Essays on competition and consumer choice

Habte, Osmis Areda

2018

Document Version:
Publisher's PDF, also known as Version of record

Link to publication

Citation for published version (APA):
Habte, O. A. (2018). *Essays on competition and consumer choice*. Lund University.

Total number of authors:
1

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Essays on competition and consumer choice

Osmis Areda Habte

LUND UNIVERSITY

DOCTORAL DISSERTATION

by due permission of the School of Economics and Management,

Lund University, Sweden.

To be defended at Holger Crafoord EC3:211, Lund

on September 27, 2018 at 14:15.

Faculty opponent

Mats Bergman, Södertörns University

Organization
Lund University
Department of Economics
P.O. Box 7082
S-220 07 Lund, Sweden

Document name
Doctoral dissertation

Date of issue
2018-09-27

Author
Osmis Areda Habte

Sponsoring organization

Title and subtitle
Essays on competition and consumer choice

Abstract

This thesis makes a contribution to the areas of deregulation, competition and consumer choice. It consists of three self-contained papers. All the research questions are examined in the context of the Swedish motor vehicle inspection market.

The first paper, *Competition Makes Inspectors More Lenient: Evidence from the Motor Vehicle Inspection Market*, investigates whether increased competition motivates monitoring firms to relax the standards of the inspection to their customers. We hypothesized that the fear of loosing customers to competitors may incentivize firms to provide a biased inspection services. We employed fixed effects and fixed effects 2SLS analyses to identify the relationship between competition and the probability of passing mandatory car inspection. The results show that firms become more lenient to their customers when they face increased competition from their rivals.

The second paper, *Opening Hours and Competition: Evidence from the Motor Vehicle Inspection Market*, examines the effect of competition on an inspection firm's incentive to provide longer opening hours. This paper uses a unique station-level panel dataset and addresses the potential endogeneity of market entry decisions using 2SLS analyses. I find that increased competition between providers leads to expanded service opening hours.

The third paper, *Deregulation, Choice and Competition in the Motor Vehicle Inspection Market*, estimates a model of demand for car inspection services to investigate car owners' station choice behavior and its implications for competition. The paper further evaluates the effect on consumer welfare of removing the state monopoly on inspection services. The results indicate that distance is an important determinant of station choice. I also find that consumers respond to price, opening hours and station size. The improvement in spatial accessibility following the deregulation increased the welfare to the average consumer by around SEK 100.

Keywords
leniency, pass rate, competition, deregulation, opening hours, non-price competition, entry, choice, consumer welfare, demand elasticity, motor vehicle inspection market

Classification system and/or index terms (if any)
JEL Classification: D12, D22, L11, L13, L84, L89

Supplementary bibliographical information

Language
English

ISSN and key title
0460-0029 Lund Economic Studies no. 211

ISBN
978-91-7753-767-0 (print)
978-91-7753-768-7 (pdf)

Recipient's notes

Number of pages
109

Price

Security classification

Distributed by Department of Economics, P.O. Box 7082, S-220 07 Lund, Sweden

Signature ______________ Date 2018-08-22

Essays on competition and consumer choice

Osmis Areda Habte

LUND UNIVERSITY

LUND ECONOMIC STUDIES NUMBER 211

Distributed by the Department of Economics
Lund University
P.O. Box 7082
S-220 07 Lund
SWEDEN

ISBN 978-91-7753-767-0 (print)
ISBN 978-91-7753-768-7 (pdf)
ISSN 0460-0029

Printed in Sweden by Media-Tryck, Lund University
Lund 2018

Contents

Paper III: Deregulation, Choice and Competition in the Motor Vehicle Inspection Market 79

Abstract

This thesis makes a contribution to the areas of deregulation, competition and consumer choice. It consists of three self-contained papers. All the research questions are examined in the context of the Swedish motor vehicle inspection market.

The first paper, *Competition Makes Inspectors More Lenient: Evidence from the Motor Vehicle Inspection Market*, investigates whether increased competition motivates monitoring firms to relax the standards of the inspection to their customers. We hypothesized that the fear of loosing customers to competitors may incentivize firms to provide a biased inspection services. We employed fixed effects and fixed effects 2SLS analyses to identify the relationship between competition and the probability of passing mandatory car inspection. The results show that firms become more lenient to their customers when they face increased competition from their rivals.

The second paper, *Opening Hours and Competition: Evidence from the Motor Vehicle Inspection Market*, examines the effect of competition on an inspection firm's incentive to provide longer opening hours. This paper uses a unique station-level panel dataset and addresses the potential endogeneity of market entry decisions using 2SLS analyses. I find that increased competition between providers leads to expanded service opening hours.

The third paper, *Deregulation, Choice and Competition in the Motor Vehicle Inspection Market*, estimates a model of demand for car inspection services to investigate car owners' station choice behavior and its implications for competition. The paper further evaluates the effect on consumer welfare of removing the state monopoly on inspection services. The results indicate that distance is an important determinant of station choice. I also find that consumers respond to price, opening hours and station size. The improvement in spatial accessibility following the deregulation increased the welfare to the average consumer by around SEK 100.

Keywords: leniency, pass rate, competition, deregulation, opening hours, non-price competition, choice, consumer welfare, demand elasticity, motor vehicle inspection market
JEL Classification: D22, L11, L13, L84, L89

Acknowledgements

I received the news of being admitted to the PhD program with a great sense of pride and happiness. Soon after the exciting news, I asked myself this question: Do I have what the life of doing a PhD demands? It was with this unanswered question and curiosity that I started the PhD program, which has been challenging and at times frustrating but obviously a rewarding experience. Without the help of many people, my thesis would not have been completed. Now, I would like to take this opportunity to say a wholehearted thank you to those who helped me throughout this journey.

First, I would like to say a heartfelt thank you to my supervisor, Håkan J. Holm. I could not imagine finishing this thesis without his patient and thoughtful mentoring and support. During my first year, I went to his office and asked him to be my supervisor. He replied to me "I am happy to help you". Indeed, Jerker helped me massively. His guidance and excellent feedback were critical for the completion of this thesis. He patiently listened to my small and vague ideas, always replied to my countless emails promptly, and entertained my request for meetings with generosity. He also put a tremendous effort into securing the rich data that is used for all of the essays in my thesis. It was with the help of Jerker that I spent one month at Boston College. More importantly, I enjoyed the simple and conducive working environment that he created between the two of us. Co-authoring a paper with him was a great opportunity for me to learn not only academic contents but also other valuable lessons. Thank you Jerker for being a very kind and considerate person, and for always caring about my well-being. It has been a privilege to be your PhD student!

I am also profoundly thankful to my assistant supervisor, Florin Maican. My working relationship with Florin started when I was a Masters student at Gothenburg University, when he was my advisor. He helped and encouraged me to apply for the PhD program, for which I am deeply grateful. The content and quality of this thesis has been improved substantially because of Florin's instrumental and invaluable comments. Thank you Florin, for believing in me and staying with me to this day.

I would also like to thank the best fellow PhD students in my cohort and across cohorts. I started the first year sharing office with Hjördis Hardardottir and Sara Moricz. Thank you for making the first year a smooth and exciting time. Mehmet Caglar Kaya, Jörgen Kratz and Jim Ingebretsen Carlson, it was a pleasure to start the PhD program with all you and thank you for being helpful and wonderful colleagues. I shared an office with Alemu Chala for almost three interesting years and had a good time talking to him about the challenges of doing a research, life and different issues. Thank you Alemu for the good times. Many PhD students have made my stay at the department an enjoyable and memorable one. I would like to thank all the present and past PhD students for creating a caring, friendly and exciting environment. I enjoyed participating in table tennis tournaments, karaoke night, PhD Christmas dinners and secret Santa games. I will cherish all of the good memories.

The comments and suggestions from Joacim Tåg at the final seminar have improved this thesis in so many ways and I thank Joacim greatly for that. My thesis also benefited from the comments I received from the participants of the microeconomics seminar at the Department of Economics at Lund University, and from many workshops and conferences. I would like to thank the Swedish Competition Authority for the generous financial support that has helped me to present my work at different international conferences. Let me take this opportunity to thank my discussant, Mats Bergman and the members of my thesis examining committee—Jan-Eric Nilsson, Anders Wretstrand and Erik Wengström—for taking their time to read my papers and for being willing to participate at my public defense.

The administrative staff at the department deserve my appreciation. I thank Jenny Lindström Wate, Mariana Anton, Nathalie Stenbeck, Rikke Barthélemy, Azra Padjan, Anna Marciniak and Marie Pihl for handling my cases professionally and in a friendly way. I would like to thank Tommy Andersson and Jerker Holm for their effort, as the coordinators of the PhD program, to continuously improve the PhD students' situation at the department. I should give credit to Pontus Hansson for encouraging me to become involved in teaching when I was hesitant, being more inclined to my research.

My interest in Industrial Organization questions was sparked by the courses that I took from Johan Stennek while I was a Masters student at Gothenburg University. Thank you Johan, for believing in me and writing a recommendation letter that landed me an admission to the PhD program at Lund University. I was introduced to the Swedish motor vehicle inspection market when I took a course given by Richard Friberg at the Stockholm School Economics. I want to thank Richard for the excellent course.

During my PhD studies, I was fortunate to spend one month at the Department of Economics, Boston College. I am grateful to Julie Holland Mortimer for hosting me, allowing me to attend her classes, and making my stay a comfortable one.

My thesis would not have been the same without the help from the Swedish Transport Agency (STA) in delivering the data. Peter Holmlund at STA was the key person in facilitating the collection of a large amount of high quality data. Without his continuous help, I would not have imagined that the collection of the data with its present quality would be possible. More importantly, Peter and I had more than 15 Skype meetings during the last four years to discuss the data and, mostly, the nature of the Swedish car inspection market. I am deeply grateful to you Peter!

I owe special thanks to my friend, Esayas, who welcomed me when I first arrived in Lund from Stockholm. He provided me with temporary accommodation, introduced me to the city, helped me to buy a cycle, one of the key things while living in Lund, and assisted me in preparing my student room. Thank you my friend!

Last but not least, I would like to express my gratitude to my family for their continuous love and never-ending support. Almost every weekend, I make a long distance call to talk to my mother in Ethiopia to get her blessings and encouraging words. Thank you mom for always including me in your prayers and for being my source of strength during the last five years! I am also thankful to my brothers and sisters, and all family members for believing in me, continuously providing me with moral support and repeatedly reminding me that what I am doing is an important step in my life. I love you all!

Lund, August 2018

Osmis

INTRODUCTION

Introduction

This thesis is a collection of three empirical papers that contribute to the areas of deregulation, competition, and consumer behavior. All of the papers focus on a single market, the Swedish motor vehicle inspection market. I will describe the background of the research questions in Section 0.1. Section 0.2 provides a brief overview of the Swedish motor vehicle inspection market. The last section concludes with a summary of the papers in the thesis.

0.1 Background

Competition has long believed to be an important tool for promoting consumer well-being through lower prices and better quality. In his popular book, Adam Smith stated “monopoly .... is a great enemy to good management” (*Wealth of Nations*, Chapter XI Part 1, p.148). A common result of a standard oligopoly model is that competition in terms of number competitors enhances consumer surplus. The relationship between market structure and market outcomes has a long history in industrial organization. A number of empirical studies have examined how local market concentration affects prices (e.g., Bresnahan and Reiss, 1991; Davis, 2005; Hosken et al., 2011; Dafny et al., 2012). These studies on the relationship between market concentration and prices are useful for two related reasons: first, the findings provide empirical evidence for the predictions of economic theories that high market concentration harms consumers: and second, antitrust agencies can directly use them in assessing horizontal mergers.

Although competition analysis and empirical studies primary focus on price effects, theory has long recognized the importance of product and service quality in welfare analysis (Chamberlin, 1933; Abbott, 1955). A firm with market power has the ability to cut back on other product characteristics that may adversely affect consumers. In contrast, a decrease in the number of competitors following a merger can still be beneficial to consumers if the benefit from the improvement in product quality outweighs the loss from higher prices (Draganska et al., 2009). It is, however, less common that antitrust authorities rigorously examine product quality dimensions: perhaps, because quality is not easier to define and measure empirically and lack of empirical evidence on how competition affects quality (Matsa, 2011). Despite its importance, there are few empirical studies on the relation between competition and quality. Among the few studies are papers by Mazzeo (2003) on airline service quality, Olivares and Cachon (2009) on inventory, Matsa (2011) on product availability, and Bloom et al. (2015) on hospital quality. Paper two of this thesis contributes to the literature on non-price competition.

In light of the positive outcomes from competition, more and more countries around the world are introducing competition into public service markets. Enhancing choice for users of public services is a popular reform model to introduce market mechanism into public service markets, including health care, education, employment services and social care (Besley and Ghatak, 2003; Hoxby, 2003; and Musset, 2012). Advocates of the user choice reform model argue that the introduction of market mechanism in delivering public services will produce a better match of users and providers, and incentives suppliers to provide higher quality service. The belief is that more choice allows consumers to easily switch between providers, which in turn puts pressure on suppliers to meet the users' needs.

The success of choice and competition in delivering public services depends on a number of factors that affect the suppliers' incentive to provide a better option. To start with, consumers have to be aware that they have the right to choose a provider. A consumer who has never had the right to choose a supplier may not actively exercise the option to choose a better alternative. Lack of access to information about the quality of products and services can also diminish consumer benefits of increased choice. Hortacsu et al. (2017) show that in the residential electricity market information intervention to inform consumers about the availability of options will benefit consumers. Chou et al. (2014) provide evidence that publicly available information on the quality of health care gives competitors an incentive to improve care, and this incentive becomes stronger when competition intensifies. The third paper of this thesis contributes to the literature on consumer choice.

Is competition always harmless to society? The administrations of many governments have started using competing private firms for the provision of services that have traditionally been delivered by government agencies. Private monitors are being used to ensure regulated entities' compliance with law and regulations in a wide range of areas, including food safety, pollution and traffic safety control, product safety, medical devices, and financial accounting (Short and Toffel, 2015).

Although delivering monitoring services via competing private firms can often be effective, such institutional arrangement needs to be designed carefully. The challenge with using private firms in delivering monitoring services is that increased competition between providers may motivate private monitors to relax the standards of the monitoring. Given that the monitoring firms are directly paid by the consumers who are subject to monitoring, consumers can pressure the monitoring firms to do the inspection to their own interests, but against the interests of the society. A good example is the credit rating industry, where credit rating agencies rate the quality of the financial products of the issuers. In this industry, the issuer chooses among competing rating firms and directly pays rating agencies for their services. The issuer-pays model can give the issuers the ability to obtain desired ratings for their financial products by threatening to switch to a competitor.

A number of theoretical and empirical studies provide evidence on the relation between competition among monitoring firms and compliance to regulations. In a theoretical work, Bolton et al. (2012) show that increased competition among rating agencies facilitates a bias towards inflated ratings, leading to a race to the bottom in rating qualities. Branco and Villas-Boas (2015) show that more competition decreases a firm's adherence to the rules and regulations of the market. The authors argument is that firms become less careful in following the rules because with more competition firms have less to lose from being caught. Empirical evidence by Bennett et al. (2013) shows that the probability of passing vehicle emission test increases with local competition. The first paper of this thesis contributes to this area in the context of the motor vehicle inspection market.

0.2 Overview of the Swedish motor vehicle inspection market

To reduce air pollution and traffic injuries, many countries have adopted regulations to carry out compulsory safety and emission inspections on motor vehicles. These regulations created a multi-billion dollar industry involving hundreds of millions of car owners around the world. In Sweden, car owners must conduct road worthiness tests on their cars periodically, mostly annually.[1] Before the market was deregulated in July 2010, it was a state-owned monopoly that provided inspection services. Presently, both the state-owned firm and other private firms provide inspection services competing for customers. Car owners have the right to choose a station for inspection services. A car has to pass the inspection to legally operate in the road. A failed car has to undergo a retest after rectifying the underlying causes of the problem that led to the failed result. To avoid financial incentives for biased monitoring, inspection stations are only allowed to perform inspections. For example, they do not sell gasoline, parts, nor do they provide repair services. The prices are not regulated, which means firms can compete in price, among other things. The regulator of the market, the Swedish Transport Agency, closely monitors the inspection firms. The supervision includes both personal visits to the testing centers and statistical analysis of data and consumer surveys.

1 Contribution of this Thesis

The papers included in this thesis use a detailed individual and station-level data to understand competition and consumer behavior the context of motor vehicle inspection market. The first paper investigates if increased competition creates a distortive incentive to the inspection firms to relax the standards of the inspection to their customers. The second paper examines the connection between local competition and a firm's choice of opening hours. The third paper investigates consumer choice behavior and its implications for demand and competition. I will also quantify the consumer benefit of liberalizing the car inspection market.

[1] An owner of a non-commercial new car must undergo the first inspection when the car reaches three years old. The second inspection when the car becomes five years old. Afterwards, the car must be inspected annually.

1.1 Competition Makes Inspectors More Lenient: Evidence from the Motor Vehicle Inspection Market

How should competing monitoring firms behave when the entities that are supposed to be monitored are their sources of revenue? It is well-documented that competition produces socially beneficial outcomes. In some markets, however, increased competition can motivate firms to deviate from regulations to retain and attract business. A good example of this is the recent financial crises where rating agencies gave attractive ratings to the financial products of their customers. It is widely believed that before the financial crisis, the rating agencies were too lenient to their customers for fear of losing them to a competitor.

In the first paper, I will examine the same topic in the context of the Swedish motor vehicle inspection market. A car owner has the right to choose an inspection station when conducting mandatory road worthiness tests. This gives car owners the opportunity to influence the results of the inspection by threatening to switch to a competitor. In particular, in markets where inspection firms face intense competition, they can use less stringent inspection as a strategy to increase their market share. This paper uses a detailed station-level panel data for all inspection stations in Sweden to examine if stations become lenient to their customers when they operate in highly competitive markets. The key challenge in estimating the effect of competition is that the measures of local competition may not be exogenous. Variations in measures of local competition across markets can be explained by unobservable factors in the model. I will use Differences-in-Differences and instrumental variables methods to address the endogeneity concern. My results indicate that the probability of passing a mandatory inspection increases with local competition. However, the results do not stand against the virtues of competition. Nevertheless, the results call for a closer regulatory control of inspection stations, especially those stations that operate in markets where competition is intense.

1.2 Opening Hours and Competition: Evidence from the Motor Vehicle Inspection Market

The second paper examines the relationship between competition and a firm's choice of opening hours. Although price is a central focus of empirical studies and antitrust authorities, the non-price dimensions of a product also have an important effect on demand and consumer welfare. A number of theoretical papers indicated that firms in retail industries can use service opening hours to influence the consumers' where to buy decisions (De-Meza, 1984; Ferris, 1990, 1991; Inderst and Irmen, 2005; Shy and Stenbacka, 2006, 2008). Empirical evidence on the connection between competition and opening hours is, however, sparse. This paper aims to fill this gap by examining the topic in the context of the motor vehicle inspection market. Suppose that consumers have idiosyncratic preferences over an ideal time to acquire inspection services, in which case a firm can use longer opening hours to increase the probability that a consumer finds his or her preferred time. Although longer opening hours attract customers, firms also incur extra cost for maintaining expanded business hours. Thus, a station manager's choice has to weigh the cost of providing longer opening hours against the probability of losing customers to a competitor in case of providing shorter opening hours. Since consumers can easily switch to a competitor when there are a large number of providers in the market, it is highly likely that the incentive to provide longer opening hours increases with local competition.

This paper uses a unique and detailed station-level panel data from the regulator, the Swedish Transport Agency. Like the concentration-price studies, the relationship between competition and opening hours is also hampered by the endogeneity of the measures of competition with respect to opening hours. Therefore, I employ the instrumental variables method to account for the endogeneity. The results indicate that local competition positively affects opening hours. The probability of providing services on weekends also increases with competition.

1.3 Deregulation, Choice and Competition in the Motor Vehicle Inspection Market

The removal of the monopoly on car inspection services has brought more choice to consumers in the Swedish motor vehicle inspection market. The deregulation intends to enhance consumer benefit through lower prices, increased spatial accessibility, longer opening hours, and better quality service. The success of the reform in benefiting the consumers, however, requires demand to become more responsive with the number of providers. It is, therefore, important to investigate consumer choice behavior to understand the nature of demand and competition in the market.

The third paper estimates a demand model for car inspection services to examine consumer preferences for station characteristics and their implications for demand and competition. This paper also quantifies the impact on consumer welfare of deregulating the market, which is specifically attributable to geographical accessibility to inspection stations. Using detailed individual-level data on the station choices of more than 920 thousand car owners, I estimate conditional and mixed logit demand models.

The results indicate that consumers put high value on proximity. I also find that consumers respond to price, opening hours and size of the station. Price and opening hours elasticities of demand varies between stations, where the elasticity a station faces increases with local competition. Lastly, removing the monopoly and the eventual improvement in spatial accessibility to inspection services have substantially increased consumer welfare.

References

Abbott, L. (1955). *Quality and Competition; an Essay in Economic Theory*. Columbia University Press, New York.

Bennett, V., Pierce, L., Snyder, J., and Toffel, M. (2013). Customer-driven misconduct: how competition corrupts business practices. *Management Science*, 59(8):1725–1742.

Besley, T. and Ghatak, M. (2003). Incentives, choice, and accountability in the provision of public services. *Oxford Review of Economic Policy*, 19(2):235–249.

Bloom, N., Propper, C., Seiler, S., and Van Reenen, J. (2015). The impact of competition on management quality: Evidence from public hospitals. *Quarterly Journal of Economics*, 82(2):457–489.

Bolton, P., Freixas, X., and Shapiro, J. (2012). The credit ratings game. *Journal of Finance*, 67(1):85–112.

Branco, F. and Villas-Boas, J. M. (2015). Competitive vices. *Journal of Marketing Research*, 52(6):801–816.

Bresnahan, T. F. and Reiss, P. C. (1991). Entry and competition in concentrated markets. *Journal of Political Economy*, 99(5):997–1009.

Chamberlin, E. H. (1933). *TheTheoryofMonopolisticCompetitio*. HarvardUniversityPress, Cambridge, MA.

Chou, S., Deily, M. E., Li, S., and Lu, Y. (2014). Competition and the impact of online hospital report cards. *Journal of Health Economics*, 34:42–58.

Dafny, L., Duggan, M., and Ramanarayanan, S. (2012). Paying a premium on your premium? consolidation in the us health insurance industry. *American Economic Review*, 102(2):1161–85.

Davis, P. (2005). The effect of local competition on admission prices in the u.s. motion picture exhibition market. *The Journal of Law and Economics*, 48(2):677–707.

De-Meza, D. (1984). The fourth commandment: is it pareto efficient? *Economic Journal*, 94(374):379–383.

Draganska, M., Mazzeo, M., and Seim, K. (2009). Beyond plain vanilla: Modeling joint product assortment and pricing decisions. *Quantitative Marketing and Economics*, 7(2):105–146.

Ferris, J. S. (1990). Time, space, and shopping: the regulation of shopping hours. *Journal of Law, Economics, and Organization*, 6(6):55–72.

Ferris, J. S. (1991). On the economics of regulated early closing hours: some evidence from canada. *Applied Economics*, 23(8):1393–1400.

Hortacsu, A., Madanizadeh, A. S., and Puller, L. S. (2017). Power to choose? an analysis of consumer inertia in the residential electricity market. *American Economic Journal: Economic Policy*, 9(4):192–226.

Hosken, D., Silvia, L., and Taylor, C. (2011). Does concentration matter? measurement of petroleum merger price effects. *American Economic Review*, 101(3):45–50.

Hoxby, C. M. (2003). *School Choice and School Productivity: Could School Choice Be a Tide That Lifts All Boats?* University of Chicago Press, Chicago.

Inderst, R. and Irmen, A. (2005). Shopping hours and price competition. *European Economic Review*, 49(5):1105–1124.

Matsa, D. (2011). Competition and product quality in the supermarket industry. *Quarterly Journal of Economics*, 126(3):1539–1591.

Mazzeo, M. J. (2003). Competition and service quality in the u.s. airline industry. *Review of Industrial Organization*, 22(4):275–296.

Musset, P. (2012). School choice and equity: current policies in oecd countries and a literature review. *OECD Education Working Papers 66*.

Olivares, M. and Cachon, G. P. (2009). Competing retailers and inventory: An empirical investigation of general motors' dealerships in isolated u.s. markets. *Management Science*, 55(9):1586–1604.

Short, J. L. and Toffel, M. W. (2015). The integrity of private third–party compliance monitoring. *Harvard Kennedy School*. Working Paper, RPP–2015–20.

Shy, O. and Stenbacka, R. (2006). Service hours with asymmetric distributions of ideal service time. *International Journal of Industrial Organization*, 24(4):763–771.

Shy, O. and Stenbacka, R. (2008). Price competition, business hours and shopping time flexibility. *Economic Journal*, 118(531):1171–1195.

PAPER I

Competition Makes Inspectors More Lenient: Evidence from the Motor Vehicle Inspection Market

with Håkan J. Holm

Abstract

We examine the impact of competition on a firm's incentive to relax the standards of its inspection to its customers in the Swedish motor vehicle inspection market, which is heavily regulated and consciously designed to mitigate incentives to deviate from the regulations. We use a panel dataset representing 22.5 million car roadworthiness tests during the period 2010–2015. Fixed effects and instrumental variable estimations, which are used to account for the endogeneity of competition, show that inspection stations that operate in highly competitive markets are more lenient to their customers than stations that operate in less competitive markets.

Keywords: leniency, pass rate, competition, deregulation, motor vehicle inspection market
JEL Classification: D22, L11, L84

We thank Florin Maican, David Edgerton, Joacim Tåg, and conference participants at the Annual Congress of the European Economic Association 2017, European Association for Research in Industrial Economics 2017, Eurasia Business and Economics Society 2017, the Swedish Workshop on Competition & Public Procurement Research 2016 and Microeconomics Seminar at Lund University for their valuable comments. We would also like to thank the Swedish Transport Agency for providing us with the data. Special thanks to Peter Holmlund (Swedish Transport Agency) for helping us obtain the data and for valuable discussions about the market. We gratefully acknowledge financial support from the Swedish Competition Authority.

1 Introduction

Individuals and firms often pay another party to be monitored in some way. For example, individuals pay accredited institutions to do tests to obtain driving licenses and firms buy accounting services to inspect their financial activity and so on. In many cases, these inspection agencies are owned and funded by the public sector and the inspection activities are carried out by civil servants. The obvious advantage of such an organization is that if the inspectors are not corrupt, then they have no obvious incentive but to do correct and unbiased inspections. In contrast, these organizations face no competition and may, therefore, become inefficient and insensitive to the customers' demand (Stiglitz, 1986). These drawbacks have motivated some governments to have competing private firms to do inspections in some markets. However, this is not unproblematic since it may give the monitor incentives to do inspections in a way that is biased and not socially desirable. It also often requires that such private agencies are regulated and also monitored. Scandals such as the Enron case and the loan ratings by the big credit rating firms (e.g., Standard and Poor and Moody's) in the sub-prime loan crisis suggest that private inspecting agencies may give their customers a too lenient treatment and that the regulation was insufficient.

Competition is one of the key ingredients to improve the quality and efficiency in markets in general. A standard result in oligopoly theory states that competition in terms of number of firms increases consumer surplus (see e.g., Tirole, 1988, Bresnahan and Reiss, 1991) and there is also evidence that competition in terms of demand substitutability has a positive effect on productivity (Syverson, 2004). In addition, it has been shown that competition increases quality (e.g., Mazzeo, 2003). At the same time there are mechanisms where increased competition may push the inspecting agency to deviate from what is socially desirable. One mechanism considered by Branco and Villas-Boas (2015) is that firms facing hard competition have less to lose when they deviate from regulations and will, therefore, have a higher probability to do so. Bolton et al. (2012) demonstrate in their model of the credit ratings game that competition allows for "ratings shopping", which results in ratings that are too high (i.e., the understating of risks).

A number of empirical studies support the view that competition may lead firms monitor their customers according to some regulation to become too lenient. For instance, Snyder (2010) provide evidence that liver transplant centers put relatively healthy patients in the intensive care unit to improve their own patients' position on the liver transplant waiting list and that this behavior was most prominent in areas where there were many transplant centers. Furthermore, Bennett et al. (2013) show that facilities facing higher local competition are more likely to let their customers pass emission tests compared to facilities facing less severe competition. Hubbard (2002) examines the California vehicle emission inspection market and provides evidence that failure rates are higher for vehicles inspected by state officials than vehicles inspected at private firms.

In this paper, we examine the impact of competition on firms' leniency to their customers in the Swedish car inspection market. We think that this market is particularly interesting to analyze for several reasons. First, it has intentionally been designed with concern about some of the distorting incentives that competition could create, as documented in earlier studied markets. One important explanation to why liver transplant centers favored their own patients was that they were able to perform more transplants (see Snyder, 2010), which then reasonably meant increased revenues. Similarly, the explanation for too lenient emission tests in Bennett et al. (2013) is that these facilities also provide other profitable services in addition to emission testing, such as repairs. Hence, the authorized facilities "trade the "high-quality" service of passing result (regardless of actual emissions) for the side payment of a valuable future stream of service and repair business worth thousands of dollars per year" (Bennett et al., 2013, P. 2). These authors also outlined that the good intention of regulating prices in the New York emission test market eliminates an important competition instrument for service providers.

In the Swedish car inspection market such obvious distorting incentives have been removed because car inspection firms are not permitted to perform any other business than to inspect cars and prices are not restricted by the regulator. Second, Sweden belongs to the set of countries with the strongest adherence to the rule of law.[1] Hence, it may be that in countries where laws and regulations

[1] Sweden was ranked 3rd of all countries in the world in the rule of Law index 2015 (see the Rule of Law Index report, 2015, by the World Justice Project).

are expected to be followed, the implementation of regulations can avoid side effects that are present in countries where the adherence to the rule of law is lower. This also means that if side-effects cannot be avoided in a county like Sweden, where the institutional structure surrounding the inspections are designed to remove distorting incentives, then it is difficult to see if these side-effects can be avoided at all. Finally, we have a relatively unique and high-quality panel dataset at station level, which allows us to carefully study the impact of competition on car inspection pass rate. The data represent all car inspections (22.5 million) conducted by all stations in Sweden during July 2010 to August 2015. Furthermore, the individual-level data containing around 460,000 car owners and the respective station each owner visited allow us to measure travel distances, reasonably approximate geographic markets and identify the number of competitors for each station. As an alternative to the previous approach, we also use administrative boundaries (municipalities) to identify geographic markets.

Most advanced economies have regulations about motor vehicle inspections. For instance, according to EU regulations, all member states are obliged to carry out periodic safety and emission inspections for most types of motor vehicles. These regulations provide the basis for a multi-billion dollar industry involving hundreds of millions of car-owners around the globe. However, there has been a debate, especially in the United States about whether these inspections can be motivated on safety grounds (Merrell et al., 1999). This debate has led many states to abolish safety inspections. The main reason for abolishing inspections is that the total social cost of inspections is higher than the gains in safety and emission reduction. One crucial condition to motivate such inspections is they are carried out efficiently and in a fair way. Despite the debate, the size of this market, and the substantial costs imposed on car owners in terms of money and time, there are only very few studies on this market. This paper partly fills this gap by analyzing a rich dataset from a recently deregulated car inspection market in Sweden where inspectors are regulated private firms.

To examine the connection between competition and car inspection pass rate, we start with a simple correlation analysis after controlling for a set of control variables. We find a positive association between local competition and pass rate. To address the possibility that this positive correlation is confounded by omitted factors, we employ two strategies. Our first strategy is to control for station-specific factors affecting both competition and pass rate. After controlling for station fixed effects, we find that competition has a positive and significant effect on the probability for a given car to pass mandatory inspection.

Our second strategy is to use instrumental variables regressions in the form of fixed effects two-stage least squares. We use population size at a municipality level as an instrument for our measure of competition; that is the number of competing stations in a geographic market. Because we control for station fixed effects, the potential correlation between our instruments and factors in the error term becomes less of a concern. Our results show that local competition has a positive and significant effect on the inspection pass rate. We find that one additional competitor (at the median) increases the probability for a given car to pass inspection between 0.43 and 0.86 percentage points. While our main interest is on the effect of competition, we also find a seasonal variation in pass rates where the average pass rate during the third quarter (July, August, and September) is much higher than the pass rate in any of the other quarters.

Our findings are robust to using various alternative approaches to define geographic markets, and to different econometric specifications and estimation methods. In general, our results suggest that even if the Swedish car inspection market has been carefully designed to mitigate adverse incentive effects of competition, increased competitive pressure induces inspection stations to be lenient to their customers. The results suggest that more effective regulatory monitoring is required in highly competitive markets where there is a potential for deviation from regulations. Policymakers should also account for the side-effects of increased competition in designing policies that aim to promote competition among monitoring firms.

The rest of the paper is organized as follows. Section 2 presents a simple theoretical model to illustrate the mechanism through which competition affects pass rates. Section 3 describes the data, it also presents how a geographic market is defined and it gives an overview of the car inspection market. Section 4 presents the specification of the model and estimation strategies. Section 5 shows our main results. Section 6 provides sensitivity analysis. Finally, section 7 presents the conclusion.

2 Theory: Illustration of the Mechanism in a Simple Theory

To see how the passing rate may be affected by the degree of competition, we will present a very simple toy model to illustrate a potential mechanism, that may apply to the Swedish car inspection market. In this market, it is assumed that each consumer demands one unit of inspection and if the owner's car does not pass, then one re-inspection is needed. The price of the inspection is p and the price of re-inspection is r. The probability that a car does not pass the inspection (hence fails) is given by σ. The costs associated with each inspection and re-inspection are c and w, respectively. The profit function in this case can, therefore, be described as $\pi = (p - c + \sigma(r - w))D(.)$, where $D(.)$ is the demand function (which will be described below).

To specify the demand, we will use a modified version of the (price) competition stage in a circular city model (see Salop, 1979 and Tirole, 1988). Let there be n identical firms that only differ with respect to their location. They are distributed equidistant $1/n$ from one another on a circle that has a perimeter of 1. Consumers are uniformly distributed along the circle and their number is normalized to one. We now assume that firms have access to the same technology so that there are no differences in costs, so that $c_i = c$ and $w_i = w$ for all $i = 1, 2, ...n$. Furthermore, it is assumed that market prices are determined centrally and are outside of the control of the local firms.[2] Hence, the only thing that the local firm can affect is the failure rate, $\sigma \in (0, 1)$, which is the probability that a car does not pass. Now, a consumer will buy the service from the firm who offers the service with lowest total expected price. Hence, a consumer located between i and $i:s$ closest competitor at distance x is indifferent between buying at i and the competitor if $p+\sigma_i r + tx = p+\sigma r + (1/n - x)t$, where t is the (marginal) transport cost and σ is the failing rate of the competitor. To avoid boundary complications, we consider markets for which $p - c < \frac{t(r-w)}{nr} < (p-c) + (r-w)$. Solving for x, we get:

$$x = \frac{(\sigma - \sigma_i)r + t/n}{2t} \tag{1}$$

[2]This partly describes the car inspection market in Sweden, where the market is served by multi-station chain firms and the prices across stations within a chain have small variation.

Noting that each firm has customers on both sides, we have that $D_i(\sigma_i, \sigma) = 2x$. The profit function can, therefore, be specified as:

$$\pi_i = (p - c + \sigma_i(r - w))\frac{(\sigma - \sigma_i)r + t/n}{t} \tag{2}$$

The first order condition is given by:

$$\frac{\partial \pi_i}{\partial \sigma_i} = \frac{(\sigma - 2\sigma_i)(r - w)r + \frac{t(r-w)}{n} - (p - c)r}{t} = 0 \tag{3}$$

This gives the best-response function:

$$\sigma_i = \frac{(r - w)\sigma + \frac{t(r-w)}{rn} - (p - c)}{2(r - w)} \tag{4}$$

From (4) we see that bacause we assume that there is a positive margin in the re-inspection market, $r - w > 0$ and that $\sigma \in (0,1)$, we can conclude that the failing rate is a strategic complement in this model. Finally, to get a tractable model we assume symmetric equilibrium so that $\sigma_i = \sigma$ gives:

$$\sigma* = \frac{t(r - w) - nr(p - c)}{nr(r - w)} \tag{5}$$

Note that given the previous assumption that we only consider markets for which $p - c < \frac{t(r-w)}{nr} < (p - c) + (r - w)$, the equilibrium failing rate will be between 0 and 1. It should be clear that the equilibrium failing rate in a local market will be decreasing in the number of firms in the market.

3 Data and Measures of Competition

This section begins with a brief description of the Swedish motor vehicle inspection market. In the remaining subsections, we describe the data in detail, discuss different approaches used to measure the degree of competition among providers and finally present a preliminary data analyses.

3.1 Overview of the Motor Vehicle Inspection Market in Sweden

A periodic car roadworthiness test has been mandatory in Sweden since its introduction in 1965. By law, vehicles are required to pass a mandatory periodic[3] inspection to operate legally on the road. A partly state-owned company,[4] AB Svensk Bilprovning , had a monopoly right to serve the entire market until the market deregulated in July 2010. The reform opens the door for accredited private firms to provide inspection services. The primary goals of the reform have been to increase the competitiveness of the market and, thereby, improve consumer welfare through increased geographical accessibility to the service, reduced prices, better service quality and longer opening hours. To further enhance competition, the government decided to sell part of the monopoly company to a private firm. Accordingly, during the year 2012 one third of the monopoly company (70 stations) was sold to a private inspection firm for a value of SEK 375 million. During the same year, the state and the other owners divided the remaining part of the company between themselves. After the separation, the state-owned company continues to provide services with around 90 stations holding the old company name, and the other owners left with 55 stations to operate under a new company name.

All of the companies that operate in the market need to obtain accreditation from a government agency: the Swedish Board for Accreditation and Conformity Assessment (SWEDAC). The regulator of the market, Swedish Transport Agency, provides the rules and regulations that inspection companies should follow such as which equipment and methods to use, and controls the competence of the inspection technicians. The Swedish Transport Agency has the responsibility to make sure the regulations are not violated by inspection companies. The agency supervises the market by visiting the inspection stations

[3] Presently, there is a 3-2-1-1 system. This means new cars that weigh no more than 3,500 kg should undergo their first mandatory inspection when they are three years old and the second inspection when they are five years old. Afterwards, they must be inspected annually. Cars for commercial use should undergo inspection every year regardless of their age.

[4] The state owns 52% and auto insurance companies and different associations own the remaining 48%. The auto insurance companies own 12% and include: Holmia Forsakrings AB, Folksam omsesidig sakforsakring, Lansforsakringar Wasa Forsakrings AB, If Skadeforsakrings AB, Trygg Hansa Forsakrings AB. The associations include: Motorbranschens Riksforbund (12%), Motormannens Riksforbund (5%), Motorforarnas Helnykterhetsforbund (5%), Kungliga Automobil Klubben (5%), Svenska Taxiforbundet (3%), Sveriges Akeriforetag (3%), and Svenska Bussbranschens Riksforbund (3%)

and conducting statistical analysis on the information provided by the inspection firms. After the deregulation, the number of stations has been increasing throughout Sweden. Table 1 presents the evolution of the number of stations during the sample period. As of August 2015, there were eight companies with a total of 422 stations for light vehicles[5] inspection. This number can be compared with around 190 stations at the time of the deregulation. Our dataset represents a total of nearly 22.5 million light-vehicle inspections that were carried out by all stations in Sweden during the period July 2010 to August 2015.

3.2 Data

We use a station-level monthly panel data over the period July 2010 to August 2015. The Swedish Transport Agency provided us with a data that represent all initial mandatory inspections (22.5 million) for vehicles under 3,500 kg conducted between July 2010 and August 2015 by all licensed stations throughout the country. The data include detailed information on the number of inspected vehicles and the percentage of vehicles that pass the inspection at the station level. The data also include information about each station's date of entry and exact address.

Our dependent variable, $Passrate$, measures the fraction of total inspected cars that pass the inspection at a given station. Our main variable of interest is $\#Stations$, which is the number of competitors that a station faces within its geographic market. In addition to indicator variables, the model controls for owners' age at a municipality level. In the following section, we discuss the different approaches that we use to identify geographic markets.

3.3 Measures of Competition

To study the effect of increased competition on pass rate, one needs to have a plausible measure of competition. In the literature, there are several different approaches to measure competition. In this paper, we measure competition for a given station simply by counting the number of other competing stations within the station's predefined geographic market. An important element

[5]The inspection market can be categorized in terms of the weights of vehicles: light vehicles ($< 3500kg$) and heavy vehicles ($> 3500kg$). Light vehicle inspection accounts for 95% of the total market. This study will focus on the light vehicle inspection market.

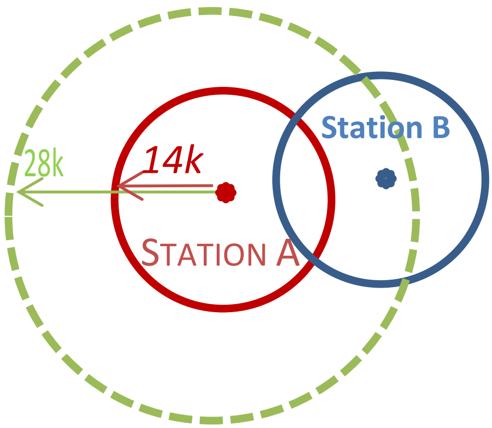

Figure 1: Graphical illustration of the measure of competition: Notes: The red circle shows the 14 km radius catchment area for Station A. Station A will have an overlapping catchment area (at least to some extent) with the catchment area of any station within the dashed green circle in the figure (i.e., any station within 28km radius of station A). Therefore, the measure of competition based on 14 km radius catchment area for Station A includes all stations within a 28 km radius.

of this approach is to identify a station's geographic market. In principle, the geographic market for a station should include all other competing stations to which the station reacts competitively. In the main analyses, we use the locations of stations and their customers to identify circular geographic markets. As a robustness test, we also identify markets based on administrative boundaries (municipalities). Below, we discuss the two alternative approaches that we use to define circular geographic markets.

The first approach is to define circular geographic areas of equal size for all stations. The first step is to determine a fixed radius that defines a station's circular catchment area. We then measure competition for a station by counting the number of other competing stations within the area double the size of the catchment area. For example, Bloom et al. (2015) define the catchment area for England's hospital market using 15 km fixed radius to all hospitals.[6] Bennett et al. (2013) use 0.2-mile radius around a facility to define a circular geographic

[6]They define each hospital's geographic market as a circular area with 30 km radius since a given hospital with 15 km catchment area will have an overlapping (at least to some extent) area with the catchment areas of any hospitals that are less than 30 km far away.

Table 1: Mean and median of competition measures, and total number of stations over the sample period

		Number of competitors (Fixed-radius approach)		Number of competitors (Variable-radius approach)	
Year	No. of stations	Mean	Median	Mean	Median
2010	190	2.5	1	2.3	1
2011	232	3.4	1	3.3	1
2012	270	5.3	2	5.6	2
2013	314	6.7	3	7.4	3
2014	380	7.9	4	8.6	4
2015	422	8.7	4	9.8	4

Table 2: Average and percentiles, station-level monthly pass rate (percentage)

Year	Average	$10th$	$25th$	$50th$	$75th$	$90th$
2010	71.1	64.3	68	71.4	74.9	78.4
2011	69.4	62.6	65.8	69.5	73.2	77.6
2012	69.9	62.8	66.2	70	74.1	77.5
2013	70.7	62.5	66.6	70.5	74.3	77.8
2014	72.1	63.9	67.9	71.8	75.5	79.2
2015	72.9	64.4	68.4	72.7	76.6	80.2

market in the New York State vehicle emission test market. In our study, each station's catchment area is defined by 14 km radius.[7] Since stations with overlapping catchment areas can be considered as substitutes in the eyes of the car owners, we count each station's number of competitors within 28 km (i.e., double the catchment area). Figure 1 presents a graphical illustration of how the geographic market is defined based on catchment area. Henceforth, we refer to this approach as *fixed-radius*. While this approach is convenient, it does not take into account variations in certain characteristics across local markets (e.g., differences in population density).[8]

The second approach tries to solve the limitations of the fixed-radius approach. This method uses the customers' origin information to define station

[7] 14 km is the median of the distribution of the road travel distances between the addresses of 458,405 car owners and the respective station each owner visited. Using actual travel distances to approximate a station's catchment area partly solves the main criticism of other studies for using arbitrary radii.

[8] Stations in sparsely populated areas are likely to have larger geographic market size than stations in densely populated areas. Not accounting for this variation may bias the estimates of the effect of competition.

Table 3: Summary statistics

Variable	Mean	Median	Std. dev.	Min	Max
Passrate (fraction)	0.709	0.710	0.063	0.250	0.973
$\#Stations$ (Variable-radius)	6.332	3.000	9.281	0.000	55.000
$\#Stations$ (Fixed-radius)	6.895	2.000	10.222	0.000	50.000
$\#Stations$ (Municipality)	1.245	0.000	2.07	0.000	12.000
Owners age (Municipality)	51.660	52.000	1.737	47.000	58.000
Population (Municipality)	91507.180	39866.000	160532.300	2565.000	911989.000

specific catchment area (Garnick et al., 1987). The Swedish Transport Agency provided us with data that contain detailed information about car owners' registered addresses and the respective station that each owner visited to get an inspection service. For our purpose, we identified the latitudes and longitudes of the addresses of 458,405 car owners and the station that each owner visited during the period June 2015 to September 2015. We then calculated the road distance that each owner travels for inspection service. By utilizing the distribution of these distances at municipality level, we define catchment area for each station.[9] The catchment area for each station is defined by the travel distance of the median customer to stations located in the focal station's municipality.[10] For example, the median customer to stations located in Stockholm municipality travels 8.5 km whereas the median customer to a station located in Arjeplog municipality travels 41 km. The relevant geographic markets for stations in Stockholm and Arjeplog municipalities are defined as circular areas around the stations with 17 km and 82 km radii respectively, which are double the size of their respective catchment area. Henceforth, we refer to this approach as *variable-radius.* We present our results based on both fixed-radius and variable-radius approaches.

3.4 Preliminary Data Analysis

The number of stations in Sweden has been increasing over the sample period. Table 1 presents the change in the number of competitors the average

[9] In this approach, stations in the same municipality will have equal size catchment area while stations' catchment areas across municipalities are allowed to vary.

[10] We also present a robustness check by defining the catchment area using the travel distances of the 75^{th} percentile customer.

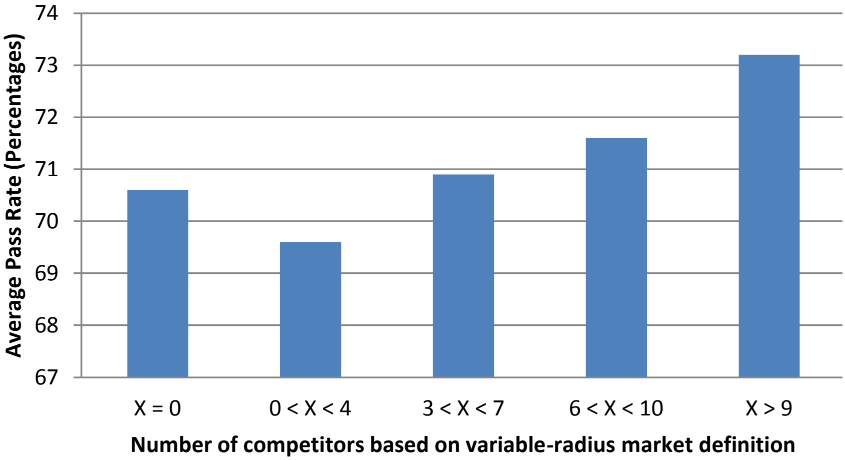

Figure 2: Pass rate and competition: Note: This figure plots the mean pass rates (in percentage) against the number of competitors (based on variable-radius market definition) stations face during the sample period. The number of competitors is denoted " X ".

station faces over time. At the end of 2010 and based on the fixed-radius approach (column 3), on average, each station faced 2.5 competitors within its geographic market, while by August 2015 this number increased to 8.7 competitors. Based on variable-radius approach (column 5), the average station faces 2.3 competitors in year 2010 and increased to 9.8 by August 2015. In both approaches (columns 4 and 6), between 2010 and 2015, the median of the number of competitors increases from 1 to 4, which is a threefold increase.

While there was an increase in the number of inspection stations over the sample period, there was also an overall upward trend in the percentage of cars that pass inspections. Table 2 presents the average and percentile breakdowns of the percentage of vehicles that pass inspections over time. Out of all the inspected vehicles during the last six months of the year 2010, 71.1 percent passed the inspection. At first, this percentage decreased first marginally for the year 2011, and it has been increasing for the rest of the sample period. Out of all the vehicles inspected during January-August of 2015, 72.9 percent has passed the inspection. In the percentile breakdowns, there are no major differences in pass rates between the year 2010 and 2015 for lower percentiles (10th and 25th). The pass rates for the year 2015 exceeds the pass rates of previous years for higher

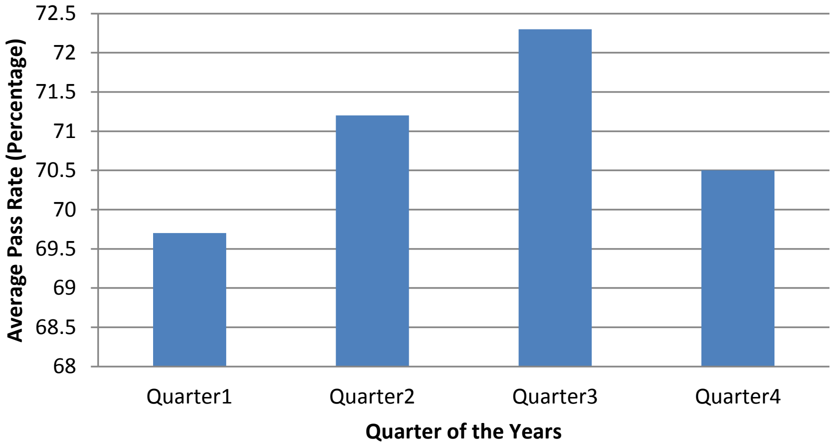

Figure 3: Average pass rate by season: Notes: This figure shows the pass rates (in percentage) against different seasons during the sample period from July 2010–August 2015. The sample period is divided into four quarters: Quarter1 represents (January, February and March), Quarter2 (April, May and June), Quarter3 (July, August and September) and Quarter4 (October, November and December)

percentiles (50th, 75th, and 90th). For example, in the year 2015, the pass rate of stations in the 50th percentile was 1.3 percentage points higher than the pass rate of the corresponding percentile in the year 2010. This increment is evident in the 75th and 90th percentiles. The difference in pass rate across percentiles for every single year has also increased over time. For example, in the year 2010, the pass rate of stations in the 90th percentile was 14.1 percentage points higher than the pass rate of stations in the 10th percentile. By 2015, this difference had increased to 15.8 percentage points.

Figure 2 presents early evidence on the relationship between competition measured by the number of rival stations and the average inspection pass rate. In Figure 2, competition is measured based on variable-radius definition of geographic market. The number of competitors that stations face is divided into five categories, from local monopolies to stations with greater than nine competitors. During the sample period, the figure suggests that, overall, there is a positive relationship between the strength of competition stations face and the average pass rate. This relationship is also evident when competition is measured using the fixed-radius approach, see Figure 4 in the appendix.

Furthermore, we checked for a seasonal variation in the average pass rates.

Figure 3 presents the average pass rate for different seasons during the sample period. The data indicate a clear seasonal variation where the average pass rate during the third quarter (July, August, and September) is higher than the pass rates in any of the other seasons.

4 Empirical Strategy and Specification

We investigate the relationship between pass rate and competition with the following regression model:

$$\begin{aligned} Passrate_{iyt} = \beta_1 + \beta_2(\#Stations_{iyt}) + \beta_3(\#Stations^2_{iyt}) + \beta_4(Ownerage_{my}) \\ + Year_y + Season_q + S_i + \epsilon_{iyt} \end{aligned} \tag{6}$$

where $Passrate_{iyt}$ is the fraction of total inspected cars that pass the inspection at station i for month t in year y. The main variable of interest is $\#Stations_{iyt}$, which measures the number of competitors that station i faces within its geographic market for the month t in year y. The quadratic term $\#Stations^2_{iyt}$ is included to allow for a nonlinear relationship between pass rate and our measure of competition. $Ownerage_{my}$ is the median car owner age at municipality m in year y. The level of care that people give to their cars may differ across owner's age. Older people may be more associated with their cars and, therefore, can maintain and service their cars more properly than their younger counterparts. It can also capture if there is income difference across age groups. We include $Year_y$, which is a full set of year dummies to capture common shocks to (common trends in) the pass rates of all stations. For example, aggregate time effects can capture changes in the inspection guidelines stations are required to follow by the regulator or the average quality of cars in the country might be improving over time. S_i denote a full set of station fixed effects that capture time-invariant unobserved heterogeneity across stations; $Season_q$ denote a full set of quarterly seasonal dummies that capture unobserved heterogeneity that is invariant for a given season over stations. ϵ_{iyt} is an error term capturing all time-varying unobserved factors for station i in month t of year y.

The main coefficients of interest are β_2, which measures how competition affects pass rate, and β_3, which captures the nonlinear relationship between competition and pass rate. As it turns out, the estimate of the quadratic term parameter supports a diminishing effect of competition on pass rate.

Identification of the parameters of equation (6) by Pooled Ordinary Least Squares (Pooled OLS) requires $\#Stations_{iyt}$ to be exogenous; that is factors in the error term that affect pass rate and station fixed effects to be uncorrelated to the measure of competition. However, the Pooled OLS estimates of the competition parameters may suffer from some degree of omitted variable bias. For example, the quality of vehicles inspected by stations that operate in a highly competitive environment could be on average better or worse than the quality of vehicles inspected by stations that operate in a relatively low competitive environment. In such cases, Pooled OLS estimates can be biased.

Since we have a panel dataset, our first strategy to address omitted variables bias is to use fixed effects estimation to control for time-invariant station-specific factors affecting both number of competitors and pass rate. The identification now moves beyond the cross-station comparison and investigates the within-station variation further. An important factor that determines the variation in pass rates between stations is variation in average quality of inspected cars. If these variations between stations are time-invariant (changing slowly over time), then the inclusion of station fixed effects removes the potential bias from unobserved heterogeneity.

While the fixed effects method removes potential bias from time-invariant omitted variables, it may not necessarily identify the causal impact of competition on pass rate if there are time-varying uncontrolled factors. Our second strategy is to use instrumental variables regressions. We propose the size of the population at a municipality level as a source of variation in the number of competitors stations face within their geographic market area.[11] Given that car inspection companies in Sweden are not allowed to provide other services but car inspection, the decision of where to locate their stations is highly dependent on population size and/or the number of registered vehicles. Empirically, the size of the population and the number of stations operating in a market are strongly correlated.

Since we have included the quadratic term $\#Stations^2_{iyt}$ and it is poten-

[11] Olivares and Cachon (2009) use population size at a market level as an instrument for the number of car dealers in their study of the impact of competition on inventory.

tially endogenous, we naturally need additional instruments. Consequently, we construct the first additional instrument, denoted henceforth POP^2_{my}, for the quadratic term by squaring the other instrument (population size in our case) as discussed both in Wooldridge (2010) and Angrist and Pischke (2009). The other source of additional instrument for the quadratic term comes from Wooldridge (2010), who proposes using the square of the fitted values of the first stage regression of $\#Stations_{iyt}$ on the potential instrument and other exogenous variables in the model. To construct this additional instrument, we model the first stage relationship between the measure of competition and population size as follows:

$$\begin{aligned}\#Stations_{imyt} = \gamma_1 + \gamma_2(POP_{my}) + \gamma_3(Ownerage_{my}) + Year_y \\ + Season_q + S_i + \nu_{iyt}\end{aligned} \tag{7}$$

where $\#Stations_{imyt}$ is the number of competitors within the geographic market area of station i located in municipality m for the month t in year y; POP_{my} is population size of municipality m in year y. After estimating equation (7) by fixed effects, we predict the fitted values of the dependent variable and take the square of it, denoted henceforth COM^2_{iyt}, to serve as the second potential instrument for the endogenous quadratic term.

The three potential instruments are: POP_{my}, population size at the municipality level, POP^2_{my}, the square of population size and, COM^2_{iyt}, the square of the fitted values of the dependent variable in equation (7). Therefore, we have three instruments for two endogenous variables, $\#Stations_{iyt}$ and $\#Stations^2_{iyt}$. The first stage equations in the 2SLS estimation are modeled as follows:

$$\begin{aligned}\#Stations_{iyt} = \delta_1 + \delta_2(POP_{my}) + \delta_3(POP^2_{my}) + \delta_4(COM^2_{iyt}) \\ + \delta_5(Ownerage_{my}) + Year_y \\ + Season_q + S_i + \zeta_{iyt}\end{aligned} \tag{8}$$

$$
\begin{aligned}
\#Stations^2_{iyt} = & \lambda_1 + \lambda_2(POP_{my}) + \lambda_3(POP^2_{my}) + \lambda_4(COM^2_{iyt}) \\
& + \lambda_5(Ownerage_{my}) + Year_y \\
& + Season_q + S_i + \eta_{iyt}
\end{aligned} \tag{9}
$$

Where ζ_{iyt} and η_{iyt} are the error terms and all the rest of the variables are as defined as in equation (6).

5 Main Results

5.1 Fixed Effects Estimates

Table 4 presents pooled and fixed effects OLS results. The variable-radius approach is used to identify a geographic market. For an accurate statistical inference, we allow for error clustering at the municipality level in all estimations of the paper (i.e., standard errors are robust against arbitrary heteroskedasticity and error correlation at the municipality level).[12] Columns (1) - (4) of Table 4 provide OLS estimates using a varying set of control variables. The last column presents fixed-effects OLS results.

The first column presents the Pooled OLS estimate of the linear term of competition with no control variables and shows that one additional rival station increases pass rate by 0.1 percentage points. Column (2) added the quadratic term of our measure of competition. The estimates suggest that the effect of competition on pass rate is positive and marginally decreasing. Column (3) includes year and quarterly seasonal dummies. The Pooled OLS estimates indicate that one additional rival station (at the median) increases the pass rate by 0.17 percentage points.

Column (4) added additional control variable, median car owners' age at the municipality level. One additional competing firm (at the median) now increases pass rate by 0.3 percentage points. To minimize potential bias from

[12] As discussed by Cameron and Miller (2015), the higher the size of within-cluster correlation of regressors and errors, the higher the need to use cluster-robust standard errors. Municipality-level clustering allows not only for within-station correlation across time periods but also for error correlations across stations in the same municipality. If we cluster at the station level, then our test statistics become much larger than the statistics we obtain at the municipality level.

Table 4: Fixed effects estimation of the impact of competition on pass rate

Variable	Pooled OLS [1]	Pooled OLS [2]	Pooled OLS [3]	Pooled OLS [4]	Fixed effects OLS [5]
$\#Stations$	0.100***	0.203***	0.188**	0.326***	0.475***
	(0.0343)	(0.0732)	(0.0763)	(0.0755)	(0.0864)
$\#Stations^2$		−0.003*	−0.003	−0.005***	−0.007***
		(0.0018)	(0.0018)	(0.0017)	(0.0013)
Owners age				0.828***	0.525**
				(0.1740)	(0.2292)
Marginal effect (at Median)	0.10	0.185	0.17	0.296	0.433
Year	NO	NO	YES	YES	YES
Q. Season	NO	NO	YES	YES	YES
Station-level fixed effects	NO	NO	NO	NO	YES
Adjusted R^2	0.022	0.025	0.067	0.107	0.665
Observations	17329	17329	17329	17329	17329

Note: The dependent variable measures the fraction of total inspected cars that pass the inspection at a given station. $\#Stations$ measures the number of rival stations within a certain radius around the focal station (see subsection 3.3 for more details about how the appropriate radius is determined for each station). *Owners age* is the median age of car owners at the municipality level. The unit of observation is station-month pair for the period July 2010–August 2015. Clustered standard errors at the municipality level are presented in parentheses (There are 229 clusters in all regressions). The coefficients and the standard errors are multiplied by 100. *** indicates significance at 1% level, ** significance at 5% level and * significance at 10% level.

unobserved factors, column (5) reports our results with fixed effects estimation. The fixed effects estimate of the competition parameter is larger than the OLS estimate suggesting that failing to account for unobserved heterogeneity, biases the true effect of competition downward. One additional rival station (at the median) now increases pass rate by 0.43 percentage points, while the transition from monopoly to duopoly increases the pass rate by 0.48 percentage points. The unconditional mean differences presented in Figure 2 shows that stations with local monopoly power have higher pass rate than stations facing at most three competitors. One possible explanation for the higher pass rate in monopoly markets could be that the average quality of cars in monopoly markets may be better than the quality of cars in areas where there are at most three competitors, which may lead to a downward bias in our estimates. Controlling this systematic differences through fixed effects could avoid the downward bias as supported by our fixed effects results.

In a regression that is not reported here, we find that the point estimates of the competition parameters remain unchanged if we substitute monthly seasonal dummies for quarterly seasonal dummies. Finally, if we estimate the specification in column (5) without controlling for year dummies, then the estimated effect of competition on pass rate increases upwards by nearly 31.5%. This tells us that if we fail to control for time fixed effects, then our estimates would be positively biased by omitted aggregate time trend. This is likely because, during the sample period, there was an overall tendency toward higher pass rates and an increase in the degree of competition for each provider, as shown in Table 1 and Table 2. However, the increase in pass rate could be driven not only by the increased competitiveness of the market but also by other factors. For example, there could be an improvement in the average quality of cars in the country over the sample period. In our estimation, year fixed effects capture this country-level trends over time that affect pass rate.

The control variables provide some interesting results. The coefficients on the seasonal dummies indicate that there is a variation in pass rates on a seasonal basis. The average pass rate during the third quarter of the sample years (July, August, and September) is higher than the average pass rate during any of the other quarters of the years. The average pass rate during the third quarter is 2.8 percentage points higher than the pass rate during the first quarter (January, February, and March) and 1.8 percentage points higher than both the second and the fourth quarters. One possible explanation would be differences in quality of inspected cars across seasons. We also do not rule out that warmer weather conditions may induce technicians to become more lenient to their customers.[13]

Finally, the coefficient on car owners' age reveals that older people are more likely to pass inspection than their younger counterparts. One explanation for this result is that older people may have higher income than younger owners and, thus could on average own a better quality car. Another explanation is that older people may maintain and service their cars more often than the younger owners.

[13] This is not a complete explanation. In our future work, we present a detailed analysis using car owner-level data that contain indicators on the quality of inspected cars.

In all of these regressions above, the measure of competition, $\#Stations$, is taken to be exogenous after controlling for observed variables and time-invariant unobserved heterogeneity. In the next section, we present the results from the instrumental variables method to account for any potential correlation between measures of competition and time-varying unobserved factors in the error term.

5.2 Instrumental Variables Estimates

Table 5 presents the results from the first-stage regressions of the respective 2SLS estimation results in Table 6. It can be seen in this table that population size has a positive and highly significant effect on the number of competitors a station faces ($\#Stations$). The table also reports first stage regressions for the quadratic term of competition ($\#Stations^2$). As expected, our third instrument (COM^2), the square of the fitted values of equation (7), has a positive and statistically significant effect on the second endogenous variable ($\#Stations^2$). We report the Kleibergen-Paap Wald statistic[14] at the bottom of Table 5 to test for a weak instrument. Because the statistics exceed the critical values, the models satisfy the weak-identification test.

[14]Weak instruments bias 2SLS estimates toward OLS (Bound et al., 1995 and Stock et al., 2002). Stock and Yogo (2005) demonstrate that the rule of thumb based on first stage F-statistic proposed by Staiger and Stock (1997) to test for weak instruments might not provide substantial assurance when we have more than one endogenous variables. We use the Kleibergen-Paap Wald statistic to test for weak instruments and the Sargan test for over-identification, both reported by the xtivreg2 command for Stata (Schaffer, 2005).

Table 5: First stages

	1	2		3		4	
Variable	#Stations	#Stations	#Stations^2	#Stations	#Stations^2	#Stations	#Stations^2
POP	45.471***	39.642***	−1241.536*	31.928**	−1153.323	1.563***	1.158
	(13.1443)	(12.8237)	(728.6745)	(12.7645)	(742.6160)	(0.3778)	(1.3922)
POP^2		−5.566***	−170.912***	−5.161***	−198.531***	−0.095**	−0.424***
		(0.4922)	(23.0783)	(0.5048)	(28.8886)	(0.0434)	(0.1363)
COM^2		0.061***	3.876***	0.061***	4.197***	0.026***	1.037***
		(0.0067)	(0.5849)	(0.0069)	(0.6053)	(0.0020)	(0.0043)
KP rk stat	11.968	25.268		36.836		28.434	
F-statistic	11.97	226.52	66.45	269.14	70.51	494.08	35228.64
R-squared	0.213	0.747	0.764	0. 762	0.788	0.888	0.937
Observations	17329	17329	17329	17329	17329	17329	17329

Note: The dependent variables are specified at the top of each column. *#Stations* measures the number of competitors a given station faces within its geographic market. *#Stations*^{2}, is the squared value of the measure of competition, *#Stations*. The first three columns contain fixed effects regressions and the last column contains OLS regression. Each column contains the first stage of the corresponding 2SLS regression in Table 6 and include all the second-stage covariates of the respective specification. POP, is population size at the municipality level; POP^2, the squared value of population size and; COM^2, the squared value of the fitted values of the dependent variable, *#Stations*, in equation (7). Robust standard errors clustered at the municipality level are in parentheses (there are 229 clusters in all regressions). The coefficients and standard errors of POP and POP^2 are multiplied by 100,000 for ease of exposition. We report the F-statistics for the joint significance of the excluded instrument(s). Kleibergen-Paap Wald rk F- statistics for weak instrument test are also reported. *** indicates significance at 1% level, ** significance at 5% level and * significance at 10% level.

Table 6: Fixed effects two stage least squares estimation

Variable	Fixed effects 2SLS [1]	Fixed effects 2SLS [2]	Fixed effects 2SLS [3]	Pooled 2SLS [4]
$\#Stations$	0.428∗∗∗	0.643∗∗∗	0.467∗∗∗	0.553***
	(0.0443)	(0.1516)	(0.1532)	(0.1347)
$\#Stations^2$		−0.0065∗∗	−0.0071∗∗∗	-0.0108***
		(0.0033)	(0.0024)	(0.0034)
Owners age			0.524∗∗	0.985***
			(0.2269)	(0.2133)
Marginal effect (at Median)	0.428	0.604	0.424	0.488
Year	NO	NO	YES	YES
Q. Season	NO	NO	YES	YES
Station-level fixed effects	YES	YES	YES	NO
$Sargan$-test (P-value)		0.8901	0.7705	0.2367
Observations	17326	17326	17326	17326

Note: The dependent variable measures the fraction of total inspected cars that pass the inspection at a given station. $\#Stations$ measures the number of competing stations within a certain radius around a focal station. *Owners age* is the median age of car owners at the municipality level. The unit of observation is a station-month pair for the period July 2010–August 2015. The first three columns present fixed effects 2SLS regressions and the last column contain Pooled 2SLS regression estimated using xtivreg2 and ivreg2 stata command (Schaffer, 2005; Baum et al., 2007). Clustered standard errors at the municipality level are presented in parentheses (There are 229 clusters in all regressions). The coefficients and standard errors are multiplied by 100. *** indicates significance at 1% level and ** significance at 5% level.

Table 6 presents fixed effects 2SLS estimates of the impact of competition on pass rate. The models satisfy the Sargan test for over-identification. Columns (1), (2) and (3) show fixed effects 2SLS estimates with a different set of control variables and column (4) presents pooled 2SLS estimates. The results in all estimations suggest that competition has a positive and statistically significant effect on pass rate. The fixed effects point estimates in column (3) suggest that one additional rival station (at the median) increases pass rate by 0.42 percentage points, which is the same magnitude as the estimate from fixed effects in Table 4. The fact that fixed effects and fixed effects 2SLS yield similar effect size of competition may suggest that the control variables of the model and the inclusion of station fixed effects reasonably account for major potential omitted variables bias. Column (4) reports the Pooled 2SLS results. Again the estimates indicate that competition has a positive and significant effect on pass rate. Adding one additional competitor increases the pass rate by 0.49 percentage points.

The control variables in our preferred specification in column (3) produce similar results as observed in the fixed effects estimation. The pass rate increases with the car owners' age. We also observed a seasonal variation in pass rate where the average pass rate in the third quarter (July, August, and September) is 2.8 percentage points higher than the pass rate in the first quarter and 1.8 percentage points higher than both the second and the fourth quarters.

Overall, all of the estimation strategies and specifications give a consistent result that competition has a positive and statically significant effect on pass rate. The results support the predictions of our simple theoretical model that stations become more lenient to their customers when they face increased competition.

6 Robustness

6.1 Using the Fixed-Radius Approach to Identify Markets

In all of the previous analyses, competition is measured in such a way that stations in different municipalities are allowed to have different catchment areas. For example, stations in Stockholm municipality have a catchment area of 8.5 km radius whereas a station in Arjeplog municipality have a catchment area of 41 km. In this section, we now repeat our analyses based on a fixed size catchment area for all stations. We use 14 km[15] to identify each station's catchment area regardless of where they are located. Therefore, the degree of competition that a station faces is measured by the number of other competing stations within a circular area of 28 km radius from the focal station.

Table 7 reports the results based on our preferred specification where all of the control variables are included. The fixed effects estimates show that competition has a statistically significant and positive effect on pass rate. Adding a rival station (at the median) now increases the pass rate by 0.36 percentage points, which was 0.43 percentage points with a variable-radius approach in the main

[15] 14 km is the median of the distribution of the calculated travel distances between the locations of around 460,000 car owners throughout Sweden and the respective station that each visited.

Table 7: Competition and pass rate: using fixed-radius approach to identify markets

Variable	Pooled OLS (1)	Fixed Effects OLS (2)	Fixed Effects 2SLS (3)
$\#Stations$	0.246***	0.384***	0.340**
	(0.0802)	(0.0909)	(0.1422)
$\#Stations^2$	−0.002	−0.005***	−0.004*
	(0.0020)	(0.0015)	(0.0025)
Owners age	0.952***	0.466**	0.465**
	(0.1781)	(0.2360)	(0.2348)
Marginal effect (at Median)	0.238	0.364	0.324
Year	YES	YES	YES
Q. Season	YES	YES	YES
Station-level fixed effects	NO	YES	YES
Adjusted R^2	0.134	0.135	
KP rk Wald F			39.362
Sargan P-val			0.3546
Observations	17329	17329	17326

Note: The dependent variable measures the fraction of total inspected cars that pass inspection at a given station. $\#Stations$ measures the number of rival stations within a 28km radius around the focal station (based on a catchment area of 14km radius for each station). *Owners age* is median age of car owners at municipality level. All regressions control for year and quarterly seasonal dummies. The unit of observation is station-month pair for the period July 2010–August 2015. Clustered standard errors at the municipality level are presented in parentheses (there are 229 clusters in all regressions). The coefficients and the standard errors are multiplied by 100. *** indicates significance at 1% level, ** significance at 5% level and * significance at 10% level.

analyses. The fixed effects 2SLS estimates suggest that one additional rival station (at the median) now increases the pass rate by 0.32 percentage points. This result can be compared with the 0.42 percentage points that we obtained in the main result. The results with the fixed-radius method of identifying catchment area once again support our hypothesis that competition increases the probability for a given car to pass mandatory inspection.

Table 8: Competition and pass rate–using municipality to identify markets

Variable	Pooled OLS [1]	Pooled OLS [2]	Fixed effects OLS [3]	Fixed effects 2SLS [4]
Panel A	Competition variable in linear form			
#Stations	0.099	0.348***	0.471***	0.537**
	(0.1367)	(0.1214)	(0.1646)	(0.2099)
Owners age		0.6334***	0.4390*	0.4390*
		(0.1997)	(0.2386)	(0.2368)
Adjusted R^2	0.049	0.072	0.132	
F-test				13.40***
Sargan P-val				0.9195
Observations	17329	17329	17329	17326
Panel B	Competition variable in logarithmic form			
log(#Stations)	0.130	0.992**	1.941***	2.958***
	(0.4722)	(0.4969)	(0.3720)	(0.8490)
Owners age		0.6341***	0.4312*	0.4268*
		(0.2000)	(0.2393)	(0.2358)
Adjusted R^2	0.048	0.070	0.135	
F-test				13.03***
Sargan P-val				0.3248
Observations	17329	17329	17329	17326
Panel C	Competition variable in quadratic form			
#Stations	-0.349	0.123	0.816***	0.431
	(0.3159)	(0.3237)	(0.2526)	(0.7016)
#Stations^2	0.0569*	0.0268	-0.0362**	0.0083
	(0.0295)	(0.0286)	(0.0162)	(0.0467)
Owners age		0.5963***	0.4328*	0.4404*
		(0.2032)	(0.2425)	(0.2355)
Marginal effect (at Median)			0.744	
Adjusted R^2	0.054	0.073	0.133	
KP rk Wald F				2.584
Sargan P-val				0.0064
Observations	17329	17329	17329	17326
Year	YES	YES	YES	YES
Q. Season	YES	YES	YES	YES
Station-level fixed effects	NO	NO	YES	YES

Note: In all the three panels, the dependent variable measures the fraction of total inspected cars that pass inspection at a given station. *#Stations* measures the number of stations within a given station's municipality. *Owners age* stands for the median age of car owners at the municipality level. The unit of observation is station-month pair for the period July 2010–August 2015. In Panel (A) and (B) Population size at municipality level and its quadratic term serve as instruments for the number of stations in a market. Panel C includes additional instrument based on the first stage regression similar to the main analyses. The first two columns contain estimates of Pooled OLS regressions, the third contains fixed effects regressions and the last column contains fixed effects 2SLS regressions. Clustered standard errors at the municipality level are presented in parentheses (there are 229 clusters in all regressions). The coefficients and the standard errors are multiplied by 100. All regressions include year and quarterly seasonal dummies. In Panel (A), the measure of competition is in linear form. In Panel (B), the measure of competition is in logarithmic form and in Panel (C) the measure of competition is in quadratic form. *** indicates significance at 1% level, ** significance at 5% level and * significance at 10% level.

6.2 Using Administrative Boundaries to Identify Markets

In the main analyses, we use the locations of car owners and stations to create a circular geographic market for each station. An alternative approach is to use administrative boundaries to identify markets. In this section, we also reestimate the main regression model using municipality to identify geographic markets. The degree of competition is measured using the number of inspection stations in the market. There are a total of 229 markets (municipalities). Table 8 reports the results. Our main variable of interest, the number of competitors in a market, enters the model in three different functional forms: linear, logarithmic and quadratic form. Panel A, B, and C present the results, respectively. All of the models satisfy the weak-identification and over-identification tests, except the quadratic specification in Panel C.

Otherwise, these analyses again support our main findings: across most of the different specifications for our measure of competition, we find that the probability of passing inspection increases with local competition. The effect of adding a rival firm on pass rate ranges from 0.35 to 0.74 percentage points.

6.3 Other Robustness Analyses

In this section, we report a range of sensitivity analyses. Table 8 reports the results of the sensitivity analyses which are based on our preferred specification, where all of the control variables are included. For comparison purpose, the first row of the table presents our preferred specification results, which correspond to columns 4 and 5 of Table 4 and column 3 of Table 6. We report the coefficients of the linear and quadratic terms of the competition variable. We focus the discussion only on the fixed effects and fixed effects 2SLS estimates.

In the main analyses, the catchment area of a station is defined based on the travel distance of the median customer in the referenced station's municipality. For example, the median customer for stations located in Stockholm municipality travels 8.5 km. We defined the catchment area for stations in Stockholm municipality as 8.5 km and the geographic market as a circular area of 17 km radius (double the catchment area). We now subject the results to a robustness test over the travel distance of the representative car owner that determines the radii. We now define each station's catchment area by the travel distance of the

Table 9: Sensitivity analysis of the impact of competition on pass rate

Specification	variable	Pooled OLS (1)	Fixed Effects OLS (2)	Fixed Effects 2SLS (3)
Baseline	$\#Stations$	0.326∗∗∗	0.475∗∗∗	0.467∗∗∗
		(0.0755)	(0.0850)	(0.1532)
	$\#Stations^2$	−0.005∗∗∗	−0.007∗∗∗	−0.007∗∗∗
		(0.0017)	(0.0013)	(0.0024)
75%ile catchment area	$\#Stations$	0.021	0.338∗∗∗	0.381∗∗∗
		(0.0772)	(0.0655)	(0.1442)
	$\#Stations^2$	0.002	−0.004∗∗∗	−0.004∗∗
		(0.0014)	(0.0009)	(0.0019)
Excl. local monopolies	$\#Stations$	0.473∗∗∗	0.388∗∗∗	0.356∗∗
		(0.0701)	(0.0901)	(0.1599)
	$\#Stations^2$	−0.008∗∗∗	−0.006∗∗∗	−0.006∗∗
		(0.0014)	(0.0013)	(0.0024)
Excl. Year 2010 & 2011	$\#Stations$	0.335∗∗∗	0.501∗∗∗	0.753∗∗
		(0.0750)	(0.0942)	(0.2945)
	$\#Stations^2$	−0.005∗∗∗	−0.008∗∗∗	−0.012∗∗∗
		(0.0017)	(0.0014)	(0.0040)
Linear time trend	$\#Stations$	0.317∗∗∗	0.480∗∗∗	0.418∗∗
		(0.0746)	(0.0903)	(0.1548)
	$\#Stations^2$	−0.005∗∗	−0.007∗∗∗	−0.005
		(0.0017)	(0.0014)	(0.0028)
Control variables	$\#Stations$	0.251∗∗∗	0.484∗∗∗	0.504∗∗∗
		(0.0824)	(0.0853)	(0.1829)
	$\#Stations^2$	−0.004∗∗	−0.007∗∗∗	−0.008∗∗∗
		(0.0016)	(0.0013)	(0.0028)
Logarithmic form	$\log(\#Stations)$	0.968∗∗∗	2.294∗∗∗	3.014∗∗∗
		(0.3269)	(0.3719)	(0.8667)
W/out quadratic term	$\#Stations$	0.144∗∗∗	0.102∗∗	0.216∗∗∗
		(0.0379)	(0.0465)	(0.0639)

Note: Each entry in the table represents separate regression and presents the coefficients on the linear and quadratic terms of the measure of competition. All regressions control for year and quarterly seasonal dummies and owners' age. The baseline results in the first row of the table correspond to our specification in columns (4) and (5) of Table 4 and column (3) of Table 6. The dependent variable measures the fraction of total inspected cars that pass the inspection at a given station. $\#Stations$ measures the number of rival stations within the geographic market area of the focal station. The unit of observation is station-month pair for the period July 2010–August 2015. Clustered standard errors at the municipality level are presented in parentheses (there are 229 clusters in all regressions). The coefficients and the standard errors are multiplied by 100. *** indicates significance at 1% level and ** significance at 5% level.

75th percentile customer in their respective municipalities. For example, for stations located in Stockholm municipality, the 75th percentile customer travels 15.5 km. This means the radius of the circular market for stations in Stockholm municipality becomes 31 km. With this alternative definition, the median number of competitors becomes 8 (which was 3 based on the 50th percentile). The estimation using this alternative definition produces a positive and significant effect of competition on the pass rate with a little reduction in the magnitude of the coefficients.

Another potential concern that may affect the results relates to the theory of supplier-induced demand. Vehicle inspection technicians may use their information advantage over car owners to induce individuals to demand more inspection services than the level the owners normally demand had there been no asymmetric information. For example, stations with local monopoly power may intentionally fail vehicles to increase their revenue from the eventual re-inspection that failed cars should undergo. If local monopolies practice such behavior, then our estimates of the effect of competition on pass rate could be biased upward. We address this concern by estimating the model on the subset of stations with at least one competitor in their geographic market (i.e., excluding stations with local monopoly power). Competition still has a positive and significant effect on pass rate. The fixed effects and fixed effects 2SLS point estimates are a little smaller than the main results.

After the market deregulated in July 2010, private firms started to enter the market more actively in the year 2012. We reestimate the model by excluding the observations from the early periods following the deregulation. After excluding the data for the years 2010 and 2011, the fixed effects estimates of the competition coefficient increases slightly. The fixed effects 2SLS estimate of the coefficient on the linear competition term increases to 0.75 from the entire sample estimate of 0.47.

In the main analyses, we control for an aggregate trend in the pass rate through year fixed effects. Therefore, we reestimate the model substituting linear time trend variable for the year fixed effects. The point estimates are almost unchanged by this substitution, indicating that both linear time trend and year fixed effects are good controls for the aggregate trend in the pass rate that is not driven by competition among providers.

We also include additional control variables in the model: mean car age and income at municipality level and monthly inspection volume at station level. Although we addressed time-invariant unobserved factors by station fixed effects, mean car age and income may control for any systematic variation in quality of inspected cars across stations that may be left unaccounted. These results confirm that our main findings are unaffected by the presence or absence of these control variables.

So far in the analyses, the competition variable enters the model in quadratic functional form to account for a non-linear relationship between competition and pass rate. An alternative way of accounting for the non-linear relationship is to use logarithmic functional form. As it turns out, including the competition variable in logarithmic functional form is also supported by the data. The 2SLS estimates show that increasing the number of nearby competitors by 10% will increase the pass rate by 0.29 percentage points. When we use the quadratic form in the main analyses, adding one additional competitor at the median (which, given that the median number of competitors is 3, corresponds to a 33% increase) increases the pass rate by 0.42 percentage points. With the logarithmic form, adding one additional competitor at the median (about 33% increase), increases pass rate by 0.86 percentage points. This result indicates that the positive and significant effect of competition still persists with an alternative way of accounting for a non-linear relationship. We also presented a result without accounting for a non-linear relationship. The last row of Table 8 shows that the positive association still persists but the magnitude of the effect decreases.

7 Conclusion

This paper examines whether increased competition motivates firms to relax the inspection standards in the motor vehicle inspection market. We hypothesized that increased competition can lead inspection stations to become lenient to their customers because of the risk of losing them to their rivals. We employ both fixed effects and fixed effects 2SLS analyses to identify the relationship between competition and the probability of passing mandatory car inspection. We find that stations become more lenient to their customers when they face more competitive pressure from rival stations.

Our results are robust to the different approaches that we follow to identify geographic markets, and different model specifications and estimation methods. Given that the regulations are more compromised in more competitive areas, and also given that limited resources are available to the regulator, our results propose the need for a stringent regulatory monitoring in highly competitive markets where there is an increased incentive for deviations from regulations.

The Swedish car inspection market is carefully designed to reduce the distorting incentives that have been observed in other similar markets (e.g., stations are not allowed to provide other services like repair or car dealership services). Furthermore, the market is closely monitored by the Swedish transport agency, and inspection firms need to obtain accreditation from the Swedish Board for Accreditation and Conformity Assessment. Despite all of the precautions that have been taken, competitive pressure still appears to influence inspection firms' compliance with regulations. If we take the findings as lower bounds on the effect of competition on firms' deviations from regulations, then policies that aim to promote competition among monitoring firms need to incorporate this adverse side of competition in the overall analysis.

Finally, although our findings indicate the adverse side of competition on firms' compliance to regulations, they do not necessarily imply that deregulating the Swedish motor vehicle inspection market has not benefited consumers in a socially desirable way. However, our results suggest that further policies that aim to promote competition among monitoring firms (e.g., selling the state-owned inspection company) should account for such socially undesirable effects.

References

Angrist, J. D. and Pischke, J. (2009). *Mostly Harmless Econometrics: An Empiricist's Companion.* Princeton University Press, Princeton, NJ.

Baum, C. F., Schaffer, M. E., and Stillman, S. (2007). ivreg2: Stata module for extended instrumental variables/2sls, gmm and ac/hac, liml, and k-class regression. *Boston College Department of Economics, Statistical Software Components S425401.* Available at http://ideas.repec.org/c/boc/bocode/s425401.html.

Bennett, V., Pierce, L., Snyder, J., and Toffel, M. (2013). Customer-driven misconduct: how competition corrupts business practices. *Management Science*, 59(8):1725–1742.

Bloom, N., Propper, C., Seiler, S., and Van Reenen, J. (2015). The impact of competition on management quality: Evidence from public hospitals. *Quarterly Journal of Economics*, 82(2):457–489.

Bolton, P., Freixas, X., and Shapiro, J. (2012). The credit ratings game. *Journal of Finance*, 67(1):85–112.

Bound, J., Jaeger, D. A., and Baker, R. M. (1995). Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak. *Journal of the American Statistical Association*, 90(430):443–450.

Branco, F. and Villas-Boas, J. M. (2015). Competitive vices. *Journal of Marketing Research*, 52(6):801–816.

Bresnahan, T. F. and Reiss, P. C. (1991). Entry and competition in concentrated markets. *Journal of Political Economy*, 99(5):997–1009.

Cameron, C. A. and Miller, D. L. (2015). A practitioner's guide to cluster-robust inference. *Journal of Human Resources*, 50(2):317–372.

Garnick, D. W., Luft, H. S., Robinson, J. C., and Tetreault, J. (1987). Appropriate measures of hospital market areas. *Health Services Research*, 22(1):69–89.

Hubbard, T. N. (2002). An empirical examination of moral hazard in the vehicle inspection market. *The RAND Journal of Economics*, 29(2):406–426.

Mazzeo, M. J. (2003). Competition and service quality in the u.s. airline industry. *Review of Industrial Organization*, 22(4):275–296.

Merrell, D., Poitras, M., and Sutter, D. (1999). The effectiveness of vehicle safety inspections: An analysis using panel data. *Southern Economic Journal*, 65(3):571–583.

Olivares, M. and Cachon, G. P. (2009). Competing retailers and inventory: An empirical investigation of general motors' dealerships in isolated u.s. markets. *Management Science*, 55(9):1586–1604.

Salop, S. C. (1979). Monopolistic competition with outside goods. *Bell Journal of Economics*, 10(1):141–156.

Schaffer, M. E. (2005). Xtivreg2: Stata module to perform extended iv/2sls, gmm and ac/hac, liml and k-class regression for panel data models. *Boston College Department of Economics*, revised 22 Feb 2015.

Snyder, J. (2010). Gaming the liver transplant market. *Journal of Law, Economics, and Organization*, 26(3):546–568.

Staiger, D. and Stock, J. H. (1997). Instrumental variables regression with weak instruments. *Econometrica*, 65(3):557–586.

Stiglitz, J. E. (1986). *Economics of the Public Sector.* W. W. Norton and Company, New York.

Stock, J., Yogo, M., and Wright, J. A. (2002). Survey of weak instruments and weak identification in generalized method of moments. *Journal of Business and Economic Statistics*, 20:518–539.

Stock, J. H. and Yogo, M. (2005). *Testing for Weak Instruments in Linear IV Regression. In: Andrews DWK Identification and Inference for Econometric Models.* Cambridge University Press, New York.

Syverson, C. (2004). Market structure and productivity: A concrete example. *Journal of Political Economy*, 112(6):1181–1222.

Tirole, J. (1988). *The Theory of Industrial Organization.* MIT Press, Cambridge, MA.

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data.* MIT Press, Cambridge, MA.

Appendices

A Pass Rate Versus Competition

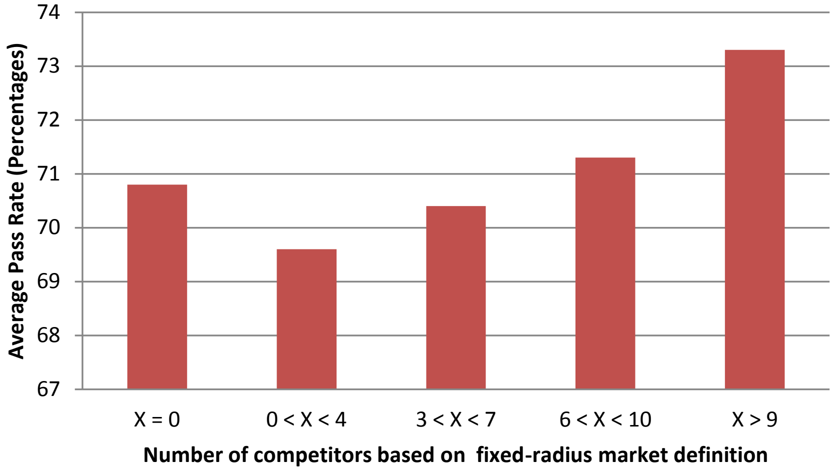

Figure 4: Pass rate and competition: Note: This figure plots the mean of the pass rates (in percentage) against the number of competitors (based on fixed-radius market definition) stations face during the sample period. The number of competitors is denoted by " X ".

PAPER II

Opening Hours and Competition: Evidence from the Motor Vehicle Inspection Market

Abstract

This paper examines the effect of competition on a firm's choice of opening hours in the motor vehicle inspection market. Competition affects the incentives faced by inspection firms when choosing opening hours, which in turn influences the probability that a consumer finds a more preferred service time. I use 2SLS analyses to resolve the potential endogeneity of market entry decisions. Using a detailed monthly station-level panel data for all inspection firms in Sweden, I find that increased competition, measured using both the number of competing stations in the geographic market and the average distance to nearby competitors, leads to longer opening hours. The probability that an inspection station provides services on weekends also increases with local competition.

Keywords: opening hours, competition, non-price competition, entry, motor vehicle inspection market
JEL Classification: D22, L11, L84

I would like to thank Håkan J. Holm and Florin Maican for their support, and helpful comments and suggestions. I am grateful to Joacim Tåg, David Edgerton, and participants at the 9th Swedish Workshop on Competition & Public Procurement Research 2017 and Microeconomics Seminar at Lund University for valuable comments. I would also like to thank the Swedish Transport Agency for providing me with the data. I am thankful to Peter Holmlund (Swedish Transport Agency) for helping me obtain the data and for valuable discussions about the market. Financial support from the Swedish Competition Authority is gratefully acknowledged.

1 Introduction

A decision about opening hours is among the key choices firms make in many service and retail industries. Prior theoretical papers have shown that firms can use opening hours as a key strategic variable in competition (De-Meza, 1984; Ferris, 1990, 1991; Inderst and Irmen, 2005; Shy and Stenbacka, 2006, 2008). However, there has been no direct attempt to empirically examine how competition influences a firm's choice of opening hours. This paper aims to empirically investigate the effect of competition, measured using both the number of firms in the geographic market and the average distance to nearby competitors, on a firm's choice of opening hours in the motor vehicle inspection market.

I focus on the demand retaining and attracting mechanisms by which local competition influences inspection firms' choices of opening hours. Suppose consumers prefer to acquire car inspection service at their ideal (preferred) time with an attractive price. Firms can expand opening hours as a means to increase the probability that consumers find a service time that best matches their preferred time. A firm's choice of opening hours, however, involves an important trade-off: although expanding opening hours attracts additional demand, it also brings cost to the firm (e.g., utility, overtime payment...etc). When choosing optimal opening hours, a station's manager should weigh the costs of longer opening hours against the costs of shorter opening hours. The costs associated with having shorter opening hours will depend on the reaction of consumers when they do not find inspection service available at their preferred time. Having shorter opening hours becomes less costly for a firm if consumers are willing to postpone or advance their transaction when the firm does not offer them their ideal time (loyalty and lack of choice can explain such behavior). On the other hand, when consumers do not find inspection service available at their ideal time, they may switch to alternative providers. This behavior is likely to be more prevalent in markets where there are a large number of service providers. This short analysis indicates that in markets where it is easy for consumers to switch, stations have stronger incentives to provide longer opening hours.

This paper relies on a unique data that contain monthly station-level information on opening hours and the sales volume of all car inspection stations that serve around 5 million cars each year in Sweden. The data set covers the period from March 2012 to May 2015 and includes rich information on the length of opening hours and the number of weekends a station provides services in a given month. One can, therefore, examine not only how long a station provides inspection services but also when a station provides the service. The data also allows me to control for a station's volume of inspections, which can be a proxy for the size of the station. The data also contains the entry dates and geographical locations of all inspection stations. Moreover, I have additional consumer-level data that contain the locations of around 460,000 car owners and the station each owner chose for inspection service. This information allows me to determine a station's catchment area, based on the distribution of the distances traveled by the the station's customers.

To examine whether competition affects a firm's choice of opening hours, I start the analysis by controlling for station-specific characteristics along with chain and time dummies. The results suggest a positive and significant effect of competition on opening hours. While the results indicate a positive association, they may be confounded by omitted factors (e.g., a firm's market entry decision may depend on the capacity of the incumbent firms, which may also influence opening hours decisions). I employ a 2SLS analysis to resolve the potential endogeneity of both the number of stations in the market and the average distance to nearby competitors. The population size at the municipality level serves to instrument my two measures of competition. The main control variable, the number of inspections, is also potentially endogenous with respect to opening hours. Longer opening hours are likely to increase a station's number of inspections. For a given station, this paper uses the average number of inspections of those stations belonging to the same chain but located in other markets as a predictor of that station's volume of inspections. Because two stations that belong to the same chain and age category are likely to have comparable sales performance, one station's sales performance can predict the other's.

My results, which control for the endogeneity of market entry decisions provide evidence that competition has a positive and significant effect on a firm's choice of opening hours. A 10% increase in the number of competing stations leads to a 0.74% increase in opening hours per week on weekdays and a 1.29 percentage point increase in the probability of providing services on weekends at least once in a given month. Similarly, a 10% increase in the average distance to the three nearest competitors leads to a 0.48% increase in opening hours per week and a 0.84 percentage point increase in the probability of providing services on weekends.

This paper contributes to the scant empirical literature on competition in opening hours. Closest to my study, Agnes and Christoph (2016) primarily examine the forms of strategic interaction in opening hours between rival firms in the Austrian retail gasoline market. Their empirical results reject the idea of opening hours decisions being strategic complements. Based on cross-sectional variation, they also find that opening hours increases as distance to the closest station decreases, but the estimation does not control for the potential endogeneity of distance between closest competitors. My paper uses monthly panel data and accounts for the endogeneity of market entry decisions to identify the empirical connection between competition and opening hours. I also measure opening hours not only using how long a station provides services but also using when a station provides services.

The existing theoretical literature on opening hours primarily focuses on examining the consequences of deregulating opening hours.[1] In this respect, the literature generates mixed results. Some theoretical studies find that liberalization of opening hours in the retail industry leads to a demand shift from small firms to large firms (Morrison and Newman, 1983; Tanguay et al., 1995). On the other hand, Wenzel (2011) finds that deregulation of opening hours does not necessarily favor large retail firms at the expense of independent small retail firms. He shows that as long as there is a small cost efficiency difference between the two firm types, small size independent firms can still benefit from deregulation. Inderst and Irmen (2005) study duopolistic competition in the retail industry where retailers can compete both in opening hours and prices. They show that retailing firms can use opening hours as a means to differentiate their products; the prices of both retailers increase following deregulation; and both retailers are better off under the deregulation. The theoretical literature on opening hours indicates that a firm's choice of opening hours has an important impact on consumers' where to buy decisions.

Opening hours can be one dimension of service quality—longer opening

[1] Opening hours have been regulated in the retail industries of many developed countries. In recent years, countries are deregulating opening hours.

hours brings cost to the firm but benefits consumers. Therefore, my work relates to the empirical literature that primarily focuses on competition in service quality. For example, Mazzeo (2003) shows that greater competition improves on-time performance in the US airline industry. Cohen and Mazzeo (2010) analyze competition and branch network expansion decision in the retail banking market. Olivares and Cachon (2009) find that General Motors' dealerships operating in more competitive markets have larger inventories than dealerships operating in less competitive markets. Watson (2009) finds a mixed result between competition and the variety of products that firms offer in the U.S. retail market for eyeglasses. Matsa (2011) examines the effect of competition on product availability in U.S. supermarkets and finds that increased competition reduces shortfalls. Bloom et al. (2015) find that increased competition between hospitals improves the quality of services as measured by the survival rate from emergency heart attacks and by management quality.

The remainder of the paper is organized as follows. Section 2 gives a brief description of the Swedish motor vehicle inspection market. Section 3 describes the data and the measures of competition. Section 4 outlines the specification of the model and identification strategy. Section 5 presents the main results. In Section 6, I present robustness checks. Section 7 concludes.

2 The Swedish Car Inspection Market: Institutional Background

In Sweden, all car owners are required by law to periodically inspect the roadworthiness of their cars by licensed inspection firms.[2] The car inspection market had been served by a partly state-owned monopoly inspection firm[3] until the government deregulated the market in July 2010. After the deregulation, private inspection firms started to provide inspections. During the period of my study (March 2012 to May 2015), seven chain companies and two single-station companies have been serving the whole market.[4]

[2] Presently, there is a 3-2-1-1 system for non-commercial cars that weigh less than 3500 kg. This means a new car should undergo its first mandatory inspection when the car becomes three years old and the second inspection when it becomes five years old. Afterward, the car must be inspected annually.

[3] The state owned 52% and auto insurance companies and different associations owned the remaining 48%.

[4] One of the chain companies, Applus Bilprovning AB, sold its five stations to Dekra Bilbrovning AB and exited the market in January 2013.

Table 1: Mean and median of competition measures, and total number of stations over the year

Year	No. of stations	No. of competitors (Fixed-radius approach) Mean	Median	No. of competitors (Variable-radius approach) Mean	Median	Avg. distance to nearby competitors Mean	Median
2012	270	6.8	3	6.5	3	28.2	25.1
2013	314	8.4	4	7.8	4	23.8	19.1
2014	380	9.8	5	8.9	5	20.5	13.1
2015	422	10.8	5	9.6	5	18.1	11.0

Notes: Distance is measured in kilometers and represents the average distance to the three nearest competitors.

The government deregulated the market to introduce competition into the market and improve consumer surplus through increased spatial accessibility to stations, longer opening hours, reduced prices and better quality of services. To promote competition between service providers, the government decided on the divestiture of the state-owned monopoly company. Accordingly, in 2012, around one-third of the company (70 stations) was sold to a private firm. Furthermore, the state and the other co-owners divided the remaining assets of the monopoly company between themselves and each established a separate inspection firm. The state owns around 90 stations retaining the old company name, and the other owners left with 55 stations to operate under a new company name.

Inspection firms need to obtain accreditation from a government agency, the Swedish Board for Accreditation and Conformity Assessment (SWEDAC). The market is closely monitored by the Swedish Transport Agency, which provides the rules and regulations that inspection firms need to follow, such as which equipment and methods to use, as well as on the competence of the inspection technicians. To avoid distorting incentives, the law prohibits inspection firms from providing any services other than car inspection services. After the deregulation, the number of inspection stations has been increasing in Sweden. Table 1 presents the evolution of the number of stations during the sample period. At the end of 2012, there were 270 stations that provided inspection services. As of May 2015, a total of 422 stations were providing vehicle inspection services.

3 Data, Measurement and Descriptive Statistics

3.1 Data

The regulator of the market, the Swedish Transport Agency, provided me with a unique and rich data that represent all inspection stations operating in Sweden. The study uses station-month level panel data that covers the period from March 2012 to May 2015.[5] The data contain detailed information on the length of opening hours per week in a given month for each station and the number of weekends a station provides inspection services in a given month. The data also include the monthly number of car inspections conducted by each station. I have information on the entry date and geographical location of each inspection station. The size of the population at the municipality level (*Population)* is collected from Statistics Sweden and the total number of registered cars at the municipality level (*#Vehciles*) from a government agency, Transport Analysis.

I measure opening hours for a station using two different variables. These are the variables that the regulator of the market follows closely. The first dependent variable, *Weekdays*, measures the total number of hours per week on weekdays a station provides services in a given month. The second dependent variable, *Weekend*, is an indicator variable equal to one if a station provides inspection services at least once on weekends (i.e, on Saturdays) in a given month.[6] The number of inspections (*#Inspection*) conducted at the station level serves to control for a station size. I also control for station age (*StationAge*) by computing the number of days from the date of entry into the market to a given month of inspection service.[7] Table 1 presents descriptive statistics for all the variables.

[5]The summer months (June, July, and August) are not included in the final data set. During the summer, a number of stations do not provide inspection services, and the opening hours of those that provide services are irregular.

[6]The results are robust to defining *Weekend* as an indicator variable equal to one if a station provides services at least two times on weekends in a given month.

[7]I use December 21, 2010 as the entry date of the stations that were owned by the monopoly company. These stations obviously were in the market before December 21, 2010. However, after the deregulation the monopoly was reorganized and obtained a new license as of December 21, 2010.

Table 2: Summary Statistics of Variables

Variable	Mean	Median	Std. dev.	Min	Max
Outcome variables					
Weekdays (hours)	49.87	50.00	7.41	13.30	78.00
Weekend (dummy)	0.39	0.00	0.49	0.00	1.00
Competition measures					
Distance(Km)	22.36	15.97	22.39	0.89	137.45
#Stations (Variable-radius)	8.31	4.00	9.99	1.00	54.00
#Stations (Fixed-radius)	9.05	4.00	11.02	1.00	50.00
#Stations (Municipality)	2.69	2.00	2.35	1.00	12.00
Covariates					
#Inspections	1599.00	1173.00	1334.00	3.00	9023.00
StationAge (days)	610.41	542.00	408.37	0.00	1765.00
Instruments					
Population(Municipality)	97464.89	42187.00	166117.40	2565.00	911989.00
#Vehicles(Municipality)	44438.96	23449.00	65324.99	1759.00	375811.00
#OtherMktInsp	1566.48	1867.94	762.76	17.00	3907.00

3.2 Measures of Competition

This paper uses two different approaches to measure my main variable of interest, local competition. The first approach measures competition at the station level using the average distance to the three closest competitors *(Distance)*. The second approach measures competition using the number of competing stations (*#stations*) within the station's circular geographic market. The second approach involves two steps. In the first step, I need to define a circular catchment area for each station using information on customer flow. There are two alternative ways of determining a catchment area. The first one uses a circular catchment area with a fixed radius for all stations regardless of their location. A fixed radius of 14 km is used to define each station's catchment area.[8] I refer to this approach, as the fixed radius approach.[9] While the fixed-radius method is convenient to implement, it does not take into account potential variations

[8] This paper benefits from data that contains information on the locations of around 460,000 car owners and the respective station each car owner chose for inspection service. Fourteen kilometers is the median (50th percentile) road distance traveled by the customers at the national level.

[9] A number of papers use this method. For example, Bloom et al. (2015) uses a fixed radius of 15 km to define the catchment area for the English public hospital market. Bennett et al. (2013) uses a fixed radius of 0.2 miles to define the catchment area for inspection facilities in the New York State vehicle emission market.

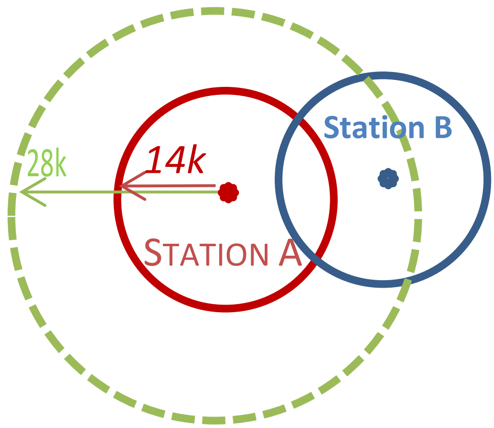

Figure 1: Graphical illustration of the measure of competition: Notes: The red circle shows the 14-km radius catchment area for Station A. Station A will have an overlapping catchment area (at least to some extent) with the catchment area of any station within the dashed green circle in the figure (i.e., any station within 28 km of station A). Therefore, the measure of competition based on a 14-km radius catchment area for Station A includes all stations within a 28 km.

in local market characteristics and differences in attributes of stations.[10] The second method tries to resolve the limitations of the fixed radius-approach.

The second approach allows a catchment area to vary from station to station. This method uses the distributions of the travel distance at the municipality level. The travel distance of the median customer[11] to all stations in a specific municipality will determine the catchment area of all stations that are located in that municipality.[12] This method, is referred to as the variable-radius method.

In the second step, the degree of competition faced by station i is measured using the number of competing stations (*#stations*) within an area that double

[10] I expect that stations in densely populated areas have smaller catchment areas than stations operating in sparsely populated areas. Similarly, I do not expect big size and small size stations to have equal size catchment areas.

[11] The results are robust to using the 75th percentile of the travel distance to define a catchment area.

[12] For example, for inspection stations in Lund municipality, the median customer travels around 19 km, whereas the median customer for stations in Stockholm municipality travels around 8.5 km.

Table 3: Opening hours per week for stations above and below the mean competition

Panel A	*Competition is measured using the average distance to closest competitors*					
Competition	Average	10th	25th	50th	75th	90th
Above Mean	50.3	40	45	50	55	63
Below Mean	49.2	45	45	47	55	55
Panel B	*Competition is measured using the number of competing stations in a market*					
Competition	Average	10th	25th	50th	75th	90th
Above Mean	50.9	40	45	50	55	63
Below Mean	49.5	45	45	47	55	55

the size of station *i's* catchment area. For example, for stations located in Stockholm municipality (catchment area has a radius of 8.5 km), I measure the competition for the station by counting the number of competing stations within 17 km. Doubling the catchment area is important since stations in Stockholm municipality have to compete for customers (will have an overlapping catchment area) with any station that is less than 17 km away from them. Figure 1 illustrates graphical illustration on how to define the geographic market.

Table 1 presents the evolution of my measures of competition over time. At the end of 2012, when the distance to the closest competitors serves to measure competition, the average station has its three nearest competitors within 28.2 km. This figure was reduced to 18.1 km at the end of May 2015. There is a similar increasing trend in local competition over time when the number of service providers in the market measures competition. Using the variable (fixed) radius approach, there were on average 6.5 (6.8) stations per geographic market at the end of 2012, whereas as of May 2015, the figures increase to 9.6 (10.8) stations.

3.3 Preliminary Data Analysis

As a preliminary descriptive evidence on the relation between competition and opening hours, Table 3 presents a comparison of opening hours per week between stations operating in markets above and below the mean level competition. Panel A and B of Table 3 show the distributions of opening hours when competition is measured using distance and number of competitors respec-

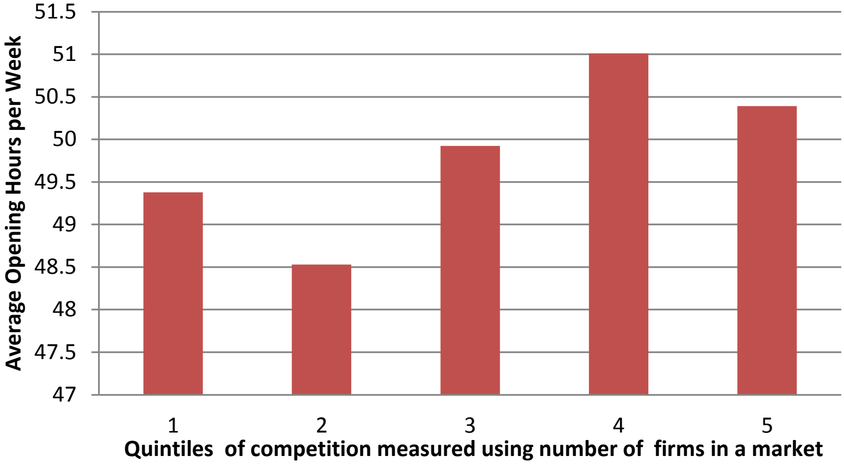

Figure 2: Opening hours by quintiles of competition: Notes: I divided my competition, measured using the number of competitors in a market (variable radius), into quintiles from lowest value (first) to highest value (fifth) along the x-axis. I show the average opening hours per week in a given month in each of the quintiles on the y-axis.

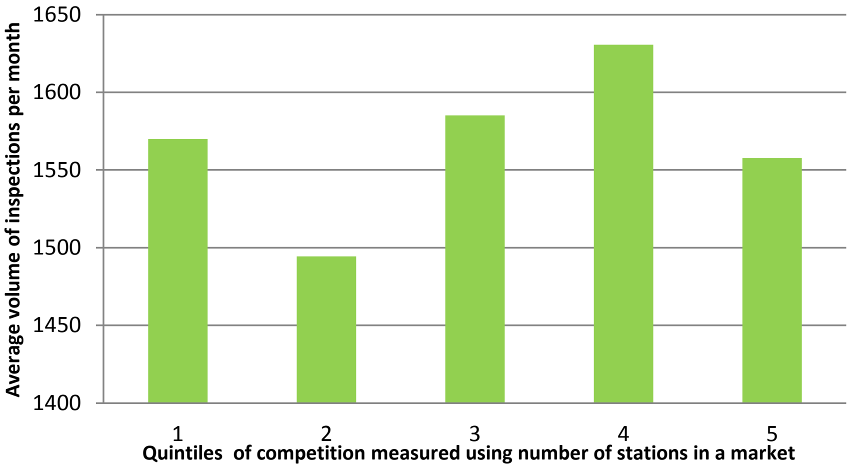

Figure 3: Average number of inspections by quintiles of competition: Notes: I divided my competition, measured using the number of competitors in the market (variable radius), into quintiles from lowest value (first) to highest value (fifth) along the x-axis. I show the average number of inspections per month in each of the quintiles on the y-axis.

tively. In both panels, the average and the median length of opening hours per

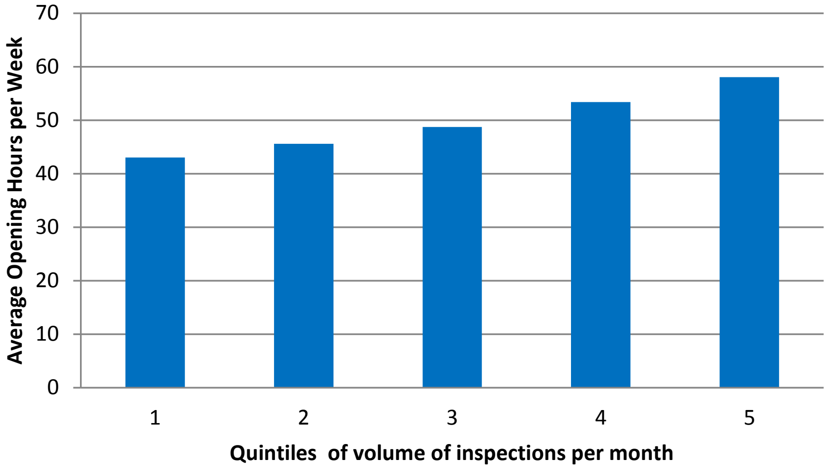

Figure 4: Opening hours by quintiles of volume of inspections: Notes: I divided volume of inspections into quintiles from lowest value (first) to highest value (fifth) along the x-axis. I show the average opening hours per week in a given month in each of the quintiles on the y-axis.

week are longer for stations operating in highly competitive markets than for stations operating in less competitive markets.

Figure 2 presents the relation between competition and opening hours. The figure divides my measures of competition (the number of stations in the market) into quintiles and shows the average opening hours in each bin.[13] The figure suggests that there is a non-monotonic association between average opening hours per week and local competition. In a similar way, Figure 4 divides the volume of inspections into quintiles and shows the average opening hours per week in each bin. There is a clear positive association between opening hours and volume of inspections.

To further explore the non-monotonic relation between opening hours and competition, Figure 3 divides competition (measured using the number of competing stations) into quintiles and shows the average volume of inspections in each bin. Figure 2 and Figure 3 indicate that differences in the stations' average volume of inspections across bins can explain the non-monotonic association between opening hours and competition. In Figure 2, for example, stations in bin two operate in a more competitive environment than stations in bin one

[13] Figure 5 in the Appendix presents a similar analysis when distance serves to measure competition.

but provide on average shorter opening hours than stations in bin one. Furthermore, Figure 3 shows that stations in bin one conduct on average a larger number of inspections than stations in bin two. I observe a similar association between stations in bin four and bin five. This is an indication that differences in the average number of inspections between the bins can explain the non-monotonic association between opening hours and competition observed in Figure 2. It is, therefore, important to control for the volume of inspections in the regression model.

4 Estimation and Identification

4.1 Econometric Framework

The goal is to examine the effect of competition on a firm's choice of opening hours. To do this, I estimate the following regression model:

$$\begin{aligned} OpeningHours_{icty} = \beta_1 + \beta_2(COMP_{ity}) + \beta_3(\#Inspections_{ity}) \\ + \beta_4(StationAge_{ity}) + Year_y + Season_t + Chain_c + \epsilon_{ity} \end{aligned} \tag{1}$$

Where i and c index the station and the chain respectively, t and y stand for the month and the year respectively. $OpeningHours$ stands for either of two of my measures of opening hours: the total number of opening hours per week in a given month or a dummy variable which takes the value of one for providing services at least once on weekends in a given month. $COMP$ stands for the degree of competition the station faces measured using either the number of competing stations ($\#Stations$) or the distance to the closest competitors (*Distance*).

The main control variable is *#Inspections*, the volume of inspections, which can capture differences in station size.[14] *StationAge* controls for the age of the station. To capture national shocks to (common trends in) the opening hours of all

[14]Syverson (2004) uses plant output as a measure of plant size in analyzing how spatial substitutability affects the productivity of plants in the U.S. ready-mixed concrete industry.

stations, I include a full set of yearly dummies, *Year*.[15] I include *Season*, which stands for monthly seasonal dummy variables, to capture, for example monthly seasonal changes in aggregate demand. Lastly, I control for unobserved chain-level differences such as working hours policy or differences in cost efficiency by including a full set of dummy variables for chain types, $Chain$. ϵ_{iyt} is an error term that captures all unobservable factors. All the variables except the dummy variables are included in logarithmic form.[16]

4.2 Identification

If inspection stations choose locations that maximize sales (profit), there may be unobservable factors in the regression model that may affect my measures of local competition. For example, a firm's market entry decision depends on the capacity of the incumbent firms, which may also influence the choice of opening hours. In addition to the endogeneity of market entry decisions, one might also worry about the endogeneity of the volume of inspections with respect to opening hours. Longer opening hours are likely to increase a station's volume of inspections. This means that unobservables that affect a station's optimal opening hours will also impact the station's volume of inspections. In the presence of such concerns, the estimates of the coefficients of both local competition and volume of inspections may be biased.

In order to address the potential bias in estimating the effect of competition on opening hours, my strategy is to use 2SLS analyses. To implement IV regression, I require potential instruments for both the volume of inspections and the measures of competition. The instruments must be correlated to the endogenous variables but should not directly affect a station's choice of opening hours. The size of the population at th municipality level serves as an instrument for local competition.[17] The first stage analyses show that the the size of the population of station *i's* municipality is strongly correlated with the level of competition station *i* faces, namely, the average distance to the three closest competitors

[15] I also substitute monthly dummies (30 month-year dummy variables) for the yearly dummies and the results persist.

[16] The logarithmic transformation builds a diminishing effect of competition on opening hours into the model.

[17] Olivares and Cachon (2009) use population size as an instrument for the number of car dealers in the market in their study of the impact of competition on inventory.

and the number of service providers in station *i's* geographic market.

For population size to serve as a valid instrument, it must not affect the choice of opening hours through other channels, except through the variables that are included in the regression model. One potential mechanism for population size to affect opening hours (other than competition) may be through affecting a station's volume of inspections, which I included in the regression equation. Thus, given my control variables, it is less likely for population size to systematically influence the opening hours through other factors in the error term.

I propose the average volume of inspections in other markets for a given month as a potential instrument for a given station's volume of inspections. A multi-station inspection firm usually operates in different counties.[18] To instrument for station $i's$ volume of inspections in a given month, I use the average volume of inspections (in that particular month) of other stations which belong to the same firm and age category[19] of station i, but are located outside of station $i's$ county. The idea behind this instrument is that stations that share some 'common characteristics' tend to have comparable sales performance, and thus may be good predictors of each other's volume of inspections.

Given the above potential instruments for local competition and volume of inspections, the following first stage equations are used for the relation between my endogenous variables and the instruments:

$$\begin{aligned} \#COMP_{imcty} = {} & \theta_1 + \theta_2(POP_{my}) + \theta_3(\#OtherMktInsp_{ity}) \\ & + \theta_4(StationAge_{ity}) + Season_t \\ & + Year_y + Chain_c + \omega_{ity} \end{aligned} \tag{2}$$

[18] Sweden is divided into 21 counties and 290 municipalities.

[19] I divided the age of stations into five categories: less than one year old; between one and two years old; between two and three years old, between three and four years old and more than four years old.

Table 4: The impact of competition on opening hours: Distance as a measure of competition

	Dependent Variable = *ln(Weekdays)*		Dependent Variable = *Weekend*	
	Pooled OLS	IV 2SLS	Pooled OLS	IV 2SLS
Variable	[1]	[2]	[3]	[4]
$ln(Distance)$	$-0.034***$	$-0.050***$	$-0.086***$	$-0.088***$
	(0.006)	(0.014)	(0.016)	(0.027)
$ln(\#Inspections)$	$0.133***$	$0.115***$	$0.363***$	$0.435***$
	(0.021)	(0.013)	(0.025)	(0.047)
$ln(StationAge)$	$-0.016***$	$-0.013***$	$-0.034***$	$-0.052***$
	(0.005)	(0.003)	(0.010)	(0.010)
Year	YES	YES	YES	YES
Season	YES	YES	YES	YES
Chain	YES	YES	YES	YES
Adjusted R^2	0.5034		0.4128	
Observations	9144	9136	9144	9136

Notes: *ln(Weekdays)* stands for the logarithm of the total weekdays' opening hours per week in a given month. *Weekend* is a dummy variable for opening at least once on weekends of a given month. *Distance* measures the average distance (km) to the three closest rival stations. The unit of observation is station - month pair for the period from March 2012 to May 2015. Robust standard errors clustered at the station level are presented in parentheses. All specifications include the control variables *#Inspections*, volume of inspections; *StationAge*, age of station; *Year*, yearly dummies; *Season*, monthly seasonal dummies and *Chain*, chain type dummies. *** indicates significance at 1% level and ** significance at 5% level.

$$\begin{aligned} \#Inspections_{imcty} = {} & \lambda_1 + \lambda_2(POP_{my}) + \lambda_3(\#OtherMktInsp_{ity}) \\ & + \lambda_4(StationAge_{ity}) + Season_t \\ & + Year_y + Chain_c + \eta_{ity} \end{aligned} \tag{3}$$

Where $COMP$ is one of the two measures of competition, either the number of competing stations or distance; POP_{my} is the population of municipality m in year y, which serves to instrument local competition; *#OtherMktInsp* is the average volume of inspections conducted by stations, that are within the same chain and age category as station i but are located outside of station *i's* county, and serves as an instrumental variable for station $i's$ volume of inspections. The other variables are similar to those in equation 1. Except for the dummy variables *Season, Year and Chain*, all the other variables are in logarithmic form.

5 Main Results

5.1 Results from OLS Estimation

The OLS estimates of Equation 1 for my two outcome variables, $Weekdays$ and $Weekend$, are reported in Tables 4 and 6. Columns 2 and 5 of the tables contain the results. In all regressions, I correct standard errors for potential arbitrary heteroskedasticity and serial correlation by clustering at the station-level. The estimates indicate that competition has a positive and significant effect on opening hours. More specifically, decreasing the average distance to the three nearest ompetitors (increasing competition) by 10% increases opening hours per week on weekdays by 0.33% and the probability of providing services on weekends by 0.82 percentage points. Similarly, increasing the number of competing stations by 10% will increase opening hours per week on weekdays by 0.17% and the probability of providing services on weekends by 0.63 percentage points. The OLS results, however, may be biased by factors unaccounted in the regression model. To resolve the potential concern that the positive association may be biased by omitted factors, I employ 2SLS analyses.

5.2 First Stages

Before presenting the 2SLS estimates, I present the first stage analysis. Columns 1 and 2 of Table 5 report the first stages for competition and volume of inspections respectively, where the distance to the three nearby competitors serves as a measure of competition. Columns 3 and 4 of Table 5 show the estimates of the first stages for competition and volume of inspections, respectively, where the number of competing stations serves to measure competition.

The estimates of the first stage equations show that population size strongly explains both measures of competition. As expected, the average volume of inspections of stations in other markets significantly predicts the volume of inspections for a given station. Most importantly, both instruments are powerful. Bound et al. (1995) and Stock et al. (2002) pointed out that weak instruments lead to biased estimates. Since I have two instruments and two endogenous variables, the usual F-test for a week-identification test would be misleading (Stock and Yogo, 2005). I, therefore, present in Table 5 the cluster and

Table 5: First stages

	$ln(Distance)$	$ln(\#Inspection)$	$ln(\#Stations)$	$ln(\#Inspection)$
	OLS	OLS	OLS	OLS
Variable	[1]	[2]	[3]	[4]
$ln(POP)$	−0.655***	0.251***	0.429***	0.251***
	(0.028)	(0.035)	(0.029)	(0.035)
$ln(\#OtherMktInsp)$	0.154**	0.569***	−0.094	0.569***
	(0.065)	(0.055)	(0.091)	(0.055)
$ln(StationAge)$	−0.062***	0.131***	0.025	0.131***
	(0.019)	(0.015)	(0.023)	(0.015)
KP rk stat	53.329		29.376	
F-statistic	287.76	69.25	102.28	69.25
Adjusted R^2	0.6246	0.5540	0.2931	0.5540
Observations	9137	9136	9137	9136

Notes: The dependent variables are specified at the top of each column. Columns 1 and 2 are the first stages for column 2 in Table 4. Columns 3 and 4 are the first stages for column 4 in Table 6. *Distance* is the average distance to the three nearest competitors. *#Stations* is the number of competing stations in the market. *#Inspections* stands for the volume of inspections. I instrument *Distance* and *#Stations* using *POP*, population size at the municipality level. I instrument *#Inspections* for station *i* using *#OtherMktInsp*, average number of inspections conducted by other stations belonging to the same chain but located outside of station *i's* county. Robust standard errors clustered at the station level are presented in parentheses. I present the F-statistics for the joint significance of the two excluded instruments. Kleibergen-Paap Wald rk F-statistics for the weak instrument test are also reported. *** indicates significance at 1% level and ** significance at 5% level.

heteroskedasticity-robust Kleibergen-Paap F-statistics. The stock-Yogo critical value for a model with two instruments and two regressors is 7.03 for maximum 10 percent size distortion. Since the values of the Kleibergen-Paap F-statistics, 53.33 and 29.38, well exceed the critical value, the statistical test supports the claim that my IV estimates do not suffer a weak instrument problem.

The reduced form relation between my instruments and measures of opening hours, *Weekdays* and *Weekend*, is also reported in the Appendix Table 9. Given that the number of competing stations increases with population size, I would expect opening hours to increase with population size. With similar reasoning, given that the volume of inspections is positively affected by the average number of inspections in other markets (*#OtherMktInsp*), I also expect a positive relation between opening hours and *#OtherMktInsp*. The estimates of the reduced form indicate that both population size and *#OtherMktInsp* have a positive and significant effect on the measures of opening hours.

Table 6: Results using number of competing stations as a measure of competition

	Dependent Variable = *ln(Weekdays)*		Dependent Variable = *Weekend*	
	Pooled	IV	Pooled	IV
	OLS	2SLS	OLS	2SLS
Variable	[1]	[2]	[3]	[4]
$ln(\#Stations)$	0.018∗∗∗	0.077∗∗∗	0.066∗∗∗	0.135∗∗∗
	(0.005)	(0.024)	(0.015)	(0.042)
$ln(\#Inspections)$	0.141∗∗∗	0.114∗∗∗	0.378∗∗∗	0.434∗∗∗
	(0.022)	(0.017)	(0.025)	(0.047)
$ln(StationAge)$	−0.016∗∗∗	−0.011∗∗∗	−0.035∗∗∗	−0.049∗∗∗
	(0.005)	(0.004)	(0.010)	(0.010)
Year	YES	YES	YES	YES
Season	YES	YES	YES	YES
Chain	YES	YES	YES	YES
Adjusted R^2	0.4785		0.4023	
Observations	9144	9136	9144	9136

Notes: *ln(Weekdays)* stands for the logarithm of the total weekdays' opening hours per week in a given month. *Weekend* is a dummy variable for providing service at least once on weekends of a given month. *#Stations* stands for the number of competing stations. The unit of observation is station-month pairs for the period from March 2012 to May 2015. Robust standard errors clustered at the station level are presented in parentheses. All specifications include the control variables: *#Inspections*, volume of inspections; *StationAge*, age of the station; *Year*, yearly dummies; *Season*, monthly seasonal dummies and *Chain*, chain type dummies. *** indicates significance at 1% level and ** significance at 5% level.

5.3 Results from IV Estimation

Columns 2 and 4 of Table 4 present my main 2SLS second-stage results when distance is used as a measure of competition. I find that decreasing the average distance to the three nearest competitors (increasing competition) by 10% (which corresponds to 2.2 km, given the average distance of 22.36 km in my data), leads to a 0.48% increase in opening hours per week on weekdays, and a 0.84 percentage point increase in the probability of opening on weekends.[20] The results are statistically significant at the 1% level.

Columns 2 and 4 of Table 6 report the 2SLS estimates when I use the number

[20] The descriptive statistics in Table 1 show that the average opening hours per week on weekdays is 49.87 and the probability for a station to provide service at least once on weekends in a given month is 39%. If I use the averages as baselines, a 10% (2.2 km) decrease in the average distance to the three nearest competitors leads to an increase by 14.36 minutes in the opening hours per week and a 2.15 percentage point increase in the probability of providing services at least once on weekends in a given month.

of competing stations to measure competition. The results show that increasing the number of competing stations by 10% (which corresponds to adding 0.83 station, given that the average number of competitors per market is 8.3), leads to a 0.74% (which, given the mean opening hours in my data, corresponds to about 22 minutes) increase in opening hours per week on weekdays, and a 1.29 percentage point increase in the probability of opening at least once on weekends for a given month.

The control variables also reveal some results. The 2SLS point estimates of the volume of inspections coefficients are positive and statistically significant at the 1% level, suggesting that both *Weekdays* and $Weekend$ increase with the volume of inspections. A 10% increase in the volume of inspections translates into a 1.14% increase in opening hours per week on weekdays and a 4.14 percentage point increase in the probability of opening on weekends.

Overall, the results provide evidence that competition has a positive and statistically significant effect on opening hours. Competition tends to create incentives for inspection firms to expand their opening hours on weekdays and to provide services on weekends. In the next section, I present a robustness analysis.

6 Robustness Checks

6.1 Using Municipality Boundaries to Identify Markets

In the main analyses, the locations of each station's customers were used to identify a circular catchment area. An alternative way of identifying the geographic markets is to use administrative boundaries. As a robustness check on the main findings, I re-estimate the main regression model using administrative boundaries of the municipalities to determine the geographic markets. The number of competing stations within a municipality is used as the measure of competition. Tabel 7 presents the results. Both the OLS and IV estimates show that my results are robust to the alternative method of defining a market. Competition is positively and significantly related to the opening hours during weekdays and the likelihood of providing services on weekends.

Table 7: The impact of competition on opening hours: Using municipality to identify markets

	Dependent Variable = *ln(Weekdays)*		Dependent Variable = *Weekend*	
	Pooled OLS	IV 2SLS	Pooled OLS	IV 2SLS
Variable	[1]	[2]	[3]	[4]
$ln(\#Stations)$	0.033∗∗∗	0.070∗∗∗	0.102∗∗∗	0.123∗∗∗
	(0.008)	(0.021)	(0.026)	(0.039)
$ln(\#Inspections)$	0.140∗∗∗	0.101∗∗∗	0.377∗∗∗	0.412∗∗∗
	(0.023)	(0.017)	(0.024)	(0.057)
$ln(StationAge)$	−0.016∗∗∗	−0.008∗∗	−0.034∗∗∗	−0.043∗∗∗
	(0.005)	(0.004)	(0.011)	(0.011)
Year	YES	YES	YES	YES
Season	YES	YES	YES	YES
Chain	YES	YES	YES	YES
Adjusted R^2	0.502		0.424	
KP rk Wald F		40.43		40.43
Observations	9144	9136	9144	9136

Notes: *ln(Weekdays)* is the logarithm of the total weekdays' opening hours per week in a given month. *Weekend* is a dummy variable for opening at least once on weekends of a given month. *#Stations* measures the number of competing stations at the municipality level. The unit of observation is station - month pairs for the period from March 2012 to May 2015. I instrument *#Stations* using population size at the municipality level. I instrument *#Inspections* for station *i* using the average number of inspections conducted by other stations belonging to the same chain but located outside of station *i's* county. Robust standard errors clustered at the station level are presented in parentheses. All specifications include: *#Inspections*, monthly volume of inspections; *StationAge*, age of a station in terms of number of days; *Year*, yearly dummies; *Season*, monthly seasonal dummies: and *Chain*, chain type dummies. *** indicates significance at 1% level and ** significance at 5% level.

6.2 Other Robustness Analyses

This section presents the results of a number of robustness checks. Table 8 presents the results of the sensitivity analyses, where each entry represents a separate regression and contains the estimates of the coefficients on competition and volume of inspections. The first row contains the baseline pooled 2SLS results.

Using alternative instrument for measures of competition. In the main analyses, population size at the municipality level serves as an instrumental variable for my measures of competition. Here, I experiment with an alternative instrument, the number of registered cars at the municipality level. The results are presented in the second row of the table. Competition has a positive and significant effect on opening hours.

Defining the catchment area using the 75th percentile on the travel distances. One concern about the geographic market definition was that I use the travel distance of the median customer to identify a station's catchment area. Now, the travel distances of the 75th percentile customer define a station's catchment area. The results are presented in the third row. The coefficient on competition when the dependent variable is *Weekdays* increases to 0.16 (baseline result was 0.08). When the dependent variable is *Weekend*, the coefficient on competition increases to 0.27 (baseline result was 0.14). These support the robustness of the main results to the alternative way of identifying a catchment area.

Fixed radius catchment area. In the main analyses, catchment areas were allowed to vary by station based on the customer flow for the station. An alternative to this approach in the literature is the fixed-radius approach, which gives equal size circular catchment areas to all stations regardless of their locations and sizes. Here, the travel distance of the median customer at the national level (14 km) serves to identify all stations' catchment areas. Row 4 presents the results. The coefficients on competition are still positive and significant at the 1% level with little difference in the magnitudes.

Opening at least two times on weekends for a given month as a dependent variable. One of my dependent variables, *Weekend*, is a dummy variable which takes the value of one when service is provided at least once on weekends (i.e., on Saturdays) for a given month. Here, instead *Weekend* is defined as a dummy variable which takes the value of one for providing service at least twice on weekends for a given month. Row 5 presents the results. The coefficient on competition measured using the average distance to nearby competitors becomes -0.15 (the main result was -0.09). The coefficient on competition measured using the number of competing stations increases to 0.23 (the main result was 0.14). These results based on the alternative definition strengthen the main results that the probability of providing service on weekends increases with local competition.

Including station fixed effects. So far the parameters of interest are identified based on cross-sectional variation. Now, the regression model is re-estimated after controlling for station fixed effects. The last row presents the results. When the dependent variable is *Weekdays*, controlling for station fixed effects increases

Table 8: Sensitivity analysis of the impact of competition on opening hours

		2SLS	2SLS	2SLS	2SLS
		Weekdays	*Weekdays*	*Weekend*	*Weekend*
Specification	Variable	(1)	(2)	(3)	(4)
Baseline	*COMP*	−0.050∗∗∗	0.077∗∗∗	−0.088∗∗∗	0.135∗∗∗
		(0.014)	(0.024)	(0.027)	(0.042)
	#Inspections	0.115∗∗∗	0.114∗∗∗	0.435∗∗∗	0.434∗∗∗
		(0.013)	(0.017)	(0.047)	(0.047)
Number of vehicles	*COMP*	−0.051∗∗∗	0.082∗∗∗	−0.089∗∗∗	0.143∗∗∗
		(0.015)	(0.026)	(0.028)	(0.045)
	#Inspections	0.116∗∗∗	0.116∗∗∗	0.436∗∗∗	0.437∗∗∗
		(0.013)	(0.017)	(0.047)	(0.046)
75%ile catchment area	*COMP*		0.155∗∗∗		0.271∗∗∗
			(0.052)		(0.097)
	#Inspections		0.088∗∗∗		0.388∗∗∗
			(0.030)		(0.064)
Fixed radius catchment area	*COMP*		0.059∗∗∗		0.103∗∗∗
			(0.017)		(0.031)
	#Inspections		0.114∗∗∗		0.433∗∗∗
			(0.014)		(0.046)
At least 2 times on weekends	*COMP*			−0.149∗∗∗	0.229∗∗∗
				(0.025)	(0.046)
	#Inspections			0.292∗∗∗	0.289∗∗∗
				(0.047)	(0.057)
Station fixed effects	*COMP*	−0.183	0.203	−0.333∗∗	0.370∗∗
		(0.137)	(0.147)	(0.146)	(0.155)
	#Inspections	0.084∗∗∗	0.074∗∗∗	0.384∗∗∗	0.367∗∗∗
		(0.022)	(0.018)	(0.058)	(0.054)

Notes: The dependent variables are specified at the top of each column. Each entry in the table represents a separate regression and presents the estimates of the coefficients on competition and the volume of inspections. Columns 1 and 3 present results when distance serves to measure competition. Columns 2 and 4 report the results when the number of rival stations serves as a measure of competition. The baseline results in the first row of the table correspond to my specifications in columns (2) and (4) of both Tables 4 and 6. Robust standard errors clustered at the station level are presented in parentheses. *** indicates significance at 1% level and ** significance at 5% level.

the standard errors of the competition parameters substantially (more than 500% and 850%). This substantial increase in the standard errors of the competition coefficients may suggest that the variation in the data may not be enough for a within-station variation identification strategy. My results, therefore, rely on cross-sectional variation to identify the parameters of interest.

The effect of competition on weekend openings, however, is still positive and significant at the 5% level after controlling for station fixed effects. In fact, the magnitude of the effect of competition increases substantially, to -0.33 (from the baseline result of -0.09) when distance serves to measure competition and to 0.37 (from a baseline of 0.14) when the number of competing stations serves to measure competition.

7 Conclusion

This paper examines whether competition can increase service opening hours. Firms, particularly in service and retail industries, can expand opening hours to offer their customers more flexible service time, which will have an important impact on consumers' where to buy decisions. Although the existing theoretical literature indicates the strategic importance of opening hours choice in attracting customers, empirical evidence for the effect of competition on opening hours is sparse. This paper fills this gap by analyzing how local competition affects a firm's choice of opening hours in the context of the motor vehicle inspection market. This article uses a unique station-month level panel data set that includes rich information on all car inspection stations in Sweden.

After controlling for the endogeneity of market entry decisions and sales volume, I find that stations offer longer opening hours and the probability of providing services on weekends also increases as stations face stronger competition. The results also show that large stations provide longer opening hours than small stations.

The results are robust to different model specifications and different measures of local competition. The findings of this paper will be important for competition authorities and courts in competition law enforcement. While in principle competition policy is believed to consider both price and non-price factors that influence consumer welfare, competition authorities tend to focus on price effects in competition analysis. One reason could be the lack of empirical evidence on how the non-price attributes of a product react to competition in a particular market. Using a unique data set in the motor vehicle inspection market, I provide strong empirical evidence that consumers enjoy expanded opening hours and weekend service in markets where local competition is intense.

References

Agnes, K. and Christoph, W. (2016). Time as a strategic variable: business hours in the gasoline market. *Applied Economics Letters*, 23(15):1051–1056.

Bennett, V., Pierce, L., Snyder, J., and Toffel, M. (2013). Customer-driven misconduct: how competition corrupts business practices. *Management Science*, 59(8):1725–1742.

Bloom, N., Propper, C., Seiler, S., and Van Reenen, J. (2015). The impact of competition on management quality: Evidence from public hospitals. *Quarterly Journal of Economics*, 82(2):457–489.

Bound, J., Jaeger, D. A., and Baker, R. M. (1995). Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak. *Journal of the American Statistical Association*, 90(430):443–450.

Cohen, A. and Mazzeo, J. M. (2010). Investment strategies and market structure: An empirical analysis of bank branching decisions. *Journal of Financial services Research*, 38(1):1–21.

De-Meza, D. (1984). The fourth commandment: is it pareto efficient? *Economic Journal*, 94(374):379–383.

Ferris, J. S. (1990). Time, space, and shopping: the regulation of shopping hours. *Journal of Law, Economics, and Organization*, 6(6):55–72.

Ferris, J. S. (1991). On the economics of regulated early closing hours: some evidence from canada. *Applied Economics*, 23(8):1393–1400.

Inderst, R. and Irmen, A. (2005). Shopping hours and price competition. *European Economic Review*, 49(5):1105–1124.

Matsa, D. (2011). Competition and product quality in the supermarket industry. *Quarterly Journal of Economics*, 126(3):1539–1591.

Mazzeo, M. J. (2003). Competition and service quality in the u.s. airline industry. *Review of Industrial Organization*, 22(4):275–296.

Morrison, S. A. and Newman, R. J. (1983). Hours of operation restrictions and competition among retail firms. *Economic Inquiry*, 21(1):107–114.

Olivares, M. and Cachon, G. P. (2009). Competing retailers and inventory: An empirical investigation of general motors' dealerships in isolated u.s. markets. *Management Science*, 55(9):1586–1604.

Shy, O. and Stenbacka, R. (2006). Service hours with asymmetric distributions of ideal service time. *International Journal of Industrial Organization*, 24(4):763–771.

Shy, O. and Stenbacka, R. (2008). Price competition, business hours and shopping time flexibility. *Economic Journal*, 118(531):1171–1195.

Stock, J., Yogo, M., and Wright, J. A. (2002). Survey of weak instruments and weak identification in generalized method of moments. *Journal of Business and Economic Statistics*, 20:518–539.

Stock, J. H. and Yogo, M. (2005). *Testing for Weak Instruments in Linear IV Regression. In: Andrews DWK Identification and Inference for Econometric Models*. Cambridge University Press, New York.

Syverson, C. (2004). Market structure and productivity: A concrete example. *Journal of Political Economy*, 112(6):1181–1222.

Tanguay, G. A., Vallee, L., and Lanoie, P. (1995). Shopping hours and price levels in the retailing industry: A theoretical and empirical analysis. *Economic Inquiry*, 33(3):516–524.

Watson, R. (2009). Product variety and competition in the retail market for eyeglasses. *Journal of Industrial Economics*, 57(2):217–251.

Wenzel, T. (2011). Deregulation of shopping hours: The impact on independent retailers and chain stores. *Scandinavian Journal of Economics*, 113(1):145–166.

Appendices

B The reduced form of the 2SLS regressions

Table 9: Reduced form of the two-stage least squares regressions

	Dependent variable = $ln(Weekdays)$	Dependent variable = $Weekend$
	Pooled OLS	Pooled OLS
Variable	[1]	[2]
$ln(Population)$	0.062∗∗∗	0.167∗∗∗
	(0.011)	(0.017)
$ln(\#OtherMktInsp)$	0.057∗∗∗	0.234∗∗∗
	(0.010)	(0.038)
$ln(StationAge)$	0.006∗∗	0.011
	(0.003)	(0.009)
Year	YES	YES
Season	YES	YES
Chain	YES	YES
Adjusted R^2	0.279	0.227
Observations	9137	9137

Notes: The dependent variables are specified at the top of each column. *ln(Weekdays)* is the logarithm of the total weekdays' opening hours per week. *Weekend* is a dummy variable for opening at least once on weekends of a given month. $Population$ is population size at the municipality level and instruments measures of competition. $\#OtherMktInsp$ is the volume of inspections by stations belonging to the same chain but located in other markets and serves to instrument volume of inspections. Robust standard errors clustered at the station level are presented in parentheses. All columns include all the control variables of the second stages of the 2SLS regressions. *** indicates significance at 1% level and ** significance at 5% level.

C Opening hours versus distance to nearby competitors

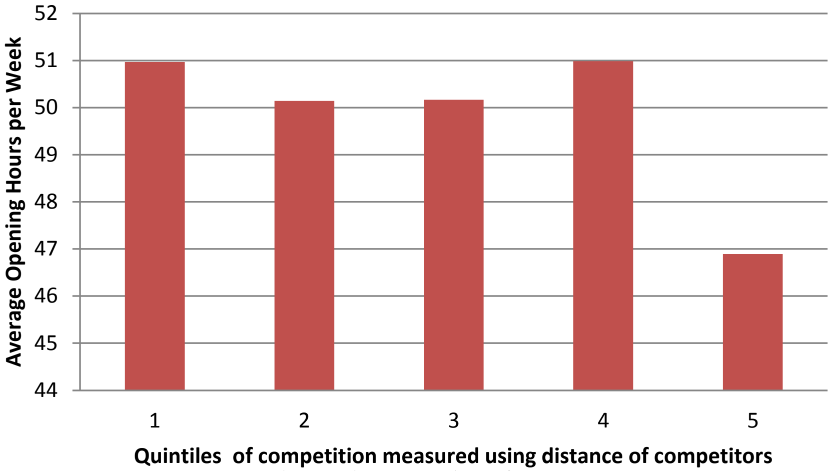

Figure 5: Average Opening hours by quintiles of competition: Notes: I divided my competition, measured using the average distance to three nearby competitors, into quintiles from lowest value (fifth) to highest value (first) along the x-zxis. I show the average hours of opening per week on weekdays in each of the quintiles on the y-axis.

Paper III

Deregulation, Choice and Competition in the Motor Vehicle Inspection Market

Abstract

I estimate a demand model for car inspection services to investigate car owners' choice of stations and its implications for competition, and to evaluate the impact on consumer welfae of removing the state monopoly on inspection services. Using detailed data on car owners' choices of station in the Swedish motor vehicle inspection market, I find that car owners are willing to pay SEK 41 or 9% more than the average price to avoid traveling one additional kilometer. Consumers are also found to respond to price, opening hours, and the size of the station. Stations that face more competitors also face more elastic demand with respect to price and opening hours. Improvement in spatial accessibility to stations following the removal of the monopoly increases welfare to the average consumer by SEK 100.

Keywords: choice, deregulation, consumer welfare, demand elasticity, motor vehicle inspection market
JEL Classification: D12; L11; L13; L89

I would like to thank Håkan J. Holm and Florin Maican for their invaluable comments and suggestions. I am also grateful to Joacim Tåg for helpful comments. I want to thank the Swedish Transport Agency for providing me with the data. I also thank Peter Holmlund (Swedish Transport Agency) for helping me obtain the data and for valuable discussions about the market. Financial support from the Swedish Competition Authority is gratefully acknowledged.

1 Introduction

Governments in several countries have adopted reforms that provide greater choice for users of public services (Besley and Ghatak, 2003; Hoxby, 2003; Musset, 2012). Governments are also turning to competing firms to provide services that have traditionally been provided by government agencies (Short and Toffel, 2015). An important motivation of such reforms is to create demand-side incentives for service providers to compete for customers by offering attractive options, implicitly assuming that the ability of consumers to swich providers will discipline firms.

With similar motivation, the Swedish government recently removed the mon opoly on car roadworthiness testing services. Before July 2010, roadworthiness inspection services were solely provided by a state-owned monopoly firm. Beginning July 2010, the market has been opened for new entrants and presently both the state-owned firm and other private firms provide car inspection services, competing for customers. Besides improving spatial accessibility to inspection stations, the other goals of the reform were to encourage greater price competition, and improve service quality and opening hours. A prerequisite for these desirable outcomes is that car owners' choices of a station be influenced by price and other non-price attributes. This paper investigates consumer preferences for station characteristics and their implications for demand and competition, and evaluates the impact of eliminating the state monopoly on consumer welfare specifically attributable to spatial accessibility.

Using the station choices by more than 920,000 car owners in Sweden in 2017, I estimate conditional and mixed logit demand models for inspection services. The estimated model is used to answer the following questions: (1) How do distance, price, opening hours, station size and other service characteristics affect the choice of station? This enables me to quantify consumers' valuations of the attributes of stations (2) How much have consumers benefited from improved geographical accessibility? and (3) How does the degree of competition between stations affects the demand elasticities of price and opening hours?

This paper uses a unique individual-level data that contain detailed information about car owners and the characteristics of all inspection stations. The data was provided to me by the regulator of the market, the Swedish Transport

Agency. For each station, the dataset contains rich information on the price of inspection, opening hours, monthly sales volume, whether the station provides drop-in service, ownership type, and the exact address where the station is located. For each car owner, the dataset also includes individual-level information on the exact address where the owner lives, which station s/he chose for inspection service, gender of the owner, age of the car, and whether the owner drives environmentally friendly car.

As with other spatially differentiated markets, I find that car owners put high value on proximity when choosing their preferred station, indicating that location is an important source of product differentiation. More specifically, owners are willing to pay SEK 41 or 9% more than the average price to avoid traveling one additional kilometer. Car owners are also more likely to choose a station with lower price and longer opening hours. The findings show that the average (median) elasticity of demand with respect to price is -0.91 (-1.02), whereas the average (median) elasticity of demand with respect to opening hours is 0.37 (0.44). The estimated demand elasticities vary between stations: stations that operate in highly competitive environments face higher demand elasticities, lending support to the notion that increased competition creates demand-side incentives for providers to meet consumers' needs.

As expected, the estimates indicate that competition decreases the likelihood of a station's being chosen. I also find that consumers attach a value of nearly SEK 43 to drop-in service. Consumers also value purchasing the service from state-owned stations by nearly SEK 34 more than purchasing the service from privately owned stations, indicating that either consumers attach value to the name of the state-owned incumbent company or the state-owned stations have unobserved attributes that are attractive to consumers. The findings also show that consumers have a preference for stations located in their own municipality than for stations located outside of their municipality.

Lastly, I examine the impact of abolishing the state monopoly on consumer welfare specifically attributable to improvement in the geographical accessibility to the stations. The number of stations increased from around 190 to 459 following the deregulation of the market and eventual entrance of private firms. Consequently, the distance to the nearest station decreased by 2.4 km for the average consumer. My welfare estimates indicate that the average consumer gained around SEK 100 in welfare from the improvement in spatial accessibility. The results of this paper indicate that even in markets where prices increased, spatial and other improvements in service attributes are essential to completely understand the welfare effects of changes in a market.[1] Since consumers value different characteristics of providers other than price, the welfare analysis could be biased if it fails to incorporate the non-price effects of market changes.

Many countries have regulations to carry out saftey and emision inspections for most types of motor vehicles. These regulations have created a multi-billion dollar industry involving hundreds of millions of car owners around the world. To the best of my knowledge, this paper is the first study to model demand for motor vehicle inspection services. My paper is part of the empirical industrial organization litraure that uses individual-level data to estimate demand models. This method is widely used to evaluate policy reforms that provide users of public services more choice of provider in health care (e.g., Beckert et al., 2012; Varkevisser et al., 2012; Gaynor et al., 2016; Santos et al., 2017), as well as in education (e.g., Hastings et al., 2005). These papers examine whether demand responds to quality in a setting where price is regulated. My demand analysis controls for price competition between providers. My paper is also broadly related to the literature on consumer choice in spatially differentiated markets (e.g., Thomadsen, 2005; Davis, 2006; Houde, 2012).

This paper is structured as follows. Section 2 describes the institutional features of the Swedish motor vehicle inspection market, Section 3 introduces the data, Section 4 presents the econometric strategy, and Section 5 presents the main results and welfare analyses. In Section 6, I carry out robustness analyses. The last section concludes.

2 The Swedish Car Inspection Market: Institutional Background

In Sweden, all car owners are required by law to periodically[2] inspect the roadworthiness of their cars by licensed inspection firms. Until July 2010, a state

[1] Compared to the pre-deregulation period, the average price for car inspection service in Sweden has increased by SEK 150.

[2] Presently, there is 3-2-1-1 system for non-commercial cars. This means, a new car should undergo the first mandatory inspection when it is three years old and the second inspection when it is five years old. Afterwards, the car must be inspected annually. Commercial cars should undergo inspection every year regardless of their age.

owned monopoly was responsible for the provision of inspection services.[3] Beginning in July 2010, the government deregulated the car inspection services and opened the market to private inspection firms. To promote competition between service providers, in 2012 the government sold around 70 stations of the monopoly to a private firm. Furthermore, the state and the other co-owners agreed to split the remaining assets of the monopoly between themselves; each established a separate inspection firm. After the separation, the state owns around 90 stations and has continued operating under the old company name. The other co-owners left, operating 55 stations under a new company name. Before the deregulation, there were around 190 state-owned stations, providing services around the country. At the end of April 2017, a total of 459 stations owned by eight firms were providing inspection services throughout the country.

Car owners have the right to choose which station to visit for inspection. A vehicle has to pass the mandatory inspection to legally operate on the road. Cars that fail inspection have to be fixed and re-inspected within a time period set by the inspecting firm. Inspection firms need to obtain accreditation from a government agency, the Swedish Board for Accreditation and Conformity Assessment (SWEDAC). The market is closely monitored by the Swedish Transport Agency, which sets the rules and regulations that inspection firms need to follow, such as what equipment and methods to use, as well as on the competence of the inspection technicians. To avoid distorting incentives, inspection firms are not allowed to provide any services other than car inspection services. Price is not regulated, thus firms have the right to set the prices for their services.

3 Data and Descriptive Statistics

I use individual-level data from the Swedish Transport Agency on all mandatory car inspections conducted by all inspection stations that operated in Sweden from January 2017 to April 2017. This study focuses on station choices by individuals who own passenger cars and light trucks that weigh less than 3500 kg, so the dataset excludes vehicles owned by organizations and vehicles that weigh

[3] The state owns 52% and different associations and insurance companies own the remaining 48%.

more than 3500 kg.[4] I further exclude station choices made by car owners for re-inspection services.[5] The final sample of the study contains station choices by 922,856 individuals at 452 stations operating throughout Sweden.[6]

For each car owner, the dataset provides detailed information on which station was chosen for the inspection, the gender of the owner, the age of the car, the exact address at which the the owner lives, and whether the car is environmentally friendly.[7] The dataset also contains rich information on the main characteristics of the stations. I know, for each station, the price of the inspection service, the number of opening hours per week in a given month, ownership type and whether the station provides drop-in service.[8] The dataset contains the market entry date of each station, which allows me to control for station age. As a proxy of station size, I use a station's average sales volume in the last six months of 2016. To capture proximity to an inspection station of a car owner's home, I compute straight-line distances using the geographical coordinates of the location at which the car owner lives and the locations of all stations providing inspection services. Finally, the degree of competition a station faces is measured in two ways, using the number of service providers in the station's geographic market[9] and distance to nearby competitors.[10]

3.1 Descriptive Statistics

Table 1 presents descriptive statistics of the characteristics of the inspection stations and car owners. Most car owners are male (65.3%). The average owner

[4] The price of inspection services for a vehicle that weighs more than 3500 kg is different from the price for a vehicle that weighs less than 3500 kg.

[5] If a car fails an initial inspection, a re-inspection is required by law. I exclude station choices for re-inspection because the price is different from an initial inspection.

[6] I drop seven stations without opening hours data. These are termed "mobile" stations, which provide limited hours of services in some days of the month, based on the number of pre-booked customers. Only 1,733 car owners chose these stations and were thus excluded from the final dataset.

[7] A car is considered to be environmentally friendly if it is exclusively powered by renewable fuels or possesses a system for any form of clean fuel alternative in addition to fossil fuels.

[8] There are some stations that provide only pre-booked inspection services. The prices for pre-booked and drop-in services are different. Since the data can not tell me whether an individual visits a station with pre-booked appointment or not, I use the price for pre-booked services in this study. However, the prices for pre-booked and drop-in services are positively correlated ($\rho = 0.71$).

[9] I use the actual travel distances of a station's customers to approximate the station's catchment area.

[10] Three versions: distance to the nearest, average distance to the two nearest and average distance to the three nearest.

Table 1: Summary Statistics of Variables

Variable	Mean	Median	Std. dev.	Min	Max	N
Station Characteristics						
Price	450.078	450	33.545	299	750	452
Opening Hours (per week)	47.766	45	6.343	13.5	76	452
Station age (days)	1584.318	1812.5	723.4	3	2476	452
Sales[a] (No. of inspected cars)	797.668	603.988	608.538	53.667	3825.167	452
Pass rate[b]	0.749	0.741	0.053	0.565	0.882	452
Drop-in service	0.887	1	0.317	0	1	452
State owned	0.199	0	0.4	0	1	452
No. of competitors within a market	3.708	3	2.789	1	16	452
Distance to nearest station (km)	10.232	2.891	15.411	0.083	92.293	452
Avg. Dist. to 2 nearest stations (km)	13.243	5.556	16.728	0.270	95.756	452
Avg. Dist. to 3 closest stations (km)	15.869	8.440	18.007	0.876	110.060	452
Car owners characteristics						
female	0.347	0	0.476	0	1	922856
Car age (days)	4474.263	4104	2182.897	368	29305	922856
Green car	0.079	0	0.27	0	1	922856
Own municipality (chosen station)	0.787	1	0.41	0	1	922856
Distance to chosen station (km)	9.326	5.156	11.033	0.008	330.069	922856

Notes: [a]the average number of inspected cars in the last six months of 2016. [b]the average pass rate in the last six months of 2016.

drives a car that is 4,474 days old. About 78.7% choose a station located in their own municipality. Nearly 7.9% drive environmentally friendly cars. There is considerable variation in the distances car owners travel for inspection service: the average car owner travels 9.3 km but one-half of the car owners travel no more than 5.2 km. Figure 1 shows the whole distribution of travel distances to the chosen stations, it indicates that the majority of car owners chose a station within a reasonable distance from their home.

On the service providers' side, the average station charges SEK 450, is 1,584 days old,[11] and provides 47.8 hours of services per week on weekdays. There are a total of 90 state owned stations. The sales volume varies considerably between stations, with the average station conducting 797 car inspections per month. The fraction of cars that pass inspection (pass rate) varies. The mean pass rate

[11]I use December 21, 2010 as the entry date of those stations that were owned by the monopoly company and were later partly sold or transferred to private firms. These stations obviously were in the market before December 21, 2010, However, after the deregulation of the market, the previous monopoly company was reorganized and obtained a new license as of December 21, 2010.

Table 2: Distribution of Distances to the *Nth* Nearest Stations

Variable	Mean	Median	P90	Std. dev.	Min	Max
Distance to the nearest	6.558	3.121	16.400	7.979	0.006	146.150
Distance to the 2^{nd} nearest	13.036	7.656	30.458	14.239	0.075	178.689
Distance to the 3^{rd} nearest	18.301	12.669	40.708	18.673	0.443	216.301
Distance to the 4^{th} nearest	22.782	17.910	46.794	21.506	1.043	259.743
Distance to the 5^{th} nearest	28.685	23.065	56.487	26.496	1.416	321.509
Distance to the 6^{th} nearest	32.937	27.002	64.125	29.106	2.018	324.923
Distance to the 7^{th} nearest	36.457	29.527	71.961	31.016	2.752	324.931
Distance to the 8^{th} nearest	39.836	32.266	77.327	33.140	3.300	328.339
Distance to the 9^{th} nearest	43.363	35.336	88.602	35.482	4.085	330.602
Distance to the 10^{th} nearest	46.130	37.852	95.835	36.648	4.985	331.479

is 74.1%. The average station has its nearest competitor at a distance of 10.2 km, whereas each station has two competitors on average within 13.2 km and three competitors within 15.9 km. We also see that there are 3.7 service providers in the average station's geographic market.

Lastly, to get a sense of whether car owners bypass their nearest station, Figure 2 presents the percentage of car owners who chose their nearest, second nearest and so on station for inspection services. We see that around 53.9% chose a station bypassing their nearest one, which indicates that various station characteristics other than just location also affect car owners' choices of station. Table 2 presents the distribution of distances from the car owner's home to nearby stations. The first row shows that the distance to the nearest station for the average car owner is 6.6 km. One-half of the car owners in the sample have access to a station within 3.1 km, and 90% can find a station located within 16.4 km of where they live.[12]

3.2 Choice Sets

To define the set of alternatives that are available to each car owner, I rely on the travel distances to the actual chosen stations. Figure 2 shows that the vast

[12] The rest of the rows of Table 2 contain the distances to the second nearest, third nearest and so on station for car owners in our sample. For example, according to row three the average car owner has access to two stations within 13 km, one-half of the sample have access to two stations within 7.7 km and 90% have access to two stations within 30.5 km.

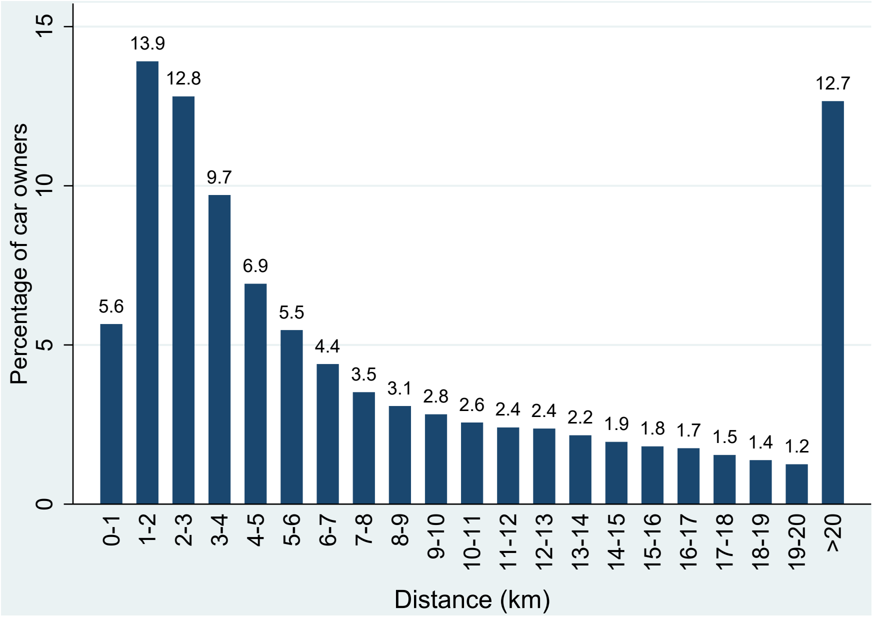

Figure 1: Distribution of distances to chosen station

majority (80.3%) chose a station from the three nearest stations to where they live. In this study, I construct car owner specific choice sets consisting of the 10 stations nearest to the owner's home.[13] As a robustness check, I will subject the main results to different ways of defining the choice sets, specifying choice sets as consisting of stations up to the nearest 11, 13 stations, and down to the nearest 8, 6, 4 and 3 stations.

4 Empirical Approach

I estimate a conditional logit random utility model of a car owner's choice of station. The model is derived based on the assumption that car owners choose a station that maximizes their utility. Assuming a linear utility function and de-

[13]This excludes 26,736 car owners from the main analysis since they chose a station outside of their 10 nearest stations. When I carry out a robustness check, the choice set is defined as up to the 13 nearest stations from each car owner's home. As a result, 15,756 individuals out of the 26,736 will be included in the analysis, since they chose their station from the 11th, 12th and 13th nearest ones to their homes.

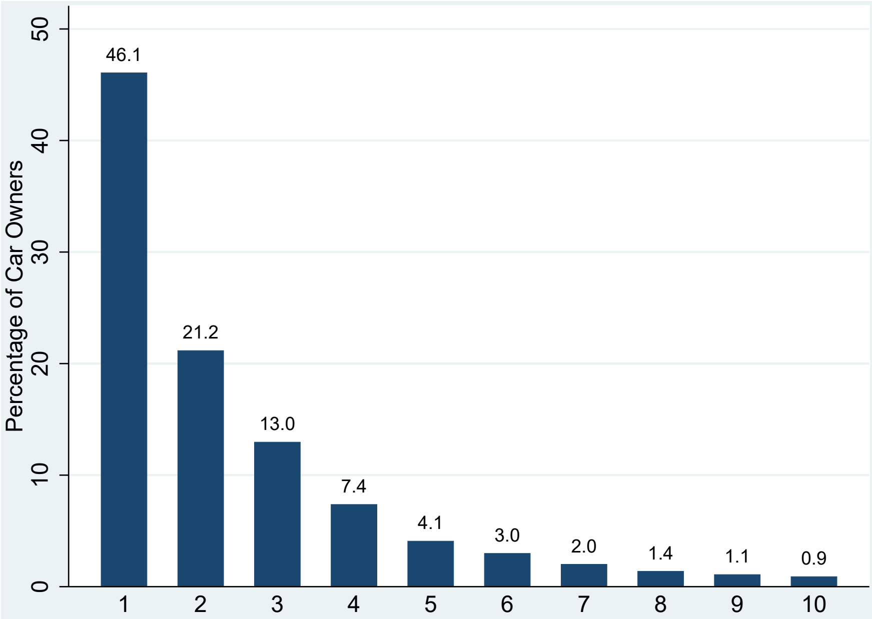

Figure 2: Percentage of car owners who went to their *Nth* nearest station

noting car owner i's choice set of stations by C_i , the utility of car owner i from choosing station $j \in C_i$ is given by

$$U_{ij} = D_{ij}\alpha_1 + D_{ij}^2\alpha_2 + \boldsymbol{x}_j'\boldsymbol{\beta} + \epsilon_{ij} = V_{ij} + \epsilon_{ij}, \tag{1}$$

where $\boldsymbol{x}_j = (x_{1j}, ..., x_{Kj})$ is a vector of K observed characteristics of station j, and D_{ij} denotes the distance from car owner i's home to station j. Here, $\alpha_1, \alpha_2, \boldsymbol{\beta}$ are parameters to be estimated, and ϵ_{ij} is a random error term representing unobservable factors that affect i's valuation of station j. Under the assumption that the random errors of the utility function, ϵ_{ij}, are independently and identically distributed with type-1 extreme value distribution, McFadden (1974) shows that the probability that car owner i chooses alternative $j \in C_i$ is

$$P_{ij} = \frac{exp(V_{ij})}{\sum_{l \in C_i} exp(V_{il})} \tag{2}$$

This model assumes homogeneous preferences for station characteristics across individuals. I capture preference heterogeneity in two ways. First, by reestimating my model for a number of separate samples: by gender, by car age, and by car type. Second, by estimating a model that allows for observable heterogeneity in preferences. In the latter case, I introduce heterogeneity into the model by interacting observable station characteristics and distance with the car owners' characteristics. The utility that car owner i derives from choosing station $j \in C_i$ is now given by

$$U_{ij} = D_{ij}\omega_1 + D_{ij}^2\omega_2 + \boldsymbol{x}_j'\boldsymbol{\rho} + \sum_{\mathrm{k}=1}^{K} D_{ij} Z_{i\mathrm{k}}\phi_{\mathrm{k}} + \sum_{\mathrm{k}=1}^{K} D_{ij}^2 Z_{i\mathrm{k}}\theta_{\mathrm{k}} + \sum_{\mathrm{k}=1}^{K} Z_{i\mathrm{k}}\boldsymbol{x}_j'\boldsymbol{\lambda}_{\mathrm{k}} + \xi_{ij} \tag{3}$$

where $\boldsymbol{x}_j$ is a vector of observed characteristics of station j, D_{ij} denotes the distance from car owner i's home to station j, $(Z_{i\mathrm{k}}, \mathrm{k} = 1, ..., K)$ denote the car owner's characteristics (gender, age of the car and whether the owner drives an environmentally friendly car), and ξ_{ij} are unobserved random error terms. The fourth, fifth and sixth terms in equation 3 represent interactions between distance and car owner characteristics, squared distance and car owner characteristics and, car owner and station characteristics, respectively. Hence, the vectors of coefficients $\boldsymbol{\rho}$, $(\boldsymbol{\lambda}_{\mathrm{k}}$, k = 1, ..., $K)$, and parameters ω_1, ω_2, $(\phi_{\mathrm{k}}$, k = 1,.... , K) and $(\theta_{\mathrm{k}}$, k = 1,.... , $K)$ will be estimated.

In this model, I am only able to capture differences in preferences according to observed characteristics of the car owners. However, heterogeneity in preferences can also arise from unobservable characteristics (Hole, 2008). To allow for unobservable heterogeneity in preferences for station characteristics, I estimate mixed logit model. The mixed logit model is the most flexible discrete choice model and can approximate any random utility model (Hensher and Greene, 2003; Train, 2003). The model produces a flexible substitution pattern since it does not have the property of Independence of Irrelevant Alternatives (IIA), which is the result of the assumption of the standard logit model that the error terms are independently and identically distributed (IID) (Hensher and Greene, 2003; Train, 2003). The mixed model accommodates heterogeneity by allowing the estimates of the model to vary with the individual. The utility associated with car owner *i's* choosing *j* is now represented by

$$U_{ij} = \boldsymbol{x}'_{ij}\boldsymbol{\beta}_i + \mu_{ij} \tag{4}$$

where $\boldsymbol{\beta}_i$ is a vector of individual-specific coefficients, $\boldsymbol{x}_{ij}$ is a vector of observable station characteristics including distance from *i*'s home to station *j* and μ_{ij} is IID according to extreme value type-1 distribution. Denoting the density of $\boldsymbol{\beta}_i$ by $f(\boldsymbol{\beta}\backslash\boldsymbol{\theta})$, the unconditional choice probability that car owner *i* chooses alternative $j \in C_i$ is

$$P_{ij}(\boldsymbol{\theta}) = \int_{\boldsymbol{\beta_i}} \frac{exp(\boldsymbol{x}'_{ij}\boldsymbol{\beta}_i)}{\sum_{l \in C_i} exp(\boldsymbol{x}'_{il}\boldsymbol{\beta}_i)} f(\boldsymbol{\beta}\backslash\boldsymbol{\theta})\, d\boldsymbol{\beta} \tag{5}$$

which is the integral of the standard logit probability integrated over all possible values of $\boldsymbol{\beta_i}$, weighted by the density of $\boldsymbol{\beta_i}$. The probability is a function of $\boldsymbol{\theta}$, which represents the parameters of the density of $\boldsymbol{\beta}$. Unlike the conditional logit model, the probability equation of the mixed logit model in equation 5 does not have a closed form solution. As a result, the integral is approximated through simulation (Hensher and Greene, 2003; Train, 2003). The researcher needs to specify the appropriate density for $\boldsymbol{\beta_i}$, draw a value from the density and calculate the integrand of equation 5. These steps are repeated several times and the average gives simulated choice probability. I specify normal and log-normal distributions for the coefficients of the station attributes and estimate the model with maximum simulated likelihood using 200 Halton draws.[14]

4.1 Elasticities, Willingness to Pay and Willingness to Travel

Since the utility function is only unique up to a positive linear transformation, the estimated coefficients convey information only about the sign of the marginal utility of the station attributes and the sign of the effect of the attributes on demand. The marginal rate of substitution between two attributes is invariant to

[14] As the number of draws increases, the simulated probability becomes less biased (Train, 2003) but increases the computational burden. For example, both Gutacker et al. (2016) and Santos et al. (2017) used 50 Halton draws to estimate mixed logit model.

the scale of utility and provides quantitative information about car owners' valuations of attributes, which can be compared between different samples of individuals. I calculate the willingness to pay (WTP) and the willingness to travel (WTT) for one unit improvement in station attributes. The WTT is derived from the ratio of the coefficient on a specific attribute to the marginal utility of distance.[15] In the same way, the WTP is derived from the ratio of the coefficient on a specific attribute to the marginal utility of income (i.e., the estimated price coefficient). The delta method is used to estimate the standard errors of the WTT and WTP estimates (Hole, 2007).

I also compute the elasticity of demand a station faces with respect to price and opening hours. The expected number of car owners choosing station j is $\hat{n}_j = \sum_{i \in S_j} \hat{P}_{ij}$, where S_j is the set of car owners whose choice sets include station j and $\hat{p}_{ij}$ is the probability that individual i chooses station j. Following Santos et al. (2017), the elasticity of demand of station j with respect to own price and opening hours is

$$\epsilon_j^x = \frac{\partial \hat{n}_j}{\partial x_j} \frac{x_j}{\hat{n}_j} = \sum_{i \in S_j} \hat{\beta}_x \hat{p}_{ij}(1 - \hat{p}_{ij}) \frac{x_j}{\sum_{i \in S_j} \hat{p}_{ij}} \quad (6)$$

where $\hat{\beta}_x$ is the estimates of the coefficient of attribute x. The distribution of (6) across all stations for both price and opening hours is presented.

I am also interested in the number of additional cars a station would obtain by lowering price by one krona and increasing opening hours per week by one hour. The estimated change in the number of car owners choosing station j resulting from changing price and opening hours by one unit is

$$\frac{\partial \hat{n}_j}{\partial x_j} = \sum_{i \in S_j} \hat{\beta}_x \hat{p}_{ij}(1 - \hat{p}_{ij}) \quad (7)$$

The distribution of (7) across all stations for both price and opening hours is presented.

[15] The quadratic form of distance is evaluated at the mean distance to the chosen stations.

5 Results

Table 3 presents the results from two model specifications. Model 1 shows results for my baseline specification with distance in its quadratic form, price, service opening hours, station size, number of competitors and station age. Furthermore, the model includes indicators for drop-in service, whether the station is located within the car owner's municipality and whether the station is owned by the state. The first columns of Tables 4, respectively, 5, present the estimates of WTP, respectively, WTT, based on the baseline model.

These parameter estimates of the baseline model are all highly significant. The distance coefficients suggest that car owners care about distance to a station. The positive coefficient on the quadratic term of distance implies that the disutility from distance declines with distance. As shown in the first column of Table 4, consumers are willing to pay SEK 41 to avoid travelling one additional kilometer. The results also show that car owners prefer stations that offer lower prices and longer opening hours. They also prefer stations that provide drop-in services and that are large in size. They value a station with drop-in service nearly SEK 43 more than a station without drop-in service.

As expected, the model estimates also indicate that stations facing large number of competitors are less likely to be chosen. After controlling for observed station characteristics, I also find that car owners prefer state-owned stations over privately owned stations, reflecting that either there are unobserved characteristics of state owned stations that have a positive effect on consumer choice or consumers attach value to the name of the incumbent state owned company.[16] The WTP estimate indicates that consumers value purchasing the service from state owned stations nearly SEK 34 more than purchasing the service from privately owned stations. The positive coefficient on the dummy for home municipality station shows that consumers prefer stations located in their home municipality to stations located in a neighboring municipality.

[16] Hortacsu et al. (2017) also find sizable incumbent brand effect in retail choice market for residential electric power in a market setting where the quality of power consumers obtain is independent of retailers.

Table 3: Choice of Stations: Estimates of Marginal utilities

	Model 1		Model 2	
Variable	Coeff.	SE	Coeff.	SE
Distance	−0.14261∗∗∗	(0.000486)	−0.15459∗∗∗	(0.001129)
Distance squared	0.00045∗∗∗	(0.000005)	0.00050∗∗∗	(0.000013)
Price	−0.00324∗∗∗	(0.000047)	−0.00371∗∗∗	(0.000118)
Opening hours	0.01257∗∗∗	(0.000281)	0.00848∗∗∗	(0.000705)
Station size	0.00051∗∗∗	(0.000002)	0.00051∗∗∗	(0.000006)
Pass rate	0.01701∗∗∗	(0.000348)	0.01784∗∗∗	(0.000859)
No. of competitors	−0.04377∗∗∗	(0.000898)	−0.01810∗∗∗	(0.002238)
Station age	0.00036∗∗∗	(0.000003)	0.00035∗∗∗	(0.000007)
Drop-in service	0.13790∗∗∗	(0.006086)	0.28937∗∗∗	(0.015083)
Municipality	0.94359∗∗∗	(0.004822)	0.96367∗∗∗	(0.011703)
State owned	0.10936∗∗∗	(0.004104)	0.29620∗∗∗	(0.010279)
Interaction with Green Car				
X Distance			−0.01850∗∗∗	(0.001823)
X Distance squared			0.00012∗∗∗	(0.000011)
X Price			0.00000	(0.000180)
X Opening hours			0.00089	(0.001010)
X Station size			−0.00003∗∗∗	(0.000009)
X Pass rate			−0.00329∗∗	(0.001290)
X No. of competitors			0.00719∗∗	(0.003265)
X Station age			0.00002∗∗	(0.000010)
X Drop-in service			0.00609	(0.022109)
X Municipality			−0.06437∗∗∗	(0.017482)
X State owned			0.09276∗∗∗	(0.015138)
Interaction with Female				
X Distance			−0.00803∗∗∗	(0.001020)
X Distance squared			0.00004∗∗∗	(0.000010)
X Price			0.00101∗∗∗	(0.000101)
X Opening hours			−0.00070	(0.000598)
X Station size			0.00003∗∗∗	(0.000005)
X Pass rate			0.00135∗	(0.000737)
X No. of competitors			−0.00982∗∗∗	(0.001905)
X Station age			0.00005∗∗∗	(0.000006)
X Drop-in service			0.02765∗∗	(0.012836)
X Municipality			0.06914∗∗∗	(0.010168)
X State owned			0.06768∗∗∗	(0.008690)
Interaction with Age of Car				
X Distance			0.00000∗∗∗	(0.000000)
X Distance squared			−0.00000∗∗∗	(0.000000)
X Price			0.00000	(0.000000)
X Opening hours			0.00000∗∗∗	(0.000000)
X Station size			−0.00000	(0.000000)
X Pass rate			−0.00000	(0.000000)
X No. of competitors			−0.00001∗∗∗	(0.000000)
X Station age			−0.00000∗∗	(0.000000)
X Drop-in service			−0.00004∗∗∗	(0.000003)
X Municipality			−0.00001∗∗∗	(0.000002)
X State owned			−0.00005∗∗∗	(0.000002)

Continued on next page

Table 3: Continued from previous page

	Model 1		Model 2	
Variable	Coeff.	SE	Coeff.	SE
BIC	2,298,900		2,295,400	
AIC	2,298,746		2,294,796	
Pseudo R^2	0.459		0.460	
No. of observations	9,228,560		9,228,560	
No. of car owners	922,856		922,856	
No. of stations	452		452	

Notes: Conditional logit models of station choice. Robust standard errors are presented in parentheses. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion. *** indicates significance at 1% level and ** significance at 5% level.

5.1 Is There Preference Heterogeneity?

I examine observable heterogeneity in preferences in two ways. First, I augment the baseline specification by including interaction terms between car owners and stations' characteristics. Second, I reestimate the baseline model for different samples: by owner gender, by car age and by whether the owner drives environmentally friendly car. I present the results for six different groups in Table 13 in the Appendix. Columns 2-7 of Tables 4 and 5 present WTP and WTT estimates respectively for each group of individuals.

Model 2 in Table 3 presents the results from the specification in (3), which includes interaction terms between observed car owner characteristics (gender, age of the car and whether the owner drives environmentally friendly car) and station characteristics. The negative coefficient on the interaction term between the dummy for environmentally friendly car owners and distance indicates that environmentally friendly car owners put more value on proximity than owners of conventional cars. Based on WTP estimates, "green" car owners are willing to pay nearly SEK 6 more than conventional car owners to avoid traveling one kilometer. I also find that "green" car owners value drop-in service and state-owned stations more than other car owners.

When we see preference differences across gender, female car owners put greater value on proximity, drop-in service, home municipality stations and state owned stations more than their male counterparts. Females are willing to pay SEK 54 while their male counterpart pay SEK 37 to avoid traveling one addi-

Table 4: Willingness to Pay (WTP)

Variable	Baseline	Green	Non-green	Male	Female	Car age below median	Car age above median
Distance (km)	41.47	46.75	41.06	36.85	54.18	41.48	41.43
Opening hours	3.88	3.69	3.89	3.58	4.65	3.38	4.38
Pass rate (%)	5.26	4.36	5.33	4.62	6.95	5.47	5.01
Station age (days)	0.11	0.12	0.11	0.1	0.15	0.11	0.11
Drop-in service	42.61	56.08	41.45	35.38	62.12	57.49	24.93
Municipality	291.6	270.3	292.71	257.13	383.79	279.88	299.36
State owned	33.79	75.8	29.95	23.54	61.84	60.26	3.11

Notes: The table presents the amount of extra money (SEK) car owners would be willing to pay for one unit improvement in station characteristics. Improvement on distance corresponds to a decrease in distance. WTP is the ratio of a coefficient on a specific station characteristic to the coefficient on price. The corresponding standard errors on the WTP estimates are computed using Delta method (*nlcom*) and presented in the appendix. The WTP for visiting government stations for car owners with above-median car age is significant at 11% level, otherwise all WTP estimates are significant at 1% level.

Table 5: Willingness to Travel (WTT)

Variable	Baseline	Green	Non-green	Male	Female	Car age below median	Car age above median
Price (kr)	24.1	21.4	24.4	27.1	18.5	24.2	24.1
Opening hours	93.7	79	94.6	97.2	85.9	81.4	105.8
Pass rate (%)	126.8	93.2	129.8	125.4	128.4	131.8	120.8
Station age (days)	2.7	2.5	2.7	2.6	2.8	2.6	2.8
Drop-in service	1027.6	1199.5	1009.4	960	1146.7	1385.3	600.6
Municipality	7031.3	5781.4	7128.8	6977.6	7084.1	6753.6	7220
State owned	814.9	1621.2	729.4	638.7	1141.5	1451.1	74.1

Notes: The table presents the number of extra meters car owners would be willing to travel for one unit improvement in station characteristics. Improvement on price corresponds to a decrease in price. WTT is the ratio of a coefficient on a specific station characteristic to the coefficient on distance. The quadratic form of distance is evaluated at the mean distance to the chosen stations. The corresponding standard errors on the WTT estimates are computed using Delta method (*nlcom*) and presented in the appendix. All WTT estimates are significant at 1% level.

tional kilometer. Females are also willing to pay SEK 27 for drop-in service, SEK 127 for home municipality stations and SEK 38 for state-owned stations more than male car owners. Finally, car owners who drive relatively new cars put higher value on drop-in service and state owned stations, but put lower value on home municipality stations than car owners who drive relatively old cars.

Table 6: Choice of Stations: Mixed Logit Model Estimates of Marginal Utilities

		Model 1		Model 2	
Variable	Parameter	Value	SE	Value	SE
Distance	Mean of coeff.	-0.208748***	(0.001649)	-1.572265***	(0.007634)
	S.D. of coeff.	0.079352***	(0.001564)	0.713426***	(0.011359)
Distance squared	Mean of coeff.	0.000232***	(0.000019)	-8.639130***	(0.055158)
	S.D. of coeff.	0.000001	(0.000006)	-0.001832	(0.043826)
Price	Mean of coeff.	-0.004770***	(0.000122)	-0.005139***	(0.000127)
	S.D. of coeff.	-0.000042	(0.000322)		
Opening hours	Mean of coeff.	0.014996***	(0.000700)	0.015628***	(0.000730)
	S.D. of coeff.	-0.000522	(0.000384)		
Station size	Mean of coeff.	0.000524***	(0.000006)	0.000537***	(0.000006)
	S.D. of coeff.	-0.000007	(0.000004)		
Pass rate	Mean of coeff.	0.018062***	(0.000899)	0.018588***	(0.000921)
	S.D. of coeff.	-0.003688	(0.004364)		
No. of competitors	Mean of coeff.	-0.012647***	(0.002320)	-0.010485***	(0.002392)
	S.D. of coeff.	-0.000971	(0.001816)		
Station age	Mean of coeff.	0.000656***	(0.000011)	0.000705***	(0.000012)
	S.D. of coeff.	-0.000975***	(0.000018)	0.001046***	(0.000018)
Drop-in service	Mean of coeff.	0.142597***	(0.016013)	0.169562***	(0.016428)
	S.D. of coeff.	0.052880	(0.038584)		
Municipality	Mean of coeff.	1.077941***	(0.016623)	1.064846***	(0.016657)
	S.D. of coeff.	-1.438582***	(0.036503)	1.317297***	(0.037303)
State owned	Mean of coeff.	0.011561	(0.012952)	-0.023239*	(0.012909)
	S.D. of coeff.	-0.850281***	(0.045355)	1.066314***	(0.034419)
No. of car owners		200,000		200,000	
No. of stations		452		452	
No. of observations		2,000,000		2,000,000	
BIC		492,496		490,859	
AIC		492,221		490,659	

Notes: Mixed logit models of station choice. In model 1, all coefficients are normally distributed. In model 2, coefficients of distance and squared distance are log-normally distributed; the coefficients on stage age, municipality and state owned are normally distributed; the coefficients on price, opening hours, station size, number of competitors and drop-in service are fixed. Robust standard errors are presented in parentheses. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion. *** indicates significance at 1% level and * significance at 10% level.

Table 7: Point Estimates of Log-Normal Coefficients

Variable	Median	Mean	S.D.
Distance	−0.207574	−0.296546	−0.302560
Distance squared	0.000177	0.000177	−0.000008

5.2 Mixed Logit Model

To allow for unobserved heterogeneity in preferences, I estimate a mixed logit model where model parameters are allowed to vary across individuals. Due to computational constraint, I estimate the mixed logit model using station choices made by a random sample of 200,000 car owners (which is more than 20% of the baseline dataset). An important issue in specifying mixed logit model is determining which station characteristics should have random coefficients and what distribution they should follow (Hensher and Greene, 2003; Hole, 2008). I estimate two alternative specifications. In the first specification, all parameters of the model are assumed to be distributed according to normal distribution. In the second specification, the coefficients on station age, indicators for home municipality stations and state owned stations will have normal distribution and the coefficients on distance will have log-normal distribution.[17] The coefficients on price, opening hours, station size, pass rate, number of competitors and indicator for drop-in service are assumed to be fixed.[18]

Model 1 in Table 6 presents the results from the first specification where all coefficients are normally distributed. The estimated mean coefficients are statistically significant and similar in sign to the conditional logit model results. Car owners prefer stations located closer to their homes and that offer lower prices. Car owners also prefer stations that provide longer opening hours, drop-in service and that are large in size. They also prefer stations located in their home municipality to stations located in neighboring municipalities. The coefficient on the indicator for state-owned stations is insignificant but has positive sign.

The standard deviation of the distance coefficient is significant, suggesting that the effect of distance differs across individuals. The estimated standard deviations of the coefficients on station age, indicators for home municipality stations and state ownership are significant, which implies that valuation

[17] A log-normally distributed variable takes only positive values. Specifying the coefficient on distance to have log-normal distribution ensures all car owners to have the same (positive) sign on the coefficient of distance. Since I expect negative coefficient on distance, I multiply the distance variable by minus one before estimation and the actual coefficient becomes the negative of the exponential of the estimated coefficient.

[18] Fixed coefficient specification follows partly from the results of the first mixed logit specification, in which the estimated standard deviations of the coefficients on these variables are insignificant suggesting no differences across individuals in valuation of these station characteristics.

of these characteristics differs across individuals. All the other coefficients have insignificant standard deviations indicating that values attached to these characteristics do not vary across individuals.

Consider now the results from the second specification where the coefficients are considered to be fixed, normally and log-normally distributed. Model 2 in Table 6 presents the results. The parameter estimates of the model are statistically significant and not different in sign to the results of the conditional logit models except for state ownership indicator. The estimated standard deviations of the coefficients on distance, station age, indicators for home municipality stations and stations owned by the state reveal the existence of preference heterogeneity across individuals. The mean coefficients on distance, price and indicator for home municipality stations are larger than those from the baseline model.

The estimates of log-normally distributed parameters on distance and squared distance in Table 6 are the means (m_k) and standard deviations (sd_k) of the natural logarithm of the coefficients. Train (2003) shows that the point estimates for the median, mean and standard deviations of the corresponding original coefficients are given by $exp(m_k)$, $exp(m_k+sd_k^2/2)$ and $exp(m_k+sd_k^2/2)\sqrt{exp(sd_k^2)-1}$ respectively.[19] The results are presented in Table 7. The negative coefficient on distance indicates that car owners dislike to travel. The estimated standard deviation of the distance coefficient is significant, implying that sensitivity to distance differs across individuals.

The results from the model specification that allow for observed heterogeneity in (3) and unobserved heterogeneity in (4) are generally similar in signs and statistical significance to the results obtained from the baseline specification in (1). I therefore continue considering the baseline model specification as a reasonable representation of the car owners' choice behavior.

5.3 The Effect of Price and Opening Hours on Demand

Using the estimates from the baseline choice model of Table 3, I illustrate the effect of price and opening hours on demand. Tables 8 and 9 present the estimated effect of price and opening hours on demand respectively. The first rows

[19] Note that since I multiplied the distance variable by negative one initially, the estimates in Table 7 are obtained after being multiplied by negative one to take that into account.

Table 8: Effect Sizes of Price

Variable	Mean	S.D.	25th percentile	Median	75th percentile	90th percentile
Elasticity of demand	−0.91	0.38	−1.21	−1.02	−0.59	−0.33
Demand change	3.74	2.91	1.87	3.08	4.75	7.22
% Demand change	0.20	0.086	0.13	0.23	0.27	0.29

Notes: Elasticity of demand: percentage change in demand resulting from one percent increase in price. Demand change: number of additional customers a station will gain from lowering price by one krona. % Demand change: the percentage change in demand resulting from lowering price by one krona.

Table 9: Effect Sizes of Opening Hours

Variable	Mean	S.D.	25th percentile	Median	75th percentile	90th percentile
Elasticity of demand	0.37	0.16	0.24	0.440	0.50	0.54
Demand change	14.55	11.31	7.30	11.98	18.46	28.06
% Demand change	0.79	0.33	0.50	0.90	1.08	1.15

Notes: Elasticity of demand: percentage change in demand resulting from one percent increase in opening hours. Demand change: number of additional customers a station will gain resulting from one hour increase per week in opening hours. % Demand change: the percentage change in demand resulting from one hour increase in opening hours.

of Tables 8 and 9 provide the elasticity of demand with respect to own price and opening hours respectively. The responsiveness to changes in price and opening hours differs across stations. The mean (median) demand elasticity with respect to price is -0.91 (-1.02) and with respect to opening hours is 0.37 (0.44). The second and third rows of Tables 8 and 9 present the number of additional customers a station will gain and the percentage change in demand respectively resulting from a reduction by one krona in the price and an increase by one hour in the opening hours per week. Reducing the price by one krona is expected to increase the number of inspected cars at a station on average by four, which is 0.20% of the predicted demand at the current price levels. Increasing opening hours by one hour per week is estimated to increase the number of inspected cars at a station on average by fifteen, which is 0.79% of the predicted demand at the current opening hours levels.

There is a variation across stations in the estimated effects on demand of changes in own-price and opening hours. The expected increase in the number of customers from a one krona reduction in price varies from seven(at the 90th

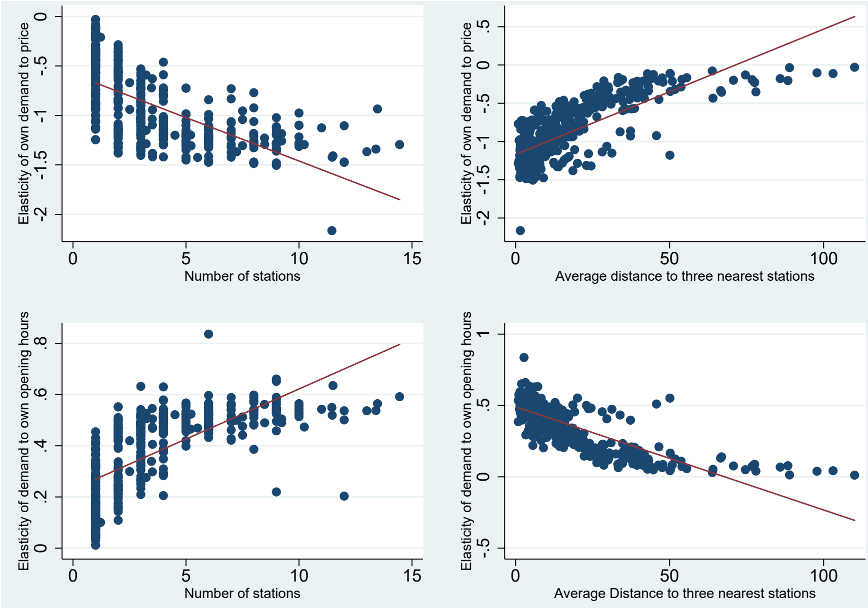

Figure 3: Elasticity of Demand by Degree of Competition. *Notes: These figures plot Price and opening hours elasticity of demand against the degree of competition a station faces (measured using both the number of stations in a given market and average distance to three nearest stations). Solid lines show best linear fit as follows: Top left (Intercept = -0.58 (SE = 0.022), slope = -0.08 (SE = 0.004),* R^2 *= 0.42); Top right (Intercept = -1.16 (SE = 0.015), slope = 0.02 (SE = 0.000),* R^2 *= 0.59); Bottom left (Intercept = 0.23 (SE = 0.009), slope = 0.04 (SE = 0 .001),* R^2 *= 0.46); Bottom right (Intercept = 0.49 (SE = 0.006), slope = -0.01 (SE = 0.000),* R^2 *= 0.64).*

percentile) to two (at the 25th percentile). The percentage change in demand from a one krona reduction in price varies from 0.29% (at the 90th percentile) to 0.13% (at the 25th percentile). Similarly, the expected increases in the number of customers from a one hour increase in opening hours per week are 28 (at the 90th percentile) and seven (at the 25th percentile). The corresponding percentage changes in demand from a one hour increase in opening hours are 1.15 at the 90th percentile and 0.5 at the 25th percentile.

Table 10: Correlation Matrix: Demand Elasticity and Competition Measures

Variable	(1)	(2)	(3)	(4)	(5)	(6)
(1)Price elasticity	1					
(2)OH elasticity	−0.9226	1				
(3) No. of competitors	−0.6456	0.6797	1			
(4)Distance to nearest	0.7349	−0.7758	−0.4959	1		
(5)Avg. distance to 2 nearest	0.7683	−0.8056	−0.5547	0.9526	1	
(6)Avg. distance to 3 nearest	0.7684	−0.7998	−0.5781	0.9145	0.9885	1

Notes: Price elasticity: elasticity of demand with respect to price. OH elasticity: elasticity of demand with respect to opening hours. No. of competitors: number of competitors a station faces within its geographic market. Distance to nearest: distance to the nearest competitor. Avg. distance to 2 nearest: average distance to two nearest competitors. Avg. distance to 3 nearest: average distance to three nearest competitors.

5.4 Demand Elasticity and Competition

The first rows of Tables 8 and 9 present the distribution of demand elasticities. The tables show that there is heterogeneity in the effects of price and opening hours across stations. The estimated elasticities with respect to price and opening hours are -0.33 and 0.54, respectively at the 90th percentile. At the 25th percentile, the demand elasticities with respect to price and opening hours are -1.21 and 0.24 respectively.

I also examine how much does the degree of competition a station faces explain the variation between stations in the elasticity of demand. Figure 3 shows the linear relation between demand elasticities and competition, measured by the number of competitors in a geographic market and distance to nearby competitors. Stations in more competitive areas face larger price and opening hours elasticities than stations in less competitive areas. The degree of competition a station faces, measured by the number of service providers within a station's geographic market, explains 42% of the variation in price elasticity of demand and 46% of the variation in demand elasticity with respect to opening hours. Similarly, about 59% of the variation in price elasticity of demand and 64% of the variation in opening hours elasticity of demand are explained by the degree of competition a station faces, here measured by the average distance to the three nearest competitors. The correlation coefficients between the estimated demand elasticities and my competition measures are presented in Table 10. There is a high level of correlation between the demand elasticities and the

Table 11: Distribution of Distances to the Nearest Station

	Distance to the nearest station (Pre-deregulation, July 2010)	Distance to the nearest station (Post-deregulation, April 2017)
Mean	8.97	6.55
Median	5.34	3.12
P75	13.17	9.16
P90	21.12	16.40
Std. dev.	8.88	7.97
No. of Stations	194	452
No. of Observations	922,856	922,856

measures of competition, once again suggesting that stations in highly competitive areas (shorter distance to nearby competitors or a larger number of nearby competitors) face higher demand elasticities than those operating in less competitive areas.

5.5 Welfare Gain from Improved Geographical Accessibility

An important goal of the deregulation was to improve geographical accessibility of the inspection stations to the vehicle owners. In this section, I will quantify the welfare gain to consumers from the improvement in spatial accessibility following the deregulation. Before the elimination of the monopoly, a total of 194 state owned stations were providing inspection services. After the deregulation and subsequent entrance of private firms, the number of stations increased substantially. As of April 2017, there were a total of 452 fixed stations providing services throughout the country. This has improved the car owners' proximity to the stations. Table 11 provides the distributions of distances from the locations of 922,856 car owners' homes to the locations of their nearest stations before and after the removal of the monopoly. The first column of the table shows that during the pre-deregulation period, the distance to the nearest station for the average car owner was 8.97 km. The last column of the table shows that the average car owner's distance to a nearest station decreased to 6.55 km as of April 2017. This means that the removal of the monopoly and subsequent new entries decreased the distance to the nearest station for the average car owner by 2.42 km compared to the pre-deregulation period.

Using two methods, I will quantify the welfare gain to consumers from im-

Table 12: The Effect on Consumer Surplus of Improvement in Spatial Accessibility (SEK)

	Average consumer	Median consumer
Consumer surplus	99.51	101.95

proved spatial accessibility. This welfare analysis does not take into considerations any supply-side adjustments by the stations to the changes in travel distances. Previous findings show that car owners are willing to pay SEK 41.47 to avoid traveling one additional kilometer. The first method uses this information. Assuming that the average car owner now travels 2.42 km less distance than in the monopoly period, the consumer surplus to the average car owner increases by SEK 100.36 (= 2.42 x 41.47). In the second method, I will analyze the change in consumer welfare using the measure of compensating variation. The change in consumer surplus for individual i is given by $\Delta E(CS)_i = \frac{1}{-\alpha}\left[\ln(\sum_{j\in C_i}\exp(V_{ij}^{STQ})) - \ln(\sum_{j\in C_i}\exp(V_{ij}^{CTF}))\right]$ (Small and Harvey, 1981), where α is the coefficient on price that converts utils into monetary value, CTF represents counterfactual and STQ represents status quo. Under the status quo, I will use the distance to all stations as of April, 2017. The counterfactual uses the distances consumers would have traveled if there had been no deregulation and no new entrants. That means, had there been no deregulation and new entrants, distance to the nearest station for the average consumer would have increased by 2.42 km compared to the status quo. I will incorporate this to the model by increasing the distance from the location of each car owner to all stations in the choice set by 2.42 km. As indicated in Table 12, the estimates show that because of the deregulation and eventual improvement in spatial accessibility, consumer surplus to the average consumer increased by SEK 99.51. Both methods give almost equal size of the effect on consumer welfare of the improvement in geographical accessibility.

6 Robustness Checks Using Specification of the Choice Set

In the main analyses, individual-specific choice set was defined as consisting of the ten nearest stations to each car owner's home. Only 26,736 individuals (2.8% of the final sample) who chose a station outside of their ten nearest stations were excluded from the final sample by specifying the choice set in this way. To explore the possible impact on my parameter estimates of the specification of the choice set, I subject the results to a number of robustness checks by varying the definition of the choice set. These sensitivity analyses include estimating models in which the number of stations included in the individual's choice set varies, starting with the 13 nearest stations, and being successively reduced to 11, 8, 6, 4, and 3 (nearest) stations. Table 16 in the Appendix presents the results, which show that my main results are robust to alternative specifications of the choice sets.

7 Conclusion

This paper estimates the demand for car inspection services in the Swedish motor vehicle inspection market so as to investigate consumer preferences for station characteristics, and to evaluate the effect on consumer welfare of eliminating the state monopoly on inspection services. Using individual-level data, conditional and mixed logit demand models are estimated to understand consumer behavior in choosing an inspection station, as well as its implication for demand and competition. As with other spatially differentiated markets, the findings show that distance is an important determinant of station choice. Consumers also prefer stations that offer lower prices and longer opening hours. The demand response to price and opening hours differs between stations: where stations in highly competitive markets face higher elasticities of demand.

I also quantified the welfare gain for consumers attributable to the improvement in spatial accessibility to stations following the removal of the state monopoly on inspection services. The improvement in consumer proximity to inspection stations leads to a substantial welfare gain to consumers. The results of my paper show the importance of taking into account various improvements in product and service characteristics other than just price, in analyzing the welfare effects of market changes.

References

Beckert, W., Christensen, M., and Collyer, K. (2012). Choice of nhs–funded hospital services in england. *Economic Journal*, 122(560):400–417.

Besley, T. and Ghatak, M. (2003). Incentives, choice, and accountability in the provision of public services. *Oxford Review of Economic Policy*, 19(2):235–249.

Davis, P. (2006). Spatial competition in retail markets: Movie theaters. *RAND Journal of Economics*, 37(4):964–982.

Gaynor, M., Propper, C., and Seiler, S. (2016). Free to choose? reform, choice, and consideration sets in the english national health service. *American Economic Review*, 106(11):3521–3557.

Gutacker, N., Siciliani, L., Moscelli, G., and Gravelle, H. (2016). Choice of hospital: Which type of quality matters. *Journal of Health Economics*, 50:230–246.

Hastings, J. S., Kane, T. J., and Staiger, D. O. (2005). Parental preferences and school competition: Evidence from a public school choice program. *National Bureau of Economic Research*, Working Paper No. 11805.

Hensher, D. A. and Greene, W. H. (2003). The mixed logit model: the state of practice. *Transportation*, 30(2):133–176.

Hole, A. R. (2007). A comparison of approaches to estimating confidence intervals for willingness to pay measures. *Health Economics*, 16(8):827–840.

Hole, A. R. (2008). Modeling heterogeneity in patients' preferences for the attributes of a general practitioner appointment. *Journal of Health Economics*, 27(4):1078–1094.

Hortacsu, A., Madanizadeh, A. S., and Puller, L. S. (2017). Power to choose? an analysis of consumer inertia in the residential electricity market. *American Economic Journal: Economic Policy*, 9(4):192–226.

Houde, J. F. (2012). Spatial differentiation and vertical mergers in retail markets for gasoline. *American Economic Review*, 102(5):2147–2182.

Hoxby, C. M. (2003). *School Choice and School Productivity: Could School Choice Be a Tide That Lifts All Boats?* University of Chicago Press, Chicago.

McFadden, D. (1974). *Conditional logit analysis of qualitative response behavior.* Academic Press, New York. in (P. Zarembka, ed.), Frontiers in Econometrics, 105–142.

Musset, P. (2012). School choice and equity: current policies in oecd countries and a literature review. *OECD Education Working Papers 66.*

Santos, R., Gravelle, H., and Propper, C. (2017). Does quality affect patients' choice of doctor? evidence from england. *Economic Journal*, 127(600):445–494.

Short, J. L. and Toffel, M. W. (2015). The integrity of private third–party compliance monitoring. *Harvard Kennedy School.* Working Paper, RPP–2015–20.

Small, K. A. and Harvey, S. R. (1981). Applied welfare economics with discrete choice models. *Econometrica*, 49(1):105–130.

Thomadsen, R. (2005). The effect of ownership structure on prices in geographically differentiated industries. *RAND Journal of Economics*, 36(4):908–929.

Train, K. E. (2003). *Discrete Choice Methods with Simulation.* Cambridge University Press, Cambridge.

Varkevisser, M., van der Geest, S., and Schut, F. (2012). Do patients choose hospitals with high quality ratings? empirical evidence from the market for angioplasty in the netherlands. *Journal of Health Economics*, 31(2):371–378.

Appendices

D Model estimates of separate samples

Table 13: Comparison of Station Choice Models by Gender, Age of Car and Car Type

Variable	All	green	non-green	male	female	age of car below median	age of car above median
Distance	-0.14261***	-0.16472***	-0.14109***	-0.13981***	-0.14860***	-0.15035***	-0.13617***
	(0.000486)	(0.001728)	(0.000506)	(0.000599)	(0.000837)	(0.000715)	(0.000669)
Distance squared	0.00045***	0.00058***	0.00044***	0.00044***	0.00048***	0.00048***	0.00042***
	(0.000005)	(0.000009)	(0.000005)	(0.000006)	(0.000008)	(0.000007)	(0.000007)
Price	-0.00324***	-0.00329***	-0.00324***	-0.00357***	-0.00258***	-0.00341***	-0.00310***
	(0.000047)	(0.000171)	(0.000049)	(0.000058)	(0.000082)	(0.000067)	(0.000067)
Opening hours	0.01257***	0.01215***	0.01257***	0.01280***	0.01199***	0.01150***	0.01357***
	(0.000281)	(0.000950)	(0.000294)	(0.000344)	(0.000489)	(0.000400)	(0.000397)
Station size	0.00051***	0.00048***	0.00051***	0.00050***	0.00053***	0.00050***	0.00051***
	(0.000002)	(0.000008)	(0.000003)	(0.000003)	(0.000004)	(0.000003)	(0.000003)
Pass rate	0.01701***	0.01435***	0.01724***	0.01651***	0.01793***	0.01862***	0.01550***
	(0.000348)	(0.001222)	(0.000364)	(0.000429)	(0.000597)	(0.000488)	(0.000499)
No. of competitors	-0.04377***	-0.03177***	-0.04490***	-0.04065***	-0.04955***	-0.03602***	-0.05239***
	(0.000898)	(0.003087)	(0.000939)	(0.001105)	(0.001546)	(0.001240)	(0.001306)
Station age	0.00036***	0.00039***	0.00036***	0.00034***	0.00039***	0.00036***	0.00036***
	(0.000003)	(0.000010)	(0.000003)	(0.000003)	(0.000005)	(0.000004)	(0.000004)
Drop-in service	0.13790***	0.18459***	0.13410***	0.12638***	0.16020***	0.19585***	0.07720***
	(0.006086)	(0.020897)	(0.006362)	(0.007501)	(0.010418)	(0.008472)	(0.008748)
Municipality	0.94359***	0.88969***	0.94704***	0.91856***	0.98970***	0.95344***	0.92721***
	(0.004822)	(0.016526)	(0.005036)	(0.005935)	(0.008281)	(0.006722)	(0.006919)
State owned	0.10936***	0.24948***	0.09690***	0.08409***	0.15948***	0.20530***	0.00962
	(0.004104)	(0.014312)	(0.004285)	(0.005045)	(0.007065)	(0.005762)	(0.005855)
BIC	2298900	185430	2113108	1528174	769480	1160847	1136563
AIC	2298746	185304	2112955	1528024	769337	1160700	1136416
Pseudo R^2	0.459	0.448	0.460	0.450	0.478	0.453	0.466
No. of obs.	9,228,560	729,250	8,499,310	6,030,730	3,197,830	4,608,190	4,620,370
No. of car owners	922,856	72,925	849,931	603,073	319,783	460,819	462,037
No. of stations	452	452	452	452	452	452	452

Notes: Conditional logit models of station choice. Robust standard errors are presented in parentheses. *** indicates significance at 1% level.

E Standard errors for willingness to pay estimates

Table 14: Standard Errors for Willingness to Pay Estimates

Variable	Baseline	Green	Non-green	Male	Female	Car age below median	Car age above median
Distance	0.6084	2.4342	0.6274	0.5998	1.7335	0.8197	0.8979
Opening hours	0.1024	0.3408	0.1071	0.111	0.2376	0.1334	0.1567
Pass rate	0.1287	0.4159	0.1351	0.138	0.3113	0.1731	0.19
Station age (days)	0.0016	0.006	0.0016	0.0015	0.0047	0.0021	0.0024
Drop-in service	2.0686	7.3614	2.1539	2.2574	4.7692	2.8801	2.9552
Municipality	4.5461	15.0422	4.7505	4.5084	12.7764	5.8914	6.8874
State owned	1.4039	6.1255	1.4408	1.4959	3.5383	2.1511	1.898

Notes: Standard errors calculated using the Delta method.

F Standard errors for willingness to travel estimates

Table 15: Standard Errors for Willingness to Travel Estimates

Variable	Baseline	Green	Non-green	Male	Female	Car age below median	Car age above median
Price (kr)	0.00035	0.00111	0.00037	0.00044	0.00059	0.00048	0.00052
Opening hours	0.00212	0.00624	0.00224	0.00264	0.00353	0.00285	0.00313
Pass rate	0.00261	0.00795	0.00275	0.00328	0.00429	0.00346	0.00391
Station age (days)	0.00002	0.00007	0.00002	0.00003	0.00004	0.00003	0.00003
Drop-in service	0.04551	0.1364	0.04805	0.05717	0.07485	0.06028	0.06833
Municipality	0.05315	0.15216	0.05624	0.06635	0.0885	0.0707	0.07922
State owned	0.03074	0.09497	0.03239	0.03845	0.05103	0.04136	0.04567

Notes: Standard errors calculated using the Delta method.

G Robustness checks using choice sets

Table 16: Choice Models with Different Nth Nearest Stations Used to Define Choice Sets

Variable	Baseline	13 nearest	11 nearest	8 nearest	6 nearest	4 nearest	3 nearest
Distance	-0.14261***	-0.14306***	-0.14321***	-0.14125***	-0.13929***	-0.14316***	-0.14162***
	(0.000486)	(0.000458)	(0.000476)	(0.000548)	(0.000722)	(0.000824)	(0.000833)
Distance squared	0.00045***	0.00043***	0.00045***	0.00045***	0.00045***	0.00055***	0.00062***
	(0.000005)	(0.000004)	(0.000005)	(0.000007)	(0.000011)	(0.000014)	(0.000012)
Price	-0.00324***	-0.00328***	-0.00326***	-0.00320***	-0.00308***	-0.00270***	-0.00245***
	(0.000047)	(0.000046)	(0.000047)	(0.000048)	(0.000050)	(0.000056)	(0.000062)
Opening hours	0.01257***	0.01275***	0.01234***	0.01360***	0.01440***	0.01578***	0.01723***
	(0.000281)	(0.000274)	(0.000278)	(0.000295)	(0.000310)	(0.000346)	(0.000422)
Station size	0.00051***	0.00049***	0.00050***	0.00052***	0.00053***	0.00053***	0.00054***
	(0.000002)	(0.000002)	(0.000002)	(0.000003)	(0.000003)	(0.000003)	(0.000004)
Pass rate	0.01701***	0.01858***	0.01813***	0.01508***	0.01355***	0.01498***	0.01386***
	(0.000348)	(0.000339)	(0.000344)	(0.000360)	(0.000381)	(0.000421)	(0.000467)
No. of competitors	-0.04377***	-0.04274***	-0.04393***	-0.04460***	-0.04679***	-0.04394***	-0.03887***
	(0.000898)	(0.000821)	(0.000867)	(0.000973)	(0.001091)	(0.001297)	(0.001514)
Station age	0.00036***	0.00037***	0.00036***	0.00035***	0.00034***	0.00032***	0.00029***
	(0.000003)	(0.000003)	(0.000003)	(0.000003)	(0.000003)	(0.000003)	(0.000003)
Drop-in service	0.13790***	0.14476***	0.13974***	0.11739***	0.10310***	0.07906***	0.07222***
	(0.006086)	(0.006025)	(0.006066)	(0.006190)	(0.006365)	(0.006841)	(0.007526)
Municipality	0.94359***	0.96417***	0.94905***	0.92567***	0.89966***	0.83690***	0.83148***
	(0.004822)	(0.004790)	(0.004800)	(0.004906)	(0.005152)	(0.005553)	(0.006126)
State owned	0.10936***	0.11527***	0.10969***	0.10397***	0.09515***	0.07764***	0.09181***
	(0.004104)	(0.004029)	(0.004074)	(0.004219)	(0.004387)	(0.004834)	(0.005331)
BIC	2,298,900	2,481,455	2,368,185	2,117,154	1,854,308	1,420,130	1,058,059
AIC	2,298,746	2,481,297	2,368,030	2,117,003	1,854,160	1,419,987	1,057,920
Pseudo R^2	0.459	0.485	0.469	0.437	0.408	0.366	0.349
No. of obs.	9,228,560	12,201,956	10,219,594	7,236,392	5,239,854	3,232,364	2,220,252
No. of car owners	922,856	938,612	929,054	904,549	873,309	808,091	740,084
No. of stations	452	452	452	452	452	452	452

Notes: Conditional logit models of station choice. Individual specific choice sets are defined as the set of the Nth nearest stations to the car owner. The baseline model is estimated based on the set of 10 nearest stations for each individual. Robust standard errors are presented in parentheses. *** indicates significance at 1% level and ** significance at 5% level.

Lund Economic Studies

1. Guy Arvidsson	Bidrag till teorin för verkningarna av räntevariationer, 1962
2. Björn Thalberg	A Trade Cycle Analysis. Extensions of the Goodwin Model, 1966
3. Bengt Höglund	Modell och observationer. En studie av empirisk anknytning och aggregation för en linjär produktionsmodell, 1968
4. Alf Carling	Industrins struktur och konkurrensförhållanden, 1968
5. Tony Hagström	Kreditmarknadens struktur och funktionssätt, 1968
6. Göran Skogh	Straffrätt och samhällsekonomi, 1973
7. Ulf Jakobsson och Göran Norman	Inkomstbeskattningen i den ekonomiska politiken. En kvantitativ analys av systemet för personlig inkomstbeskattning 1952-71, 1974
8. Eskil Wadensjö	Immigration och samhällsekonomi. Immigrationens ekonomiska orsaker och effekter, 1973
9. Rögnvaldur Hannesson	Economics of Fisheries. Some Problems of Efficiency, 1974
10. Charles Stuart	Search and the Organization of Marketplaces, 1975
11. S Enone Metuge	An Input-Output Study of the Structure and Resource Use in the Cameroon Economy, 1976
12. Bengt Jönsson	Cost-Benefit Analysis in Public Health and Medical Care, 1976
13. Agneta Kruse och Ann-Charlotte Ståhlberg	Effekter av ATP - en samhällsekonomisk studie, 1977
14. Krister Hjalte	Sjörestaureringens ekonomi, 1977
15. Lars-Gunnar Svensson	Social Justice and Fair Distributions, 1977
16. Curt Wells	Optimal Fiscal and Monetary Policy - Experiments with an Econometric Model of Sweden, 1978
17. Karl Lidgren	Dryckesförpackningar och miljöpolitik - En studie av styrmedel, 1978
18. Mats Lundahl	Peasants and Poverty. A Study of Haiti, London, 1979
19. Inga Persson-Tanimura	Studier kring arbetsmarknad och information, 1980
20. Bengt Turner	Hyressättning på bostadsmarknaden - Från hyresreglering till bruksvärdesprövning, Stockholm 1979
21. Ingemar Hansson	Market Adjustment and Investment Determination. A Theoretical Analysis of the Firm and the Industry, Stockholm 1981
22. Daniel Boda Ndlela	Dualism in the Rhodesian Colonial Economy, 1981

23.	Tom Alberts	Agrarian Reform and Rural Poverty: A Case Study of Peru, 1981
24.	Björn Lindgren	Costs of Illness in Sweden 1964-75, 1981
25.	Göte Hansson	Social Clauses and International Trade. An Economic Analysis of Labour Standards in Trade Policy, 1981
26.	Noman Kanafani	Oil and Development. A Case Study of Iraq, 1982
27.	Jan Ekberg	Inkomsteffekter av invandring, 1983
28.	Stefan Hedlund	Crisis in Soviet Agriculture?, 1983
29.	Ann-Marie Pålsson	Hushållen och kreditpolitiken. En studie av kreditrestrik-tioners effekt på hushållens konsumtion, sparande och konsumtionsmönster, 1983
30.	Lennart Petersson	Svensk utrikeshandel, 1871-1980. En studie i den intraindustriella handelns framväxt, 1984
31.	Bengt Assarsson	Inflation and Relative Prices in an Open Economy, 1984
32.	Claudio Vedovato	Politics, Foreign Trade and Economic Development in the Dominican Republic, 1985
33.	Knut Ödegaard	Cash Crop versus Food Crop Production in Tanzania: An Assessment of the Major Post-Colonial Trends, 1985
34.	Vassilios Vlachos	Temporära lönesubventioner. En studie av ett arbetsmarknadspolitiskt medel, 1985
35.	Stig Tegle	Part-Time Employment. An Economic Analysis of Weekly Working Hours in Sweden 1963-1982, 1985
36.	Peter Stenkula	Tre studier över resursanvändningen i högskolan, 1985
37.	Carl Hampus Lyttkens	Swedish Work Environment Policy. An Economic Analysis, 1985
38.	Per-Olof Bjuggren	A Transaction Cost Approach to Vertical Integration: The Case of Swedish Pulp and Paper Industry, 1985
39.	Jan Petersson	Erik Lindahl och Stockholmsskolans dynamiska metod, 1987
40.	Yves Bourdet	International Integration, Market Structure and Prices. A Case Study of the West-European Passenger Car Industry, 1987
41.	Krister Andersson and Erik Norrman	Capital Taxation and Neutrality. A study of tax wedges with special reference to Sweden, 1987
42.	Tohmas Karlsson	A Macroeconomic Disequilibrium Model. An Econometric Study of the Swedish Business Sector 1970-84, 1987
43.	Rosemary Vargas-Lundius	Peasants in Distress. Poverty and Unemployment in the Dominican Republic, 1989

44.	Lena Ekelund Axelson	Structural Changes in the Swedish Marketing of Vegetables, 1991
45.	Elias Kazarian	Finance and Economic Development: Islamic Banking in Egypt, 1991
46.	Anders Danielson	Public Sector Expansion and Economic Development. The Sources and Consequences of Development Finance in Jamaica 1962-84, 1991
47.	Johan Torstensson	Factor Endowments, Product Differentiation, and International Trade, 1992
48.	Tarmo Haavisto	Money and Economic Activity in Finland, 1866-1985, 1992
49.	Ulf Grönkvist	Economic Methodology. Patterns of Reasoning and the Structure of Theories, 1992
50.	Evelyne Hangali Maje	Monetization, Financial Development and the Demand for Money, 1992
51.	Michael Bergman	Essays on Economic Fluctuations, 1992
52.	Flora Mndeme Musonda	Development Strategy and Manufactured Exports in Tanzania, 1992
53.	Håkan J. Holm	Complexity in Economic Theory. An Automata Theoretical Approach, 1993
54.	Klas Fregert	Wage Contracts, Policy Regimes and Business Cycles. A Contractual History of Sweden 1908-90, 1994
55.	Per Frennberg	Essays on Stock Price Behaviour in Sweden, 1994
56.	Lisbeth Hellvin	Trade and Specialization in Asia, 1994
57.	Sören Höjgård	Long-term Unemployment in a Full Employment Economy, 1994
58.	Karolina Ekholm	Multinational Production and Trade in Technological Knowledge, 1995
59.	Fredrik Andersson	Essays in the Economics of Asymmetric Information, 1995
60.	Rikard Althin	Essays on the Measurement of Producer Performance, 1995
61.	Lars Nordén	Empirical Studies of the Market Microstructure on the Swedish Stock Exchange, 1996
62.	Kristian Bolin	An Economic Analysis of Marriage and Divorce, 1996
63.	Fredrik Sjöholm	R&D, International Spillovers and Productivity Growth, 1997
64.	Hossein Asgharian	Essays on Capital Structure, 1997
65.	Hans Falck	Aid and Economic Performance - The Case of Tanzania, 1997
66.	Bengt Liljas	The Demand for Health and the Contingent Valuation

		Method, 1997
67.	Lars Pålsson Syll	Utility Theory and Structural Analysis, 1997
68.	Richard Henricsson	Time Varying Parameters in Exchange Rate Models, 1997
69.	Peter Hördahl	Financial Volatility and Time-Varying Risk Premia, 1997
70.	Lars Nilsson	Essays on North-South Trade, 1997
71.	Fredrik Berggren	Essays on the Demand for Alcohol in Sweden - Review and Applied Demand Studies, 1998
72.	Henrik Braconier	Essays on R&D, Technology and Growth, 1998
73.	Jerker Lundbäck	Essays on Trade, Growth and Exchange Rates, 1998
74.	Dan Anderberg	Essays on Pensions and Information, 1998
75.	P. Göran T. Hägg	An Institutional Analysis of Insurance Regulation – The Case of Sweden, 1998
76.	Hans-Peter Bermin	Essays on Lookback and Barrier Options - A Malliavin Calculus Approach, 1998
77.	Kristian Nilsson	Essays on Exchange Rates, Exports and Growth in Developing Countries, 1998
78.	Peter Jochumzen	Essays on Econometric Theory, 1998
79.	Lars Behrenz	Essays on the Employment Service and Employers' Recruitment Behaviour, 1998
80.	Paul Nystedt	Economic Aspects of Ageing, 1998
81.	Rasha M. Torstensson	Empirical Studies in Trade, Integration and Growth, 1999
82.	Mattias Ganslandt	Games and Markets – Essays on Communication, Coordination and Multi-Market Competition, 1999
83.	Carl-Johan Belfrage	Essays on Interest Groups and Trade Policy, 1999
84.	Dan-Olof Rooth	Refugee Immigrants in Sweden - Educational Investments and Labour Market Integration, 1999
85.	Karin Olofsdotter	Market Structure and Integration: Essays on Trade, Specialisation and Foreign Direct Investment, 1999
86.	Katarina Steen Carlsson	Equality of Access in Health Care, 1999
87.	Peter Martinsson	Stated preference methods and empirical analyses of equity in health, 2000
88.	Klas Bergenheim	Essays on Pharmaceutical R&D, 2000
89.	Hanna Norberg	Empirical Essays on Regional Specialization and Trade in Sweden, 2000
90.	Åsa Hansson	Limits of Tax Policy, 2000
91.	Hans Byström	Essays on Financial Markets, 2000

92. Henrik Amilon	Essays on Financial Models, 2000
93. Mattias Lundbäck	Asymmetric Information and The Production of Health, 2000
94. Jesper Hansson	Macroeconometric Studies of Private Consumption, Government Debt and Real Exchange Rates, 2001
95. Jonas Månsson	Essays on: Application of Cross Sectional Efficiency Analysis, 2001
96. Mattias Persson	Portfolio Selection and the Analysis of Risk and Time Diversification, 2001
97. Pontus Hansson	Economic Growth and Fiscal Policy, 2002
98. Joakim Gullstrand	Splitting and Measuring Intra-Industry Trade, 2002
99. Birger Nilsson	International Asset Pricing, Diversification and Links between National Stock Markets, 2002
100. Andreas Graflund	Financial Applications of Markov Chain Monte Carlo Methods, 2002
101. Therése Hindman Persson	Economic Analyses of Drinking Water and Sanitation in Developing Countries, 2002
102. Göran Hjelm	Macroeconomic Studies on Fiscal Policy and Real Exchange Rates, 2002
103. Klas Rikner	Sickness Insurance: Design and Behavior, 2002
104. Thomas Ericson	Essays on the Acquisition of Skills in Teams, 2002
105. Thomas Elger	Empirical Studies on the Demand for Monetary Services in the UK, 2002
106. Helena Johansson	International Competition, Productivity and Regional Spillovers, 2003
107. Fredrik Gallo	Explorations in the New Economic Geography, 2003
108. Susanna Thede	Essays on Endogenous Trade Policies, 2003
109. Fredrik CA Andersson	Interest Groups and Government Policy, A Political Economy Analysis, 2003
110. Petter Lundborg	Risky Health Behaviour among Adolescents, 2003
111. Martin W Johansson	Essays on Empirical Macroeconomics, 2003
112. Joakim Ekstrand	Currency Markets - Equilibrium and Expectations, 2003
113. Ingemar Bengtsson	Central bank power: a matter of coordination rather than money supply, 2003
114. Lars Pira	Staples, Institutions and Growth: Competitiveness of Guatemalan Exports 1524-1945, 2003
115. Andreas Bergh	Distributive Justice and the Welfare State, 2003

116. Staffan Waldo	Efficiency in Education - A Multilevel Analysis, 2003
117. Mikael Stenkula	Essays on Network Effects and Money, 2004
118. Catharina Hjortsberg	Health care utilisation in a developing country -The case of Zambia, 2004
119. Henrik Degrér	Empirical Essays on Financial Economics, 2004
120. Mårten Wallette	Temporary Jobs in Sweden: Incidence, Exit, and On-the-Job Training, 2004
121. Tommy Andersson	Essays on Nonlinear Pricing and Welfare, 2004
122. Kristian Sundström	Moral Hazard and Insurance: Optimality, Risk and Preferences, 2004
123. Pär Torstensson	Essays on Bargaining and Social Choice, 2004
124. Frederik Lundtofte	Essays on Incomplete Information in Financial Markets, 2005
125. Kristian Jönsson	Essays on Fiscal Policy, Private Consumption and Non-Stationary Panel Data, 2005
126. Henrik Andersson	Willingness to Pay for a Reduction in Road Mortality Risk: Evidence from Sweden, 2005
127. Björn Ekman	Essays on International Health Economics: The Role of Health Insurance in Health Care Financing in Low- and Middle-Income Countries, 2005
128. Ulf G Erlandsson	Markov Regime Switching in Economic Time Series, 2005
129. Joakim Westerlund	Essays on Panel Cointegration, 2005
130. Lena Hiselius	External costs of transports imposed on neighbours and fellow road users, 2005
131. Ludvig Söderling	Essays on African Growth, Productivity, and Trade, 2005
132. Åsa Eriksson	Testing and Applying Cointegration Analysis in Macroeconomics, 2005
133. Fredrik Hansen	Explorations in Behavioral Economics: Realism, Ontology and Experiments, 2006
134. Fadi Zaher	Evaluating Asset-Pricing Models in International Financial Markets, 2006
135. Christoffer Bengtsson	Applications of Bayesian Econometrics to Financial Economics, 2006
136. Alfredo Schclarek Curutchet	Essays on Fiscal Policy, Public Debt and Financial Development, 2006
137. Fredrik Wilhelmsson	Trade, Competition and Productivity, 2006
138. Ola Jönsson	Option Pricing and Bayesian Learning, 2007

139. Ola Larsson	Essays on Risk in International Financial Markets, 2007
140. Anna Meyer	Studies on the Swedish Parental Insurance, 2007
141. Martin Nordin	Studies in Human Capital, Ability and Migration, 2007
142. Bolor Naranhuu	Studies on Poverty in Mongolia, 2007
143. Margareta Ekbladh	Essays on Sickness Insurance, Absence Certification and Social Norms, 2007
144. Erik Wengström	Communication in Games and Decision Making under Risk, 2007
145. Robin Rander	Essays on Auctions, 2008
146. Ola Andersson	Bargaining and Communication in Games, 2008
147. Marcus Larson	Essays on Realized Volatility and Jumps, 2008
148. Per Hjertstrand	Testing for Rationality, Separability and Efficiency, 2008
149. Fredrik NG Andersson	Wavelet Analysis of Economic Time Series, 2008
150. Sonnie Karlsson	Empirical studies of financial asset returns, 2009
151. Maria Persson	From Trade Preferences to Trade Facilitation, 2009
152. Eric Rehn	Social Insurance, Organization and Hospital Care, 2009
153. Peter Karpestam	Economics of Migration, 2009
154. Marcus Nossman	Essays on Stochastic Volatility, 2009
155. Erik Jonasson	Labor Markets in Transformation: Case Studies of Latin America, 2009
156. Karl Larsson	Analytical Approximation of Contingent Claims, 2009
157. Therese Nilsson	Inequality, Globalization and Health, 2009
158. Rikard Green	Essays on Financial Risks and Derivatives with Applications to Electricity Markets and Credit Markets, 2009
159. Christian Jörgensen	Deepening Integration in the Food Industry – Prices, Productivity and Export, 2010
160. Wolfgang Hess	The Analysis of Duration and Panel Data in Economics, 2010
161. Pernilla Johansson	From debt crisis to debt relief: A study of debt determinants, aid composition and debt relief effectiveness, 2010
162. Nils Janlöv	Measuring Efficiency in the Swedish Health Care Sector, 2010

163. Ai Jun Hou	Essays on Financial Markets Volatility, 2011
164. Alexander Reffgen	Essays on Strategy-proof Social Choice, 2011
165. Johan Blomquist	Testing homogeneity and unit root restrictions in panels, 2012
166. Karin Bergman	The Organization of R&D - Sourcing Strategy, Financing and Relation to Trade, 2012
167. Lu Liu	Essays on Financial Market Interdependence, 2012
168. Bujar Huskaj	Essays on VIX Futures and Options, 2012
169. Åsa Ljungvall	Economic perspectives on the obesity epidemic, 2012
170. Emma Svensson	Experimenting with Focal Points and Monetary Policy, 2012
171. Jens Dietrichson	Designing Public Organizations and Institutions: Essays on Coordination and Incentives, 2013
172. Thomas Eriksson	Empirical Essays on Health and Human Capital, 2013
173. Lina Maria Ellegård	Political Conflicts over Public Policy in Local Governments, 2013
174. Andreas Hatzigeorgiou	Information, Network and Trust in the Global Economy – Essays on International Trade and Migration, 2013
175. Gustav Kjellsson	Inequality, Health, and Smoking, 2014
176. Richard Desjardins	Rewards to skill supply, skill demand and skill match-mismatch – Studies using the Adult Literacy and Lifeskills survey, 2014
177. Viroj Jienwatcharamongkhol	What Drives Exports? - An Empirical Evidence at the Firm Level, 2014
178. Anton Nilsson	Health, Skills and Labor Market Success, 2014
179. Albin Erlanson	Essays on Mechanism Design, 2014
180. Daniel Ekeblom	Essays in Empirical Expectations, 2014
181. Sofie Gustafsson	Essays on Human Capital Investments: Pharmaceuticals and Education, 2014
182. Katarzyna Burzynska	Essays on Finance, Networks and Institutions, 2015

183. Mingfa Ding	Corporate Ownership and Liquidity in China's Stock Markets, 2015
184. Anna Andersson	Vertical Trade, 2015
185. Cecilia Hammarlund	Fish and Trips in the Baltic Sea – Prices, Management and Labor Supply, 2015
186. Hilda Ralsmark	Family, Friend, or Foe? Essays in Empirical Microeconomics, 2015
187. Jens Gudmundsson	Making Pairs, 2015
188. Emanuel Alfranseder	Essays on Financial Risks and the Subprime Crisis, 2015
189. Ida Lovén	Education, Health, and Earnings – Type 1 Diabetes in Children and Young Adults, 2015
190. Caren Yinxia Nielsen	Essays on Credit Risk, 2015
191. Usman Khalid	Essays on Institutions and Institutional change, 2016
192. Ross Wilson	Essays in Empirical Institutional Analysis, 2016
193. Milda Norkute	A Factor Analytical Approach to Dynamic Panel Data Models, 2016
194. Valeriia Dzhamalova	Essays on Firms' Financing and Investment Decisions, 2016
195. Claes Ek	Behavioral Spillovers across Prosocial Alternatives, 2016
196. Graeme Cokayne	Networks, Information and Economic Volatility, 2016
197. Björn Thor Arnarson	Exports and Externalities, 2016
198. Veronika Lunina	Multivariate Modelling of Energy Markets, 2017
199. Patrik Karlsson	Essays in Quantitative Finance, 2017
200. Hassan Sabzevari	Essays on systemic risk in European banking, 2017
201. Margaret Samahita	Self-Image and Economic Behavior, 2017
202. Aron Berg	Essays on informational asymmetries in mergers and acquisitions, 2017

203. Simon Reese	Estimation and Testing in Panel Data with Cross-Section Dependence, 2017
204. Karl McShane	Essays on Social Norms and Economic Change, 2017
205. Elvira Andersson	From Cradle to Grave: Empirical Essays on Health and Economic Outcomes, 2017
206. Yana Pryymachenko	Heavy Metal Exposure in Early Life – Health and Labour Market Perspectives, 2017
207. Alemu Tulu Chala	Essays on Banking and Corporate Finance, 2017
208. Jim Ingebretsen Carlson	Essays on economic behavior, focusing and auctions, 2018
209. Jörgen Kratz	Essays on Matching, 2018
210. Anna Welander Tärneberg	Essays on Health in Developing countries, 2018
211. Osmis Areda Habte	Essays on competition and consumer choice, 2018