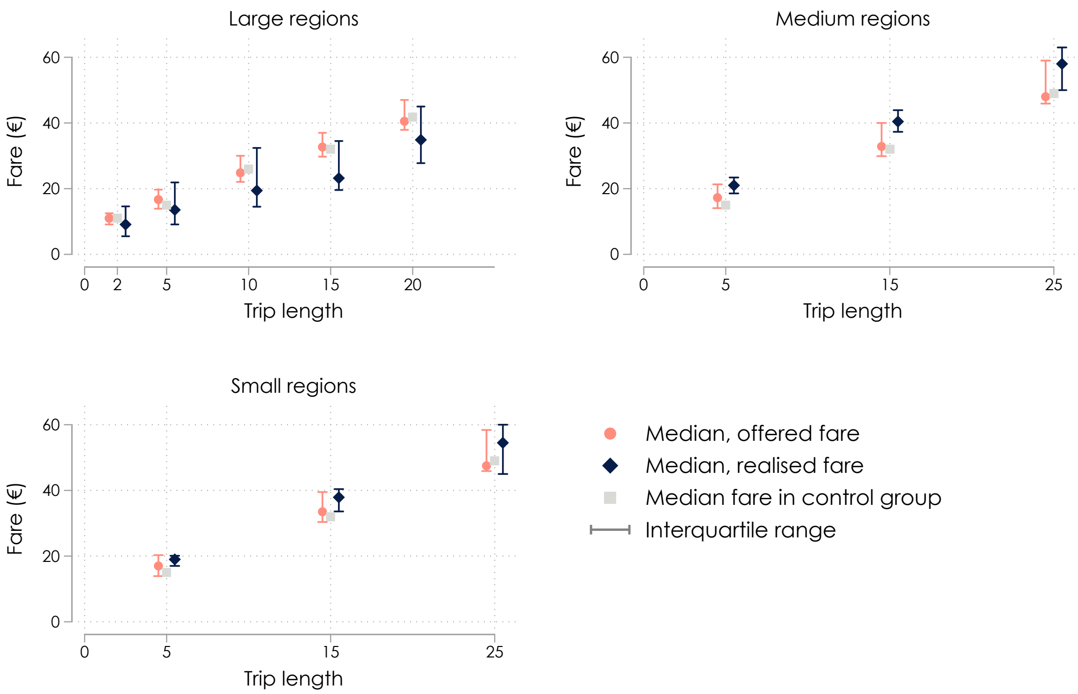

Figure 1: Offered and realised taxicab fares

The pattern differs markedly in small and medium-sized regions. In these markets, the interquartile range of realised fares is considerably narrower, particularly for shorter trips, and the median realised fare exceeds the median offered fare. This suggests that lower-priced alternatives play a more limited role. Even when cheaper options are at times available, consumers appear less likely to access them, and realised prices frequently remain above pre-deregulation levels.

Table 3 reports difference-in-differences estimates of the reform's effect on realised fares. The post-treatment year is 2022, consistent with the period for which realised-fare data are available. The realised-fare data include both privately paid trips and trips reimbursed by the public social insurance system. Because publicly reimbursed trips are priced through procurement contracts and may not reflect competitive private-market pricing, we estimate effects both for the full sample and for a restricted sample excluding reimbursed trips.

To identify reimbursed trips, we match the realised-fare data with administrative records from the national social insurance agency covering all reimbursed taxi trips in 2022. Matching is based on company identifier, trip start time, and trip origin. These variables do not always uniquely identify trips, and as a result we are able to remove approximately half of the reimbursed trips from the realised-fare dataset. Consequently, the difference between the full-sample and restricted-sample estimates likely understates the true gap between publicly reimbursed and privately paid trips.

The difference-in-differences results indicate that realised fares increased by 3.7 percent in small regions and by 22.9 percent in medium-sized regions. In large regions, we estimate a sizable negative effect. In small regions, the decline in realised prices observed in the full sample is driven entirely by publicly reimbursed trips, where competitive procurement has reduced prices. Because only part of these trips can be excluded from the data—and other forms of publicly financed trips remain in the sample—the estimated private-market price increases in small regions are likely conservative. In markets where publicly reimbursed rides represent a large share of total demand, the true increase in privately paid fares may therefore be larger than our estimates suggest.

´

Table 3: DiD estimates on realised fares

	Small regions		Medium regions		Large regions	
	(1) All trips	(2) Kela-trips removed	(3) All trips	(4) Kela-trips removed	(5) All trips	(6) Kela-trips removed
Treatment	0.000	0.000	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Post	0.123***	0.112***	0.121***	0.112***	0.114***	0.112***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Treatment × Post	-0.141***	0.037***	0.035***	0.229***	-0.243***	-0.278 ***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.000)	(0.000)
Control at baseline	2.890***	2.780***	3.103***	2.671***	2.809***	2.762***
	(0.015)	(0.007)	(0.002)	(0.004)	(0.009)	(0.078)
Observations	2,944,058	1,394,076	6,451,006	3,528,559	18,025,664	15,762,666
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Table presents differences-in-differences estimates of treatment effects on realised fares (logarithmic). Pre-treatment fares are calculated for each trip using 2017 regulated fares, and Åland's fares are calculated by using the yearly maximum fares. Time fixed effects include both time-of-day and day-of-week. Standard errors clustered at regional level are presented in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

To better understand why fares differ across regions, we estimate descriptive regressions relating offered fares to observable market characteristics. Table 4 reports region-specific regressions where the dependent variable is the logarithm of the offered fare and region fixed effects are included.

Two patterns stand out. First, in large regions, dispatch services that operate exclusively through mobile applications offer significantly lower fares on average. The coefficient on App-only dispatch is large and negative in column (3), indicating that app-based platforms price substantially below traditional dispatch centres. Administrative data on realised fares from the national transport authority show a similar pattern: the distribution of realised fares for trips booked via applications is skewed toward lower prices. This suggests that consumers in large markets actively select cheaper options when they are visible and easily comparable.

A possible explanation is reduced search costs. Mobile applications allow consumers to observe prices before booking and to compare alternatives at low cost. In addition, large urban areas provide more alternatives for taxi rides, such as public transportation. This increases the price elasticity of demand for taxi services: when fares are high, consumers can switch to

Table 4: Descriptive regressions on logarithms of offered fares

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

Notes: Dependent variable in all regressions is log(fare). App-only dispatch refers to dispatch centres which only operate through mobile applications. Peak demand is an interaction term of *Outside business hours* and *Friday or Saturday*, since demand is usually high during these nights. 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 centre. Standard errors are clustered at regional level and are presented in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

alternative modes. In smaller and more remote areas, substitutes are limited, which weakens competitive pressure and increases the effective bargaining power of taxi firms.

Second, market structure is strongly correlated with pricing. The number of dispatch centres operating in a region is negatively associated with offered fares across all region types. The magnitude of this association is larger in small regions, where the absolute number of dispatch centres is lower. Economically, an increase from two to three dispatch centres is likely to intensify competition more than an increase from ten to eleven. Thus, marginal entry has a stronger competitive effect in thinner markets.

Other controls behave as expected. Longer trips are associated with higher fares, and fares increase outside regular business hours. Peak-demand effects are modest in large regions, possibly reflecting greater supply flexibility.

Overall, the regression evidence suggests that both search frictions and market concentration contribute to regional price differences. The theoretical model in Section 5 formalizes these mechanisms and explains why deregulation generates heterogeneous outcomes depending on market density and the degree of dispatch competition.

4.2 Taxi markets, firms and employees

Next, we examine how deregulation affected firms and taxi drivers. Our outcomes include firm revenue, employment, profits, total costs (including fuel costs), driver income, and driver experience. The difference-in-differences estimates are reported in Tables A.5–A.11 in the Online Appendix.

Figure B.1 shows the evolution of market-level aggregates by region size. Prior to deregulation, aggregate industry revenue was relatively stable across regions. After the reform, only large regions exhibit an increase in total industry revenue. The total number of taxi drivers had been declining in all regions before the reform. This trend reversed in large and medium-sized regions, where the number of drivers began to rise. The number of firms followed a similar pattern: a gradual decline before deregulation, followed by a sharp increase in large regions after 2018.

Firm Revenue and Size

In small regions, deregulation did not significantly affect average firm revenue. In medium-sized regions, average revenue increased by approximately 5.6 percent. At the same time, the average number of employees per firm increased (Table A.6), suggesting some expansion among incumbent firms and possibly increased market concentration. In small regions, changes in employment per firm are not statistically significant.

Large regions display a different adjustment. The average revenue per firm declined by approximately 6 %. This reduction coincides with a substantial increase in the number of firms. Because aggregate revenue rose only modestly, entry mechanically reduced revenue per firm (see Figure B.1). The number of employees per firm also decreased, although the estimate is not statistically significant. These patterns indicate that deregulation led to market fragmentation in large regions, with entry of smaller firms and reduced average firm scale.

Firm Profit and Costs

Profit margins, which we measure as profits relative to revenue, declined in small and large regions. The estimate is also negative in medium-sized regions, though not statistically significant. In general, deregulation appears to have reduced profitability in most markets.

This result may seem surprising, given that the fares increased in most regions. However, cost developments help reconcile this pattern. Total costs as a share of revenue increased in all regions, with the largest increase, approximately 14 percent, occurring in large regions. Rising fuel costs explain part of the increase in small and medium-sized regions. In large regions, the increase likely reflects intensified competition, platform commissions, marketing expenditures, or lower capacity utilisation per firm. In small regions, where average revenue remained unchanged but costs increased, taxis may be operating with lower utilization rates. If demand did not expand and entry remained limited, deregulation may have reduced coordination without generating sufficient competitive pressure to raise efficiency.

4.2.1 Driver outcomes

At the employee level, driver income declined by approximately 5 percent in small regions and 10 percent in medium-sized regions. The estimate for large regions is not statistically significant. These findings suggest that part of the adjustment to deregulation occurred through reduced driver earnings, particularly outside the largest markets.

We also observe a decline in average driver experience in medium-sized and large regions. Because employment histories are observed only from 2008 onward, experience is mechanically truncated, and the estimates therefore represent lower bounds. The decline is consistent with entry of new firms and drivers following deregulation.

Overall, the evidence at the firm and worker-levels suggests that deregulation induced substantial structural change in large markets, characterised by entry and reduced average firm scale, while smaller markets experienced more limited entry but, nonetheless, declining profitability and driver income. These adjustments align with the broader pattern that the effects of deregulation depend critically on the size and density of the local market.

5 Theoretical Framework

We consider a static, steady-state model of ride-hailing in homogeneous space à la Castillo et al. (2024). While Castillo et al. (2024) 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 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.[11] As such, the objective of the analysis is to demonstrate that variations in a alone can explain key regional differences both pre- and post-deregulation.

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

$$N = I + tQ + TQ. \tag{4}$$

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 throughout the space.

Notice that T is both the average waiting time for the rider and 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 represented by $T(I)$, which decreases in I. That is, the shorter the waiting time, the more idle taxis there are. If potential riders and idle taxis are uniformly distributed over a n-dimensional Euclidean space and the taxis drive in a straight line at a constant speed, then $T(I) \propto I^{-\frac{1}{n}}$ (Castillo et al., 2024).

For the purposes of the model, it is convenient to define the inverse function $I(T)$, which exists due to the monotonicity of $T(I)$. By isolating Q in (4) and substituting $I(T)$, we obtain the trip supply

$$S(T,N) = \frac{N - I(T)}{t + T}. \tag{5}$$

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

[11] Equivalently, one could standardise 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.

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.[12] 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, we can obtain a convenient closed-form solution to the market equilibrium. While the existence of an equilibrium can be proven with less structure as in Castillo et al. (2024), the second-order partial derivatives, which we need for the analysis, are tedious for an implicit function and would nevertheless require additional assumptions to determine their sign.

For the purpose of defining the profits of taxi firms and dispatch centres, let $\tau \in [0,1]$ denote the share of the price collected by the dispatch centre (which is essentially a 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:

$$\pi = ((1-\tau)p - c(1+T))\,q - F, \tag{6}$$

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

In (6), 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 results in higher insurance costs through additional mileage).

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

$$Q(p,N) = \begin{cases} \frac{ar(p)(N-ar(p))}{N-ar(p)+1} & \textit{if } N > ar(p) \textit{ and } \pi \geq 0 \\ 0 & \textit{otherwise} \end{cases}, \tag{7}$$

[12]This last property is what creates the possibility of a bad equilibrium (a "wild goose chase") studied by Castillo et al. (2024).

$$T(p,N) = \begin{cases} \frac{1}{N-ar(p)} & \textit{if } N > ar(p) \textit{ and } \pi \geq 0 \\ +\infty & \textit{otherwise} \end{cases}. \tag{8}$$

All proofs are in Online Appendix C.

Note that

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

where $\hat{p}$ is defined by

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

That is, if $p < \hat{p}$, the market is in a wild-goose-chase (WGC) equilibrium (Castillo et al., 2024), where a higher price would both increase the number of rides and decrease the waiting time.

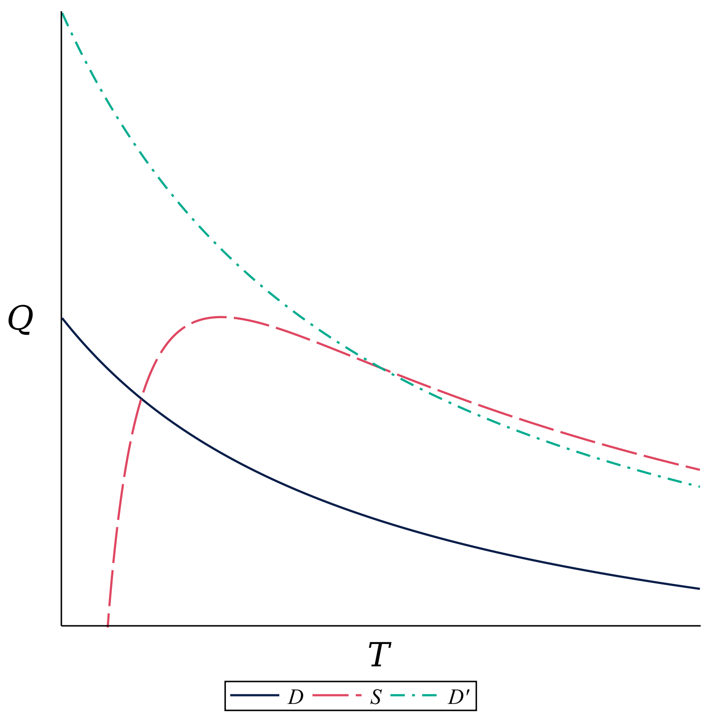

Figure 2: Supply and demand of taxi trips

Figure 2 illustrates the above-mentioned possibility. The figure depicts how the supply and demand for taxi rides depend on T, while other factors subsequently shift these curves up or down. When demand (D) is sufficiently low, it intersects supply (S) in the latter's upwardsloping region. However, when demand is higher (D'), due to a lower price or a higher number of potential riders, the intersection occurs in the downward-sloping region of supply.

5.2 Pre-Deregulation Equilibrium

Before 2018, fares and entry into the Finnish taxi market were regulated. The regulator set price ceilings periodically, and effectively these were charged throughout the country. The number of licences was 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 numbers 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*

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

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

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

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

Figure 3 illustrates the pre-deregulation equilibria for two local markets that have the same p and n but different a's. Although the number of trips demanded in the large market is higher

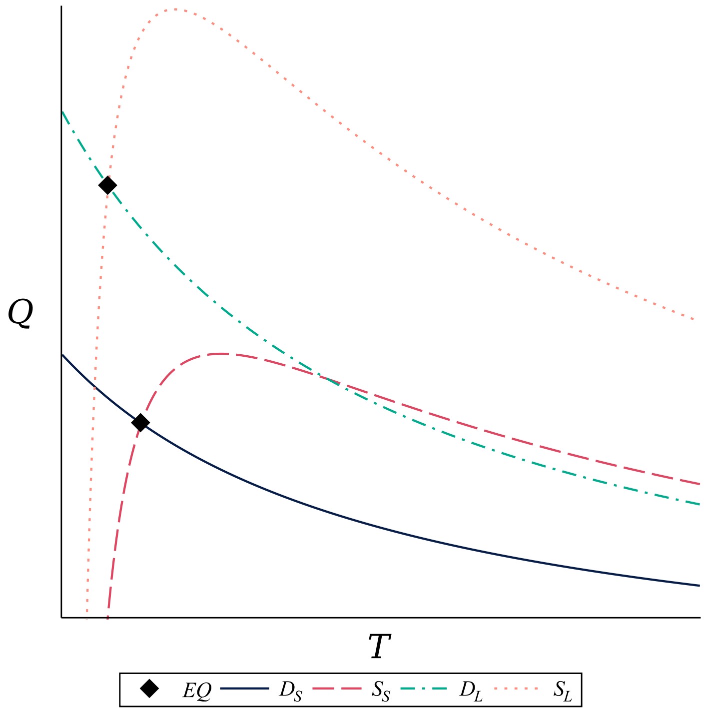

Figure 3: Pre-deregulation equilibria

than in the small market ($D_L > D_S$), the difference is even greater in supply ($S_L > S_S$) due to economies of scale. Hence, the large market enjoys, both relatively and in absolute terms, more rides as well as lower waiting times in equilibrium. Given the pre-deregulation constraint of having the same p and n for all local markets of varying a, it is also possible that some local markets get stuck in a "perpetual" WGC equilibrium even if the regulator's 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 centres. 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 on a cost-recovery basis. Post-deregulation, however, they may have obtained pricing power over both the riders and taxi firms. Among the taxi firms, there were new entrants that were not shareholders of the local dispatch centre.

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

Regardless of the structure of the dispatch centre market, the post-deregulation taxi firm industry can be considered competitive. As such, the number of taxis depends on the free-entry condition, $\pi = 0$.[13]

Although the dispatch centres faced competition, especially in the more populous areas, for simplicity, we first consider the problem of a monopoly dispatch centre. This will give us an idea of the pricing incentive and how it varies geographically when unhindered by competition. As such, the problem of the dispatch centre is to maximise the aggregate revenue, τpQ, such that $\pi = 0$. However, by substituting the constraint into the objective function, we see that the centre's problem becomes

$$\max_{p,N} \Pi = pQ - c(1+T)Q - NF. \tag{9}$$

Through p and τ, the dispatch centre 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 taxi firms. Again, we substitute $an = N$ in (9) to analyse the relative number of taxis.

The post-deregulation markets are assumed to be isolated, which implies that irrespective of the dispatch centre market structure, there will be no WGC equilibria and the price should

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

always be chosen such that $p > \hat{p}$.[14] At the same time, 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 studied 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,*

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

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

Proposition 3. *Let* p^* *and* n^* *denote the unique maximising point of* (9). *Then,*

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

Furthermore, there exists $\hat{a}$ *such that if* $r'' \equiv d^2 r(p)/dp^2 \leq 0$ *and* $a > \hat{a}$*, then*

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

The intuition behind the result is as follows. A higher number of potential riders creates an incentive to increase the price. However, due to economies of scale, the decrease in marginal costs outweighs the increase in marginal revenue. Thus, it becomes optimal to have lower fares in more populous areas. At the same time, due to scale economies, the number of idle taxis is

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

less critical in more populous areas that have sufficient size. Thus, the relative number of taxis is smaller as the centre sets a higher dispatch fee.

In order to assess whether the interregional 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 centre to a competitive market. Perfect competition and free entry should lead to an outcome in which 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 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 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 that the market can bear enters. Both riders and taxis are assumed to multi-home, and the competition between the dispatch centres drives also their profits to zero and $\tau = 0$. Formally, the maximum entry equilibrium is a solution to

$$\max_{p,n} an \text{ s.t. } \mathscr{F}(p,n) = 0. \tag{10}$$

Proposition 4. *Let p^{**} and n^{**} denote the unique maximising point of* (10)*. Then,*

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

We see from Propositions 3 and 4 that both market structures exhibit a negative relationship between the equilibrium price and population size. Although market power obviously affects the price level, we see that, regardless 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.

However, market power, rather than matching technology, seems to be responsible for 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. In fact, from the data we see that the number of dispatch centres increases with the population size. Although we will not consider the entry of the dispatch centres, the level of competition between dispatch centres may also be attributed to the varying population sizes and distances.

5.4 Other considerations

In addition to market power, the lack of entry in smaller regions despite the increase in 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 scale economies. Following the deregulation of the taxi market, there was now public procurement of publicly funded trips. These procurement rounds led 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 taxi 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 led to discoordination and worse distribution of idle taxis, where individual drivers conglomerated too heavily at 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 multi-homing, 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 Welfare effects

This section evaluates the welfare implications of the 2018 taxi market deregulation. Data limitations—most notably the absence of pre-reform waiting-time data—prevent a full structural welfare analysis. We therefore combine reduced-form evidence on prices, entry, and profits with theoretical predictions to infer the likely direction of welfare effects across regions.

The reform resulted in substantial regional heterogeneity. In large municipalities, prices declined and entry increased. In small and medium-sized regions, prices rose and entry remained limited. On the producer side, firm profits and driver income evolved differently across regions, reflecting intensified competition in thicker markets. Because the Finnish taxi market is highly concentrated geographically—approximately 88 percent of firm revenue is generated in large regions—the aggregate welfare impact is likely dominated by developments in these markets. However, taxis arguably play a more essential role in small and medium-sized regions where public transport is limited. Regional welfare comparisons are therefore economically meaningful despite differences in market size.

We organize the discussion around consumer surplus, producer surplus, and broader market adjustments.

Large municipalities

In large municipalities, average fares declined following deregulation. Under standard demand assumptions, lower prices increase consumer surplus. In addition, the number of active firms and dispatch platforms increased substantially. Our model (Proposition 1) predicts that equilibrium waiting times are decreasing in the number of taxis. Although we do not observe pre-reform waiting times directly, the post-reform increase in fleet size implies improved availability and reduced expected waiting times.

Supplementary evidence on post-reform waiting times (Online Appendix D) indicates relatively short arrival times in large cities. Together, price reductions and increased availability strongly suggest an increase in consumer surplus in large municipalities.

Figure 4 shows that the regional sum of profits and labor income in large municipalities declined following the reform. A downward trend is already visible after 2014, likely reflecting Uber's brief entry prior to formal deregulation. After 2018, profits initially declined further before partially recovering, consistent with intensified competition and potential short-run price competition aimed at expanding market share.

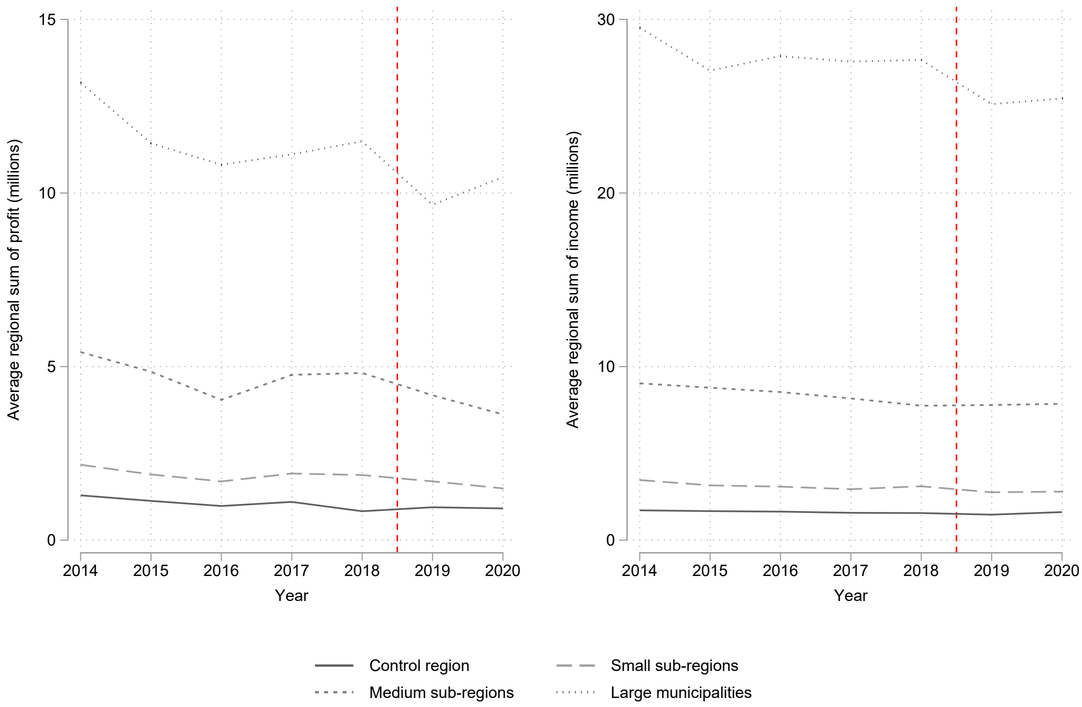

Figure 4: Average regional sum of profit and income

The reduction in regional profits and driver income is consistent with the observed decline in prices. In competitive models with free entry, increased competition compresses markups and redistributes surplus from producers to consumers. Our findings align with such a mechanism.

Taken together, the evidence points to a redistribution from producers to consumers, with likely positive net welfare effects in large municipalities. Lower prices, greater entry, and improved availability imply gains in allocative efficiency and consumer surplus, while producer surplus declines.

Small municipalities

The welfare implications in relatively small markets differ substantially. In small and medium-sized regions, average fares increased after deregulation. Unlike in large cities, we observe no substantial increase in the number of taxis. In the absence of entry or improvements in availability, higher prices directly reduce consumer surplus.

Because we lack pre-reform waiting-time data, we cannot rule out improvements in service quality or reduced waiting times. However, the relatively stable number of taxis suggests that any such gains are unlikely to offset the price increases. The most plausible interpretation is therefore that consumer welfare declined in these regions.

Figure 4 indicates that the regional sum of profits declined slightly, while total labor income shows no clear increase. This pattern suggests that higher prices did not translate into higher aggregate producer surplus. Instead, increased dispersion or higher costs may have absorbed part of the price increase.

In thin markets, deregulation can weaken the coordination previously provided by regulated pricing and centralised dispatch. If entry does not sufficiently increase to discipline prices, consumers face higher fares without matching efficiency gains. The evidence is consistent with such a mechanism.

The combination of higher prices and limited entry suggests that overall welfare likely declined in smaller regions. Consumers appear to have lost, and producers did not experience offsetting gains sufficient to compensate for those losses.

Market Transparency and Non-Price Dimensions

Beyond prices and profits, deregulation paved the way for new service characteristics.

For app-based users, transparency has increased substantially. Modern applications provide ex ante price quotes, estimated arrival times, driver identification, vehicle characteristics, and customer ratings. Relative to the regulated regime, this represents a significant expansion of information available to consumers and may reduce search costs and quality uncertainty.

In contrast, for street-hailing or rank-based customers, price dispersion and quality variation have increased. Under regulation, fares and service standards were uniform. Post-reform, fares and service quality vary across visually similar taxis. Although vehicles are required to display fare information, comparing prices across cars may entail non-trivial search costs. For consumers who rely on street hails—arguably more common among tourists and elderly individuals—market transparency may have deteriorated.

These opposing developments imply that welfare effects also differ across consumer types. Digital adoption likely mediates the gains from deregulation.

7 Conclusion

This paper studies the effects of the complete deregulation of the Finnish taxi market, where entry restrictions and national fare ceilings were simultaneously removed. Leveraging an exogenous discontinuity in regional policy implementation and combining novel fare data with administrative firm- and worker-level registers, we document substantial and systematic heterogeneity across markets.

Taxi markets of different sizes followed very different post-reform paths. In large regions, entry expanded sharply, market fragmented, and price dispersion increased significantly. Although average posted fares increased, realised fares are concentrated at the lower end of the distribution, implying consumers choosing cheaper providers. Profit margins declined and average firm size fell, suggesting intensified competition.

Paid taxi fares increased by 3.7% in small regions and 22.9% in medium regions, yet entry remained limited. Profits and driver income decreased despite higher prices. These patterns indicate that the deregulation did not generate sufficient competitive pressure in smaller markets to offset cost increases or coordination losses. Our theoretical framework explains this divergence through economies of scale in matching and differences in dispatch platform competition. In large markets, greater demand improves matching efficiency and supports competitive outcomes. In smaller markets deregulation may have weakened coordination without inducing sufficient entry, leading to higher prices and lower surplus.

More broadly, our results highlight that the effects of deregulation depend critically on market characteristics and institutional context. A uniform national policy may therefore generate regionally asymmetric outcomes. Understanding how platform competition, matching frictions, and public procurement interact with deregulation remains an important direction for future research.

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Online appendix

A Tables

Table A.1: Subgroup division

Control	Treatment				
Åland	**Small regions**	Municipalities	**Medium regions**	Municipalities	**Large regions**
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, Virolahti*			
	Imatra	*Imatra, Parikkala, Rautjärvi, Ruokolahti*			
	Forssa	*Forssa, Humppila, Jokioinen, Tammela, Ypäjä*			

Table A.2: Characteristics of the control and treatment region by region size

	Control	Treatment		
	Åland	Small regions	Medium regions	Large regions
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)	5 866.4	4 240.4	7 132.9	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	2 440	21 800
	(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 region. Population density is calculated by dividing population by the land area of the region. Median income represents the mean of regions' median income. Statistics are obtained from Statistics Finland.

Table A.3: Firm characteristics by region size

	Small regions	Medium regions	Large regions	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 (in €)

	Real	Calculated	Difference
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: Revenue

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	-1817.537	58031.251**	53413.104***
	(4250.466)	(19324.245)	(1881.192)
Post	62768.271***	45186.440***	30283.861**
	(6160.250)	(6379.422)	(8815.707)
Treatment x Post	11153.979	373.734	-24970.068***
	(6540.559)	(9668.812)	(2239.921)
Control at baseline	280430.473*	2048034.352	134562.023***
	(143861.464)	(1140606.974)	(7929.592)
Observations	5876	10298	13465
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 2, where the dependent variable is a firm's revenue. Robust standard errors are presented in parentheses. Statistical significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.6: Employees

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	-0.004	0.821***	1.038***
	(0.061)	(0.134)	(0.078)
Post	0.364***	0.128	0.124
	(0.073)	(0.078)	(0.217)
Treatment x Post	0.002	0.086	-0.461***
	(0.060)	(0.095)	(0.100)
Control at baseline	3.450*	9.205*	1.660***
	(1.692)	(4.854)	(0.211)
Observations	5876	10298	13465
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 2, where the dependent variable is a firm's number of employees. Robust standard errors are presented in parentheses. Statistical significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.7: Profit as a percentage of revenue

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	0.029***	0.058***	0.031***
	(0.006)	(0.006)	(0.004)
Post	0.015	-0.036	-0.105*
	(0.026)	(0.031)	(0.045)
Treatment x Post	-0.105***	-0.087***	-0.157***
	(0.023)	(0.024)	(0.029)
Control at baseline	0.020	0.037	-0.004
	(0.048)	(0.070)	(0.008)
Observations	5865	10263	13403
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 2, where the dependent variable is a firm's profit as a percentage of their revenue. Robust standard errors are presented in parentheses. Statistical significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.8: Costs as a percentage of revenue

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	-0.011***	-0.061***	-0.085***
	(0.003)	(0.005)	(0.002)
Post	0.026**	0.009	0.086**
	(0.010)	(0.021)	(0.026)
Treatment x Post	0.041***	0.072***	0.098***
	(0.007)	(0.013)	(0.013)
Control at baseline	0.375***	0.625***	0.407***
	(0.051)	(0.193)	(0.005)
Observations	5864	10263	13403
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 2, where the dependent variable is total costs as a percentage revenue. Robust standard errors are presented in parentheses. Statistical significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.9: Fuel costs as a percentage of revenue

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	0.019***	0.018***	-0.005*
	(0.001)	(0.002)	(0.002)
Post	-0.026***	-0.029***	-0.018***
	(0.004)	(0.005)	(0.001)
Treatment x Post	0.023***	0.023***	0.014***
	(0.003)	(0.002)	(0.003)
Control at baseline	0.059*	0.310**	0.017***
	(0.033)	(0.135)	(0.002)
Observations	5863	10259	13399
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 2, where the dependent variable is fuel costs as a percentage of revenue. Robust standard errors are presented in parentheses. Statistical significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.10: Income

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	3480.922***	582.749	2514.418***
	(518.230)	(424.088)	(235.008)
Post	5310.951***	4575.498***	2572.050***
	(804.688)	(441.739)	(572.247)
Treatment x Post	-3329.801***	-5524.663***	-3423.705***
	(632.797)	(457.238)	(810.506)
Control at baseline	30306.260***	35366.583***	29542.391***
	(2530.954)	(2358.477)	(305.494)
Observations	10139	19749	29495
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 2, where the dependent variable is taxi driver income. Robust standard errors are presented in parentheses. Statistical significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.11: Experience in the taxi sector in years

	(1) Small regions	(2) Medium regions	(3) Large municipalities
Treatment	0.362***	0.282***	0.440***
	(0.040)	(0.046)	(0.041)
Post	0.275***	0.378***	0.422***
	(0.061)	(0.037)	(0.042)
Treatment x Post	-0.099	-0.314***	-0.136***
	(0.059)	(0.061)	(0.028)
Control at baseline	3.759***	3.486***	4.360***
	(0.192)	(0.179)	(0.042)
Observations	10341	19953	29767
Time Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The table reports the coefficients of interest of the standard difference-in-differences regression specified in Equation 2, where the dependent variable is taxi driver's experience in years. Statistical significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

B Figures

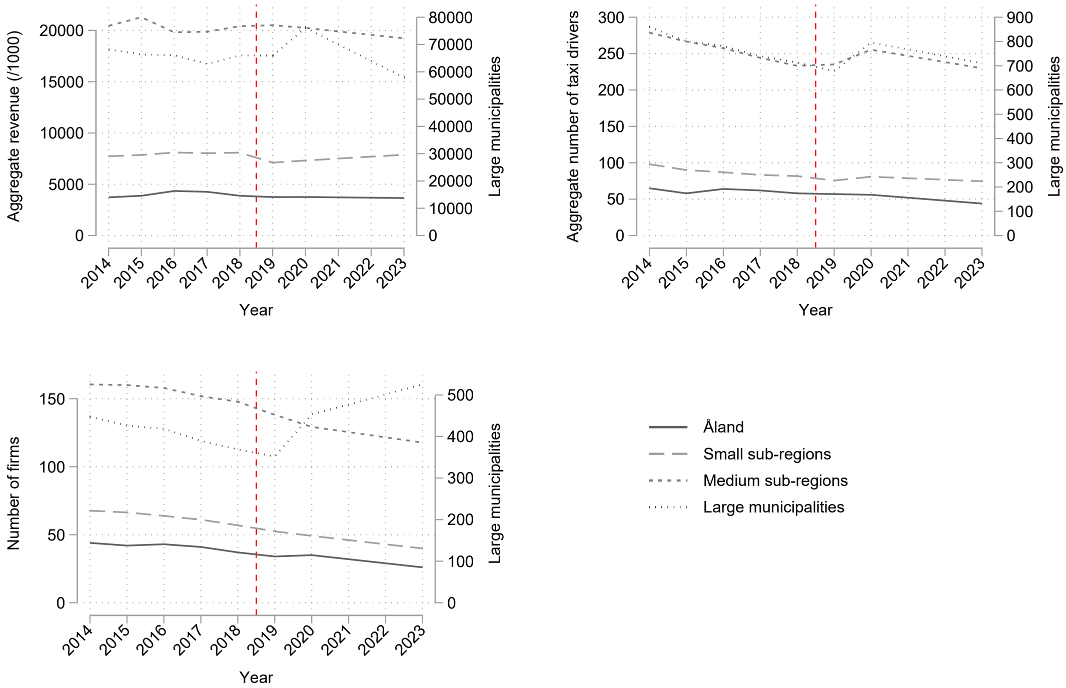

Figure B.1: Evolution of market level variables

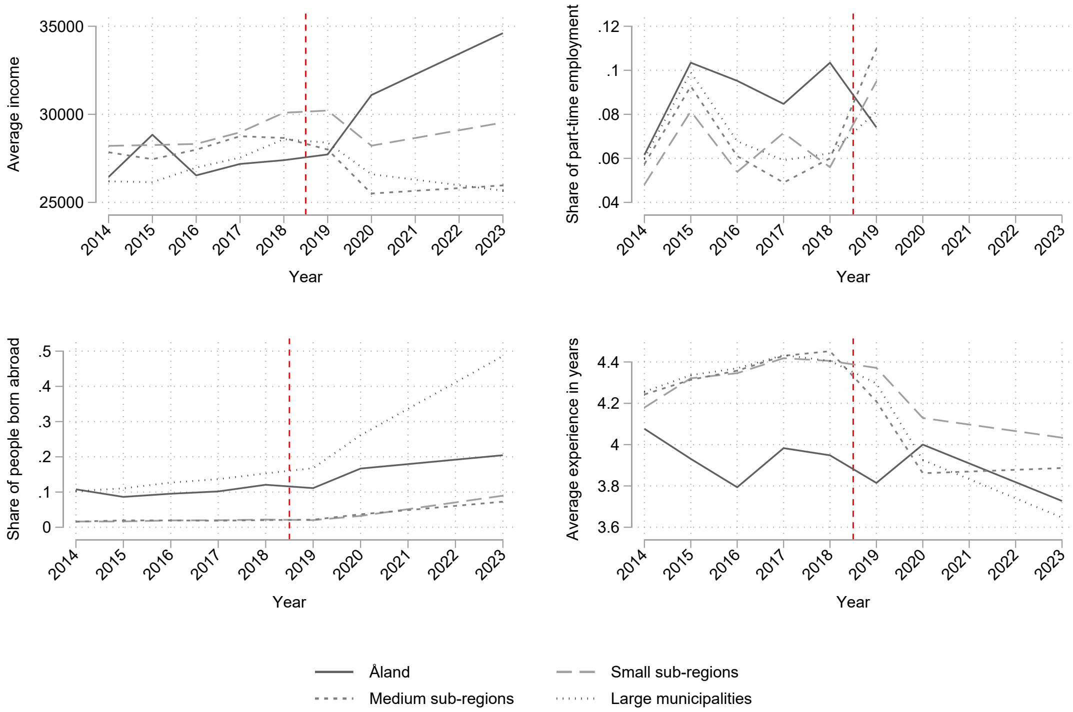

Figure B.2: Evolution of employee level variables

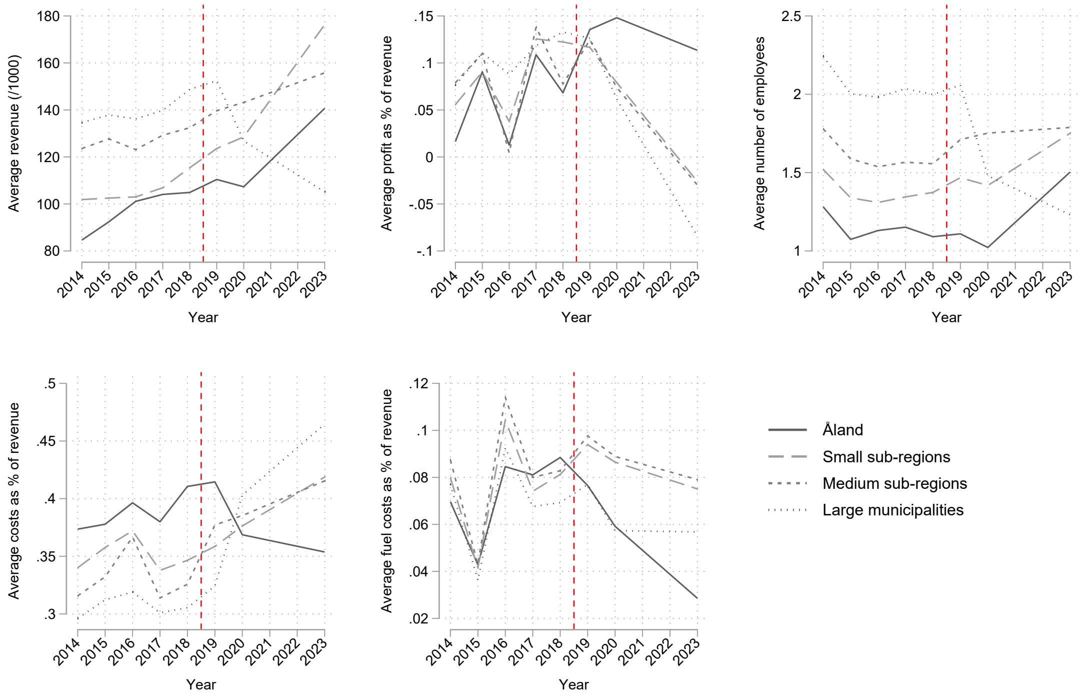

Figure B.3: Evolution of firm level variables

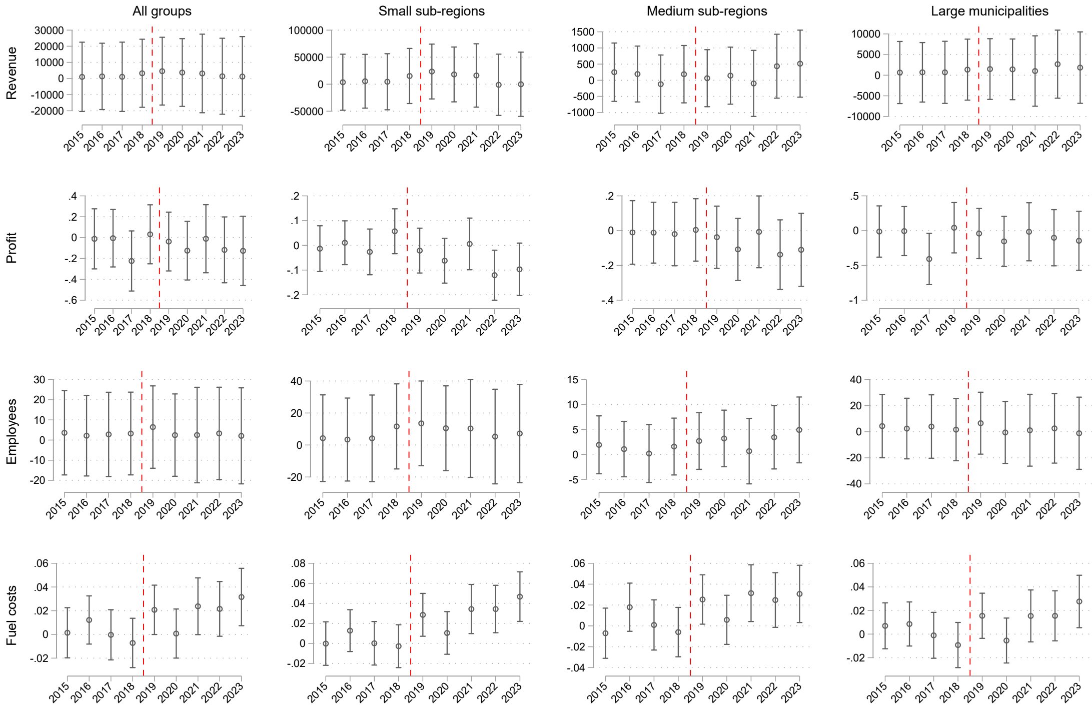

Figure B.4: Testing of parallel trends assumption for firms

Notes: Figures plot the interaction effects by year, meaning each year-treatment pair depicts the additional effect of treatment in each year relative to the base year. The plotted point shows the estimated coefficient for each respective year-treatment pair, and the line depicts the 95% confidence interval.

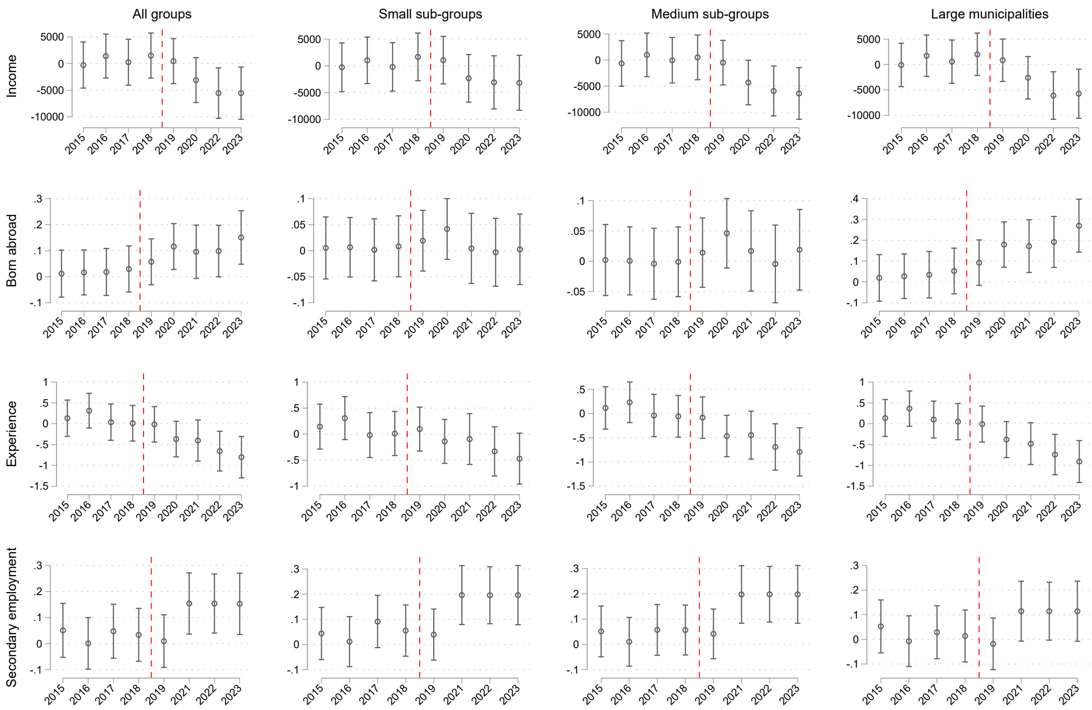

Figure B.5: Testing of parallel trends assumption for employees

Notes: Figures plot the interaction effects by year, meaning each year-treatment pair depicts the additional effect of treatment in each year relative to the base year. The plotted point shows the estimated coefficient for each respective year-treatment pair, and the line depicts the 95% confidence interval.

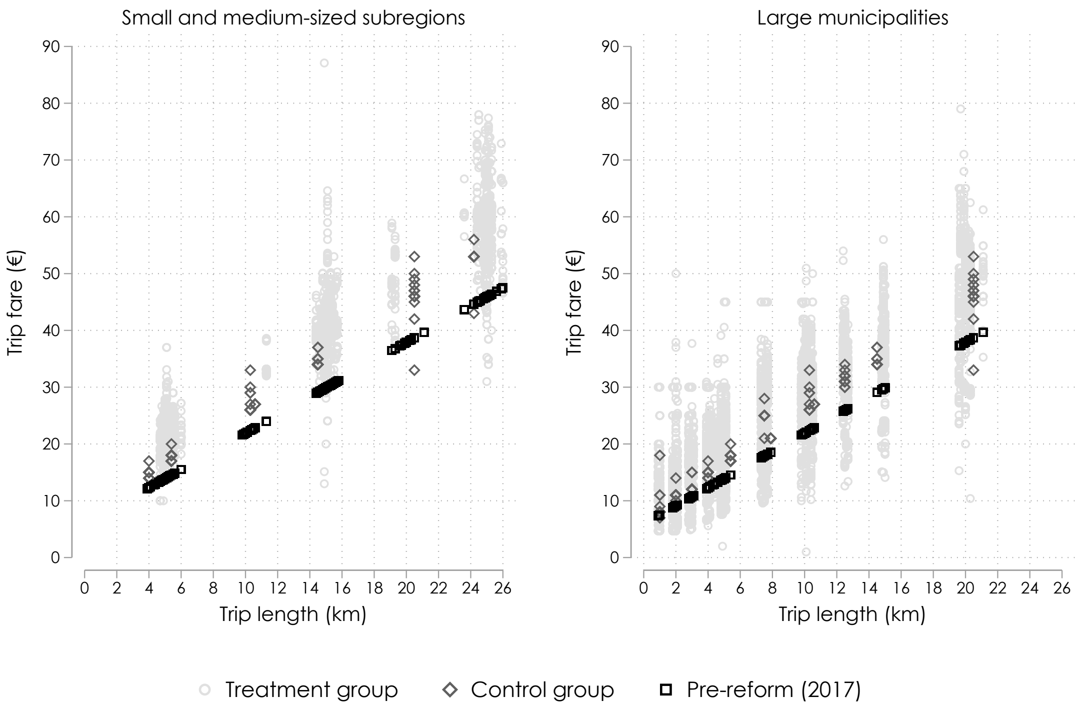

Figure B.6: Spread of offered fares for business hours

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.

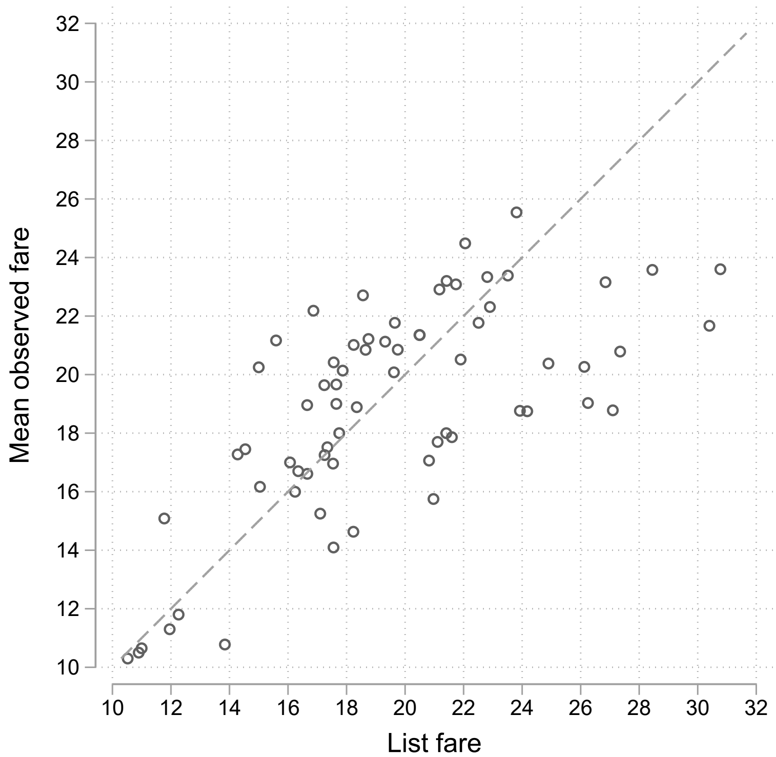

Figure B.7: Correlation between observed fares and fares calculated using list fares, 5km trips
Notes: Each observation is a pair of an average observed 5km fare and list fare for each dispatch centre in our data.

C Proofs

Proof of Proposition 1. Set

$$D(p,T) = \frac{ar(p)}{1+T} = \frac{N-1/T}{1+T} = S(p,T). \tag{11}$$

By solving (11) for T, we obtain (8). Then, substitute (8) in $D(p,T)$ and denote this by $Q(p,N)$ to obtain (7).

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. □

Proof of Proposition 2. Substitute $an = N$ in (7) and (8) to obtain

$$Q(a,p,n) = \frac{a^2 r(p)(n-r(p))}{a(n-r(p))+1}, \tag{12}$$

$$q(a,p,n) = \frac{Q(p,n)}{an} = \frac{ar(p)(n-r(p))}{(a(n-r(p))+1)n}, \tag{13}$$

and

$$T(a,p,n) = \frac{1}{a(n-r(p))}. \tag{14}$$

Differentiating (12),(13) and (14) with respect to a yields

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

and

$$\frac{\partial T}{\partial a} = -\frac{1}{a^2(n-r(p))} < 0.$$

Finally, substitute (12) and (14) in (6) to obtain

$$\pi(p,n) = \frac{(1-\tau)par(p)(n-r(p))}{(a(n-r(p))+1)n} - \frac{cr(p)}{n} - F. \tag{15}$$

Differentiating (15) with respect to a yields

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

$\square$

The following lemma will be used in the proofs of Propositions 3 and 4.

Lemma 1. $\partial \mathscr{F}(p,n)/\partial p = 0$ *implies that*

$$r' = \frac{ar(p)(n-r(p))(a(n-r(p))+1)}{p(na+1)-(p-c)(a(n-r(p))+1)^2} < -\frac{r(p)}{p}.$$

Proof. First, note that

$$\frac{\partial \mathscr{F}(p,n)}{\partial p} = (ar(p)(n-r(p))(a(n-r(p))+1) - r'(p(na+1)-(p-c)(a(n-r(p))+1)^2))$$

$$\times \frac{a}{(a(n-r(p))+1)^2} = 0 \leftrightarrow r' = \frac{ar(p)(n-r(p))(a(n-r(p))+1)}{p(na+1)-(p-c)(a(n-r(p))+1)^2} < -\frac{r(p)}{p}$$

and

$$\frac{\partial \mathscr{F}(p,n)}{\partial p} + car' < 0 \leftrightarrow$$

$$p\left(a(n-r(p))^2 + n - 2r(p)\right)r' + r(p)\left(n-r(p)\right)\left(a(n-r(p)+1\right) < 0. \tag{16}$$

Since in (16)

$$\left(a(n-r(p))^2 + n - 2r(p)\right) < \left(n-r(p)\right)\left(a(n-r(p)+1\right) \leftrightarrow r(p) > 0,$$

it is necessary that $r' < -r(p)/p$. $\square$

Proof of Proposition 3. Let $\mathscr{F}_i$ and $\mathscr{F}_{ij}$ denote first- and second-order partial derivatives of (9) with respect to variables i and j, where $i, j \in \{p,n,a\}$.

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

$$\mathscr{F}_p = \frac{\left(p\left(a(n-r(p))^2+n-2r(p)\right)r'+r(p)\left(n-r(p)\right)\left(a(n-r(p))+1\right)\right)a^2}{\left(a(n-r(p))+1\right)^2} - car' = 0$$

and

$$\mathscr{F}_n = \frac{p\,a^2 r(p)}{\left(a(n-r(p))+1\right)^2} - aF = 0,$$

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

By Cramer's rule,

$$\frac{\partial p^*}{\partial a} = \frac{\begin{vmatrix} -\mathscr{F}_{pa} & \mathscr{F}_{pn} \\ -\mathscr{F}_{na} & \mathscr{F}_{nn} \end{vmatrix}}{D} \tag{17}$$

and

$$\frac{\partial n^*}{\partial a} = \frac{\begin{vmatrix} \mathscr{F}_{pp} & -\mathscr{F}_{pa} \\ \mathscr{F}_{pn} & -\mathscr{F}_{na} \end{vmatrix}}{D}, \tag{18}$$

where

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

by Assumption (3). Thus, (17) and (18) have the same sign as their numerators.

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

$$\mathscr{F}_{pa} = \frac{\left(p\left(n^2a+n-(na+2)\,r(p)\right)r'+r(p)\left(n-r(p)\right)\left(a(n-r(p))+1\right)\right)a}{\left(a(n-r(p))+1\right)^3}. \tag{19}$$

Since

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

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

and

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

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

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

$$\mathscr{F}_{na} = -\frac{(a(n-r(p))-1)\,r(p)\,pa}{(a(n-r(p))+1)^3}. \tag{20}$$

Using (19) and (20), the numerator of (17) simplifies to

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

where the negative sign is implied by Lemma 1 as $r'p + r(p) < 0$.

For the next part of the proof, note that

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

since $r'p + r(p) < 0$ and $a(n+r(p))+1 > a(n-r(p))+1$, and that $\mathscr{F}_{pp} < 0$ by Assumption 3. Thus, the numerator of (18),

$$-\mathscr{F}_{na}\mathscr{F}_{pp} + \mathscr{F}_{pa}\mathscr{F}_{pn}, \tag{21}$$

is positive if

$$\mathscr{F}_{na} \geq 0 \leftrightarrow a \leq \frac{1}{n-r(p)}.$$

Hence, it is necessary (but not sufficient) for $\partial n^*/\partial a < 0$ that $a > 1/(n-r(p))$, so suppose this is the case.

Note that

$$\mathscr{F}_{pp} = \frac{2\left((a(n-r(p))+1)\left(a(n-r(p))^2 + n - 2r(p)\right) - (na+1)\,pr'\right) r'a^2}{(a(n-r(p))+1)^3} + Z,$$

where

$$Z \equiv -\frac{ar''}{(a(n-r(p))+1)^2}(p(na+1) - (p-c)(a(n-r(p))+1)^2).$$

Since

$$p(na+1)-(p-c)(a(n-r(p))+1)^2<0$$

by Lemma 1,

$$Z \leq 0 \leftrightarrow r'' \leq 0.$$

Given the assumptions that $\mathscr{F}_{na}<0$ and $r'' \leq 0$, (21) is less than or equal to

$$-\mathscr{F}_{na}(\mathscr{F}_{pp}-Z)+\mathscr{F}_{pa}\mathscr{F}_{pn}. \tag{22}$$

Using (19) and (20), (22) simplifies to

$$\frac{a^3\left(n\,p^2\,(r')^2+pr(p)\left(2a\,(n-r(p))^2+r(p)\right)r'+(r\,(p))^2\,(n-r\,(p))\right)}{(a(n-r(p))+1)^4},$$

which has the same sign as

$$n\,p^2\,(r')^2+pr(p)\left(2a\,(n-r(p))^2+r(p)\right)r'+(r\,(p))^2\,(n-r\,(p)) \tag{23}$$

in its numerator.

Now, consider (23) as a quadratic function of r', which is negative between its two roots

$$r'_{1,2}=\frac{r(p)}{2np}\left(-2a\,(n-r(p))^2-r(p)\pm\sqrt{A}\right)<0, \tag{24}$$

where

$$A=4\left(a\,(n-r(p))^2+\frac{r(p)}{2}\right)^2-4n\,(n-r(p))$$

and

$$A>0 \leftrightarrow a>\frac{2\sqrt{n(n-r(p))}-r(p)}{2\,(n-r(p))^2}.$$

Using Lemma 1, note that

$$\frac{\partial r'}{\partial a} = \frac{Br(p)(n-r(p))}{C^2} > 0,$$

where

$$B = r(p)\,a^2 p\,(n-r(p)) + (a(n-r(p))+1)^2 c > 0$$

and

$$C = p(na+1) - (p-c)(a(n-r(p))+1)^2.$$

As such, there are hypothetically two a's that coincide with the roots (24). However, the larger root is unattainable and beyond the parameter range determined by Lemma 1:

$$r_1' = \frac{r(p)}{2np}\left(-2a\,(n-r(p))^2 - r(p) + \sqrt{A}\right) > -\frac{r(p)}{p}$$

$$\leftrightarrow -2a\,(n-r(p))^2 + 2n - r(p) + \sqrt{A} > 0 \leftrightarrow A - \left(-2a\,(n-r(p))^2 + 2n - r(p)\right)^2 > 0$$

$$\leftrightarrow 8n\,(n-r(p))\,(a(n-r(p))-1) > 0 \leftrightarrow a > \frac{1}{n-r(p)}.$$

Thus, there is some $\hat{a}$ that coincides with the smaller root,

$$r_2' = \frac{r(p)}{2np}\left(-2a\,(n-r(p))^2 - r(p) - \sqrt{A}\right),$$

in (24) and (23) is negative for all $a > \hat{a}$.

□

Proof of Proposition 4. The Lagrangian of (10) is

$$L = na + \lambda \mathscr{F}(p,n). \tag{25}$$

By Assumption (3), the only critical point of $\mathscr{F}(p,n)$ is far away from the boundary of the constraint set. Hence, the constraint qualification will be satisfied at any candidate for a solution.

Since $\mathscr{F}(p,n)$ is strictly concave by Assumption (3), (25) (as a sum of concave and strictly concave functions) is also strictly concave and the first-order conditions,

$$L_n = a + \lambda \mathscr{F}_n = 0, \tag{26}$$

$$L_p = \lambda \mathscr{F}_p = 0, \tag{27}$$

$$L_\lambda = \mathscr{F}(p,n) = 0, \tag{28}$$

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

By combining (26), (27) and (28), we have two equations that define p^{**} and n^{**}:

$$\mathscr{F}_p = 0, \tag{29}$$

$$\mathscr{F}(p,n) = 0. \tag{30}$$

By Cramer's rule,

$$\frac{\partial p^{**}}{\partial a} = \frac{\begin{vmatrix} -\mathscr{F}_{pa} & \mathscr{F}_{pn} \\ -\mathscr{F}_a & \mathscr{F}_n \end{vmatrix}}{E} \tag{31}$$

and

$$\frac{\partial n^{**}}{\partial a} = \frac{\begin{vmatrix} \mathscr{F}_{pp} & -\mathscr{F}_{pa} \\ \mathscr{F}_p & -\mathscr{F}_a \end{vmatrix}}{E}, \tag{32}$$

where

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

by strict concavity of $\mathscr{F}(p,n)$, (29), and $\mathscr{F}_n < 0$. Thus, (31) and (32) have the same sign as their numerators.

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

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

Since

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

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

and

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

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

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

$$\mathscr{F}_a = \frac{par(p)\,(n-r(p))}{(a(n-r(p))+1)^2} > 0.$$

Note that

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

since

$$a(n+r(p))+1 > a(n-r(p))+1$$

and, by Lemma 1, $pr'+r(p) < 0$.

Given that $\mathscr{F}_n < 0, \mathscr{F}_{pa} < 0, \mathscr{F}_a > 0$ and $\mathscr{F}_{pn} < 0$, the numerator of (31) is negative:

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

Finally, since $\mathscr{F}_p = 0, \mathscr{F}_a > 0$ and $\mathscr{F}_{pp} < 0$, the numerator of (32) is positive:

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

□

D Availability of taxis

We collect data on the availability and time-to-arrival (TTA) of taxis. Unlike the fares, we do not have data on TTA from the pretreatment period. However, there is evidence that there was a serious shortage of taxis during high-demand hours, especially in large cities.[15] Therefore, our main objective is to examine the 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 D.1 is the time to arrival. We find that ordering a taxi in a city or urban centre is correlated with 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 the 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. The distance from the taxi rank is only available for large regions.

When looking at large regions, 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, the fare appears to correlate significantly with TTA only in medium-sized regions, where a higher fare means a lower TTA. The fact that this is not the case in large regions is surprising, but could be due in part to app-only dispatch centres that capture this effect, as their services are significantly cheaper, as shown in Table 4.

Finally, peak demand hours are correlated with approximately 30 seconds faster average time to arrival when focusing on large regions. We further study how the time of day correlates with TTA by looking at the estimated marginal means of time-to-arrival. We find that, if anything, there seems to be a slightly shorter average time to arrival during peak hours (that is, around the time restaurants close), indicating that supply responds to demand peaks. Furthermore, the number of available cars does not differ between different times of the day.

[15] 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 D.1: 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 centres 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 centre. Distance from rank to pickup is only available for large regions which have public information on the locations of taxi ranks. Standard errors are clustered at regional level and are presented in parentheses.