

A Service of

ZBW

Leibniz-Informationszentrum Wirtschaft Leibniz Information Centre for Economics

Habte, Osmis; Holm, Håkan J.

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

Working Paper, No. 2017:19

**Provided in Cooperation with:** Department of Economics, School of Economics and Management, Lund University

*Suggested Citation:* Habte, Osmis; Holm, Håkan J. (2017) : Competition Makes Inspectors More Lenient: Evidence from the Motor Vehicle Inspection Market, Working Paper, No. 2017:19, Lund University, School of Economics and Management, Department of Economics, Lund

This Version is available at: https://hdl.handle.net/10419/260228

#### Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

#### Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



# WWW.ECONSTOR.EU

Working Paper 2017:19

Department of Economics School of Economics and Management

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

Osmis Habte Håkan J. Holm

December 2017



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

Osmis Areda Habte<sup> $\dagger$ </sup> Hakan J. Holm<sup> $\ddagger$ </sup>

First version: May 25, 2016 This version: December 23, 2017

#### Abstract

We examine the impact of competition on firms' leniency towards their customers in a heavily regulated market, which is consciously designed to mitigate incentives to deviate from the regulation. Using a panel data set representing 22.5 million periodic vehicle roadworthiness tests during the period 2010-2015, we show that inspection stations operating in more competitive markets are more lenient to their customers than stations operating in less competitive markets. We present both fixed effects and instrumental variable estimates of the effect of competition on firms' incentive to be lenient to their customers.

JEL Classification: D22; L11; L84

Keywords: leniency; pass rate; inspection behavior; competition; deregulation; inspection market

<sup>\*</sup>We thank Florin Maican, David Edgerton and seminar 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 Swedish Transport Agency for providing us the data. Special thanks to Peter Holmlund (Swedish Transport Agency) for helping us obtain the data and being available for several discussions about the market. We gratefully acknowledge financial support from the Swedish Competition Authority.

<sup>&</sup>lt;sup>†</sup>Department of Economics, Lund University, P.O. Box 7082, SE-222 07 Lund, Sweden. E-mail: osmis.habte@nek.lu.se

<sup>&</sup>lt;sup>‡</sup>Department of Economics, Lund University, P.O. Box 7082, SE-222 07 Lund, Sweden. E-mail: hj.holm@nek.lu.se

#### 1 Introduction

Often individuals and firms pay another party to get monitored in some way. Individuals pay accredited institutions to do tests to obtain driving licenses and firms buy accounting services to inspect their financial activity etc. 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 they have no obvious incentive but to do correct and unbiased inspections. On the other hand, such organizations face no competition and may therefore become inefficient and insensitive to customers' demand (see e.g., Stigliz, 1986). These drawbacks have motivated some governments to have competing private firms to do inspections on 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 like 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 not sufficient.

Competition is one of the key ingredients to improve the quality and efficiency in markets in general. It is a standard result in oligopoly theory 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 (see e.g., Syverson, 2004). In addition, it has been shown that competition increases the quality in markets (see 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 to deviate from regulations and will therefore have a higher probability to do so. Bolton, Freixas and Shapiro (2012) demonstrate in their model of the credit ratings game that competition allows for "ratings shopping" which result in too high ratings (i.e., the understating of risks).

There are also a number of empirical studies supporting that competition may lead the firms who are to monitor their customers according to some regulation become too lenient. For instance, Snyder (2010) provide evidence that liver transplant centers did 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, Bennet et al. (2013) show that facilities facing higher local competition are more likely to let their customers to pass emissions tests compared to facilities facing less severe competition.

In this paper, we examine the impact of competition on firms' leniency towards their customers in the Swedish car inspection market. We think this market is particularly interesting to analyze for several reasons. First, it has intentionally been designed with concern about some of the incentive effects where competition creates distortions on earlier studied market. To start with 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 facilities in addition to emissions testing also provide other profitable services like 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" (Bennet et al., 2013, P. 2). They also outlined that the good intention of fixing testing prices in New York emission testing market eliminates an important competition instrument for facilities.

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

<sup>&</sup>lt;sup>1</sup>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.

laws and regulations 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, it is difficult to see if these side-effects can be avoided at all. Finally, we have relatively a unique and high quality panel data at station level that represent all inspections (22.5 million) conducted by all stations in Sweden during July, 2010 to August, 2015 and that allow us to carefully investigate the causal impact of competition on car inspection pass rate. Furthermore, the micro-level data that contain the addresses of 458, 405 car owners and the corresponding station each owner visited allow us to measure travel distances and to reasonably define geographic markets, which is an important element to measure competition.

In this paper, our primary objective is to investigate a causal relationship between competition and firms' leniency towards their customers. Our relatively unique data allow us to employ two strategies to carefully investigate the effect of competition on car inspection pass rate. The first strategy is to control for station-specific factors affecting both competition and pass rate. We show that controlling for station fixed effects explain a large amount of variation in pass rates across stations. Adding station fixed effects to a specification that already accounts for observable covariates increases adjusted  $R^2$  value by more than 0.65. If the major source of potential bias in the regression of pass rate on competition is time-invariant factors, the inclusion of fixed effects will control for various confounding factors.

Our second strategy is to use instrumental variables regressions to estimate the impact of competition on pass rate. We use population size at a municipality level as an instrument for the measure of competition, the number of rival stations in a geographic market. We argue that since we control for station fixed effects in the two stage least squares regressions, the potential correlation between our instruments and the error term decreases reasonably.

Our results show that the probability for a car to pass mandatory inspec-

tion increases with market competition. We also look at seasonal variation in pass rate. We found that 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. We further looked at a potential difference in behavior in terms of pass rate between new entrants and incumbents. We have not found any evidence that suggests a difference in being lenient to customers between new entrants and incumbents.

Our findings are robust to using alternative approaches to define geographic markets and measure competition, 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, increased competition appears to encourage inspection stations to be lenient to their customers. The results suggest that more effective monitoring is required and regulators should put more effort in highly competitive markets where there is a potential for deviation from regulations. Policy makers should also account for the side-effects of increased competition in policies that aim to promote competition.

The outline of the paper is as follows: Section 2 presents a simple model to illustrate the mechanism through which competition affects pass rates. Section 3 describes the data and presents overview of the market. Section 4 presents specification of the model and estimation strategies. Section 5 shows our main results. Section 6 provides sensitivity analysis and further results based on alternative definition of market area. Section 7 presents 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, which 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 one re-inspection is needed. The price of the inspection is p and the price of re-inspection is r. The probability a car does not pass the inspection (hence fails) is given by  $\sigma$ . 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 to 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 differs with respect to their location. They are distributed equidistant 1/n from one another on a circle which 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  $i = 1, 2, \dots, n$ . Furthermore, it is assumed that market prices are determined centrally and is outside of the control of the local firms<sup>2</sup>. Hence, the only thing that the local firm can affect is the failing rate,  $\sigma \in (0,1)$ , which is the probability a car does not pass. Now, a consumer will buy the service from the firm who offers it with the 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  $\sigma$  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:

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

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:

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

<sup>&</sup>lt;sup>2</sup>This is close to the reality in the car inspection market in Sweden since the majority of the stations belong to chain companies and the prices appear to be decided centrally. thus, price for inspection service does not differ across stations of the same chain who operate in different local markets.

The first order condition is give by:

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

This gives the best-response function:

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

From (4) we see that since 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 < t/n < p - c + r - w, the equilibrium failing rate will be between 0 and 1. It should be clear that the 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 strength of competition and finally present a preliminary data analysis.

#### 3.1 Overview of the Motor Vehicle Inspection Market in Sweden

Periodic car roadworthiness test has been mandatory in Sweden ever since its introduction in 1965. By law, vehicles are required to pass a mandatory periodic<sup>3</sup> inspection to operate legally on the road. A partly state owned company<sup>4</sup>, 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 deregulation of the market was accompanied by divestiture of the monopoly company to private firms. Accordingly, during the year 2012 one third of the monopoly company (70 stations) was sold to Opus Bilprovning AB 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 owns 87 stations holding the old company name, AB Svensk Bilprovning, and the other owners left with 55 stations to operate under a new company name, Besikta Bilprovning i Sverige AB.

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

<sup>&</sup>lt;sup>3</sup>Presently, there is 3-2-1-1 system. This means, brand-new vehicles should undergo their first mandatory periodic inspection when they are three years old and the second inspection when they are five years old. Afterwards, the vehicles must be inspected annually. There is an ongoing investigation by the government to implement a 4-2-2-2 system, which is in line with EU directive. With the new proposal, vehicles undertake the first inspection when they are 4 years old and afterwards, they must be inspected every two years.

<sup>&</sup>lt;sup>4</sup>The state owns 52% and auto insurance companies and different associations own the remaining 48% of it. 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%) och Svenska Bussbranschens Riksforbund (3%)

agency supervises the maket by visiting the inspection stations 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 8 companies with a total of 422 stations for light vehicles<sup>5</sup> inspection. This number can be compared with around 190 stations at the time of the deregulation. During the year 2015, three big companies account for 81 percent of the inspections in the country: AB Svensk Bilprovning (32%), Opus Bilprovning AB (28%) and Besikta Bilprovning i Sverige AB (21%). Our data set 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 unbalanced panel data over the period July 2010 to August 2015. The Swedish Transport Agency provides us 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 set consists of 17,329 stations - month observations representing all licensed inspection stations in Sweden. The data include rich 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 measures the strength of competition each station faces. In the following section, we discuss different approaches we use to measure competition. In addition, we construct dummy variables to serve as control variables. To control for stations' age, we create a dummy variable, *stationage*, that takes a value of one if the station is younger than one

<sup>&</sup>lt;sup>5</sup>The inspection market can be categorized in terms of the weights of vehicles: light vehicles (< 3500kg) and heavy vehicles (> 3500kg). The 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.

year old and a value of zero otherwise. We also construct quarterly seasonal dummies<sup>6</sup> to control for seasonal effects.

#### 3.3 Measures of competition

In order to study the effect of increased competition on pass rate, one needs to have a plausible measure of the strength of competition. In the literature, there are 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 of this approach is to identify a reasonable size of a station's geographic market. In principle, the geographic market size for a station should include all other competing stations to which the station reacts competitively. In this study, we follow two alternative approaches to define geographic market area.

The first approach is to define equal size circular geographic areas for all

 $<sup>^6{\</sup>rm We}$  define binary variables for these categories: Inspections conducted from January through March; April to June; July to September and October to December

firms in the market. The first step is to determine a certain fixed radius that defines a firm's circular catchment area. We then measure competition for a focal firm by counting the number of other competing firms 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 as 15km<sup>7</sup>. Bennet et al. (2013) use 0.2 mile radius circular market to measure competition in the vehicle emission test market for New York State. In our study, each station's catchment area is defined by 14km radius<sup>8</sup>. Since stations with overlapping catchment areas can be considered as substitutes in the eyes of car owners, we measure competition for each station as the number of other competing stations within 28km radius. Figure 1 presents graphical illustration on how 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 for variation in certain characteristics across local markets for example in terms of population density<sup>9</sup>.

The second approach tries to solve the limitations of the fixed-radius approach. This method uses customers' origin information and defines catchment area based on the distribution patterns of each firm's customers (Elzinga and Hogarty, 1978; Garnick et al., 1987). Swedish Transport Agency provides us detail data that contain information about car owner's registered addresses and the corresponding station each owner visited to get inspection service. For our purpose, we measured the latitude and longitude of the addresses of 458,405 car owners and the corresponding station each owner visited during the period June, 2015 to September, 2015. We then measure the Euclidean distance each owner travels to get the service. By utilizing the

 $<sup>^{7}</sup>$ They define the geographic market as a circular area with 30km radius for each hospital since a given hospital with 15km catchment area will have an overlapping ( at least to some extent) area with the catchment areas of any hospitals that are less than 30km far away.

<sup>&</sup>lt;sup>8</sup>14km is the median of the distribution of the measured travel distances between the addresses of 458,405 car owners and the corresponding stations they visited. Using actual travel distances to approximate the catchment area partly solves the main criticism for other studies to using arbitrary radii.

<sup>&</sup>lt;sup>9</sup>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.

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

distribution of these distances at municipality level, we define the catchment area<sup>10</sup> for each station. The catchment area for each station is defined by the distance the median customer (50th percentile)<sup>11</sup> travels at each station's corresponding municipality. For example, the median customer in Stockholm municipality travels 8.5km whereas the median customer in Arjeplog municipality travels 41km. The relevant geographic markets for stations in Stockholm and Arjeplog municipalities are defined as circular areas around the stations with 17km and 82km radii respectively, which are double the size of their corresponding catchment areas. Henceforth, we refer to this approach as *variable-radius*.

One potential problem with this approach is that not all stations that are included in a given station's market area will necessarily include that focal station in their geographic markets. Moreover, our measure of competition may suffer from endogeneity if higher pass rates attract long distance car owners which in turn means larger catchment area <sup>12</sup>. However, since we use the distances of the median customers to define catchment areas, it is less likely for pass rate to affect the competition measure. Since no single approach is totally ideal to define geographic market and measure competition, we present our results based on both approaches.

<sup>&</sup>lt;sup>10</sup>In this approach stations in the same municipality have same size catchment area while stations across different municipalities are allowed to have different catchment area.

<sup>&</sup>lt;sup>11</sup>We also present a robustness check by defining the catchment area by the travel distances of  $75^{th}$  percentile customer.

<sup>&</sup>lt;sup>12</sup>In hospital sector studies, unobserved (to the researcher) hospital qualities may attract longer distance customers and thus lead to larger catchment area, which may bias the effect of competition on costs and patients' outcomes (Kessler and McClellan, 1999).

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

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
Inspection Year	2012.942	2013.000	1.521	2010.000	2015.000
Stationage (dummy)	0.237	0.000	0.426	0.000	1.000
Population(Municipality)	91507.180	39866.000	160532.300	2565.000	911989.000

#### 3.4 Preliminary data analysis

The number of stations in the country has been increasing over the sample period. Table 1 presents the change in the average number of competitors a station faces over time, using both approaches (Fixed and Variable radius) to define geographic market. At the end of 2010 and based on the fixed-radius approach (column 3), on average each station faces 2.5 competitors within its defined geographic market, while by August, 2015, this number increases to 8.7 competitors. Based on variable-radius definition (column 5), this number was 2.3 in year 2010 and increased to 9.8 by year 2015. In both approaches (columns 4 and 6), between 2010 and 2015, the median of number of competitors increases from 1 to 4, a 300% 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 vehicles 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 year 2010, 71.1 percent passes the inspection. This percentage decreased first marginally for the year 2011 and has been increasing for the rest of the sample period. Out



Figure 2: Pass rate and Competition: Notes: This figure plots the mean of the 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".

of all the vehicles inspected during January - August of 2015, 72.9 percent has passed the inspection. When it comes to percentile breakdowns, there is no major differences in pass rates between year 2010 and 2015 for lower percentiles (10th and 25th ). The pass rates for year 2015 exceeds the pass rates of previous years for higher percentiles (50th, 75th and 90th). For example, in 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 year 2010. This increment is evident in the 75th and 90th percentiles. The difference in pass rate across percentiles for each single year has also increased over time. For example, in 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 an 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 stations face is



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)

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 evident when competition is measured using the fixed-radius approach as well, see Figure 4 in the appendix.

Furthermore, we checked if there is seasonal variation in 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 present the econometric approach applied to investigate the impact of competition on the results of cars inspection. The relationship between pass rate and competition is modeled as:

$$Passrate_{iyt} = \beta_1 + \beta_2(\#Stations_{iyt}) + \beta_3(\#Stations_{iyt}^2) + \beta_4(Stationage_{iyt}) + Year_y + Season_q + S_i + \epsilon_{iyt}$$
(6)

where  $Passrate_{iut}$  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  $\#Stations_{int}$ , which measures the number of competitors station i faces within its geographic market for month t in year y. We include the quadratic term  $\#Stations_{iut}^2$ , to allow for nonlinear relationship between our measure of competition and pass rate. The main control variables are a set of dummies and fixed effects. We control for a station's age by *Stationage*, an indicator variable which takes a value of one for stations younger than one year old and a value of zero otherwise. This variable captures if new entrants with limited customer base use leniency as an entry strategy. We include  $Year_y$ , 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 regulators or the average quality of cars in the country might be improving overtime.  $S_i$  denote a full set of station fixed effects that capture timeinvariant 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.  $\epsilon_{iyt}$  is an error term capturing all time-varying unobserved factors for station i in month t of year y. The errors  $\epsilon_{iyt}$  might be correlated across time and stations.

The main coefficients of interest are  $\beta_2$ , which measures how competition affects car - inspection pass rate and  $\beta_3$ , which captures nonlinear relationship between competition and pass rate. As it turns out, the estimates of the quadratic term parameter support a diminishing effect of competition on pass rate.

Identification of the parameters of equation (6) by Pooled Ordinary Least Squares (Pooled OLS) require  $\#Stations_{iyt}$  to be exogenous i.e factors in the error term that affect pass rate and the station fixed effects to be uncorrelated to the measure of competition. However, the Pooled OLS estimates of the competition parameters are likely to suffer from some degree of omitted variable bias. For example, the quality of vehicles inspected by stations that operate in 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 situation, Pooled OLS estimates are biased and inconsistent.

Since we have a panel date set, our first strategy to address omitted variables bias is to use fixed effects estimation to control for time invariant station-specific factors affecting both competition and pass rate. This estimation method allows the measure of competition,  $\#Stations_{iyt}$ , to be correlated to  $S_i$ . The identification now moves beyond the cross - station comparison and investigates further the within - station variation. This means we are asking weather a given station tends to be lenient toward its customers when facing more competitive environment. An important factor that determines the variation in pass rates across stations is variation in average quality of inspected cars. If these variations across stations are time-invariant (changing slowly overtime), 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<sup>13</sup>. Our second strategy is to use instrumental variables regressions to identify the causal impact of competition on pass rate. We propose the size of population at a municipality level<sup>14</sup> as a source of variation in the number of competitors stations face within their geographic market area<sup>15</sup>. Given that car inspection companies in Sweden are not allowed to

<sup>&</sup>lt;sup>13</sup>Fixed effects would not allow correlation between time-varying variables in the error term and the measure of competition. There might be systematic changes overtime in the average quality of inspected vehicles between stations with different competitive environments. For example, the average quality of vehicles inspected in stations operating in less competitive environments might have been improving over time better than vehicles inspected at stations operating in high competitive environments, or vice versa. Furthermore, fixed effects make measurement error bias worse due to a loss of variation in the data for its within variation identification.

<sup>&</sup>lt;sup>14</sup>Sweden is divided into 21 counties and 290 municipalities.

<sup>&</sup>lt;sup>15</sup>Olivares and Cachons (2009) use population size at a market level as an instrument

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 population and the number of stations operating in a market are strongly correlated.

Since we have included the quadratic term  $\#Stations_{iyt}^2$  and it is potentially endogenous, we naturally need additional instruments. We construct the first additional instrument, denoted henceforth  $POP_{my}^2$ , for the quadratic term by squarring 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). He 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:

$$#Stations_{imyt} = \gamma_1 + \gamma_2(POP_{my}) + \gamma_3(Stationage_{iyt}) + Year_y + Season_q + S_i + \nu_{iyt}$$
(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  $COM_{iyt}^2$ , 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,  $POP_{my}^2$ , the square of population size and,  $COM_{iyt}^2$ , the square of the fitted values of the dependent variable in equation (7). We therefore have three instruments for two endogenous variables,  $\#Stations_{iyt}$ and  $\#Stations_{iyt}^2$ . The first stage equations in the 2SLS estimation are modeled as follows.

for the number of car dealers in their study of the impact of competition on inventory.

$$#Stations_{iyt} = \delta_1 + \delta_2(POP_{my}) + \delta_3(POP_{my}^2) + \delta_4(COM_{iyt}^2) + \delta_5(Stationage_{iyt}) + Year_y + Season_q + S_i + \zeta_{iyt}$$
(8)

$$#Stations_{iyt}^{2} = \lambda_{1} + \lambda_{2}(POP_{my}) + \lambda_{3}(POP_{my}^{2}) + \lambda_{4}(COM_{iyt}^{2}) + \lambda_{5}(Stationage_{iyt}) + Year_{y} + Season_{q} + S_{i} + \eta_{iyt}$$

$$(9)$$

Where all the variables are as defined as in equation (6) and the error terms are asumed to be distributed independently of all the observed covariates and instruments.

# 5 Main Results

# 5.1 Fixed Effects Estimates

We start estimating equation (6) by pooled and fixed effects OLS. Table 4 presents the estimation results. Competition is measured based on variableradius definition of 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 serial correlation at the municipality level)<sup>16</sup>. The first column presents the Pooled OLS estimates with no controls and shows that an increase in the number of competitors is associated with high pass rates. one additional rival station increases pass rate by 0.1 percentage points.

<sup>&</sup>lt;sup>16</sup>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 between stations in the same municipality. If we cluster at the station level, our test statistics become much lager than the statistics we obtain at the municipality level

Column (2) of Table 4 includes the linear and quadratic terms of the measure of competition (#Stations and  $\#Stations^2$ ). The Pooled OLS estimates suggest that the effect of competition on pass rate is positive and marginally decreasing. Column (3) includes a set of control variables: a station's age, year and quarterly seasonal dummies. The Pooled OLS estimates indicate that one additional rival station (at the median) increases the pass rate by 0.178 percentage points<sup>17</sup>.

To minimize potential bias from unobserved heterogeneity, column (4) presents our basic results with fixed effects. 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 0.47 percentage points. The Adjusted  $\mathbb{R}^2$  value increases to 0.664 from 0.071 when we include station fixed effects suggesting that systematic time-invariant differences across stations, for example in terms of the average condition of vehicles at the time of inspections, explain a greater source of variation in pass rates across stations. This result may also explain the relationship between competition and pass rate presented in Figure 2. The higher average pass rate in local monopolies compared to markets with fewer number of competitors could be the result of systematic differences in the overall condition of inspected vehicles between the two markets (i.e., at the time of inspection cars might be on average well maintained in monopoly markets than in markets with fewer competitors)<sup>18</sup>.

$$\frac{\partial Passrate_{iyt}}{\partial \#Stations_{iyt}} = \beta_2 + 2\beta_3(\#Stations_{iyt}) \tag{10}$$

<sup>18</sup>Naturally, one can expect that not controlling for station-level fixed effects biases the estimates of the competition parameter upward because in the urban areas (where competition is expected to be high) the cars are relatively new and latest models. However, car inspection results do not seem to be solely predicted by age and model of cars. According to a report (http://sverigesradio.se/sida/artikel.aspx?artikel=5955240) by a state owned inspection company, one in six just three year old cars (17%) inspected during the year

<sup>&</sup>lt;sup>17</sup>Once we include the quadratic term to control for nonlinear relationship, we do not interpret the coefficient on  $\#Stations_{icyt}$  in isolation. The marginal effect is calculated as:

	Pooled	Pooled	Pooled	Fixed effects	Fixed effects
	OLS	OLS	OLS	OLS	OLS
Variable	[1]	[2]	[3]	[4]	[5]
#Stations	0.100***	0.203***	0.197 * * *	0.470 * * *	0.463***
$\#Stations^2$	(0.034)	(0.073) -0.0030* (0.0018)	(0.075) -0.0032* (0.0018)	(0.086) -0.0073*** (0.0013)	(0.083) -0.0069*** (0.0012)
Marginal effect (at Median)	0.10	0.185	0.178	0.426	0.422
Year	NO	NO	YES	YES	YES
Q. Season	NO	NO	YES	YES	YES
Stationage	NO	NO	YES	YES	YES
#Stations x Stationage Station level	NO	NO	NO	NO	YES
fixed effects	NO	NO	NO	YES	YES
Adjusted $R^2$ Observations	$0.022 \\ 17329$	$0.025 \\ 17329$	$0.071 \\ 17329$	$0.664 \\ 17329$	$0.664 \\ 17329$

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

Notes: 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). The unit of observation is station - month pair for the period July, 2010 - August, 2015. The first three columns contain estimates of Pooled OLS regression and the last two columns contain fixed effects OLS regression. 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. With the exception of column (4) and (5), all regressions do not include station-fixed effects. Column (1) contains regression with no control variables. Column (2) includes the linear and quadratic terms of the measure of competition. Column (3) includes all the control variables: year, quarterly seasonal and station age dummies. *Stationage* is a dummy variable which takes the value of one if a station is younger than one year old and a value of zero otherwise. Column (4) contains fixed effects OLS regression of the specification in column (3). Column (5), expands the control variables by including #StationsXstationage, an interaction term between #Stations and Stationage. \*\*\* indicates significance at 1% level and \* significance at 10% level.

This is supported by the fact that as we control for unobserved heterogeneity, the effect of competition on pass rate at the median is more than double the result in column (3) that does not control for it.

In a regression 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 in column (4). Finally, if we estimate the specification in column (4) without controlling for year dummies, the fixed effects estimate of the effect of competition increases upwards by

<sup>2013</sup> fail their first mandatory inspection. When we look at the region level, the failure rate in and around Stockholm region increases to 21%, which is higher than the national level. The head of inspections at the company associates much of the problem to the negligence of drivers.

nearly 0.16 percentage points. This tells us that if we fail to control for time fixed effects, our estimates would be positively biased by omitted aggregate trend. This is likely because during the sample period, there was an overall tendency toward higher pass rates and an increase in competitiveness throughout the market as shown in Table 1 and Table 2. However, the increase in average 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 condition of vehicles 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 in the model further reveal some interesting results. The coefficients on the quarterly seasonal dummies indicate a variation in pass rates on a seasonal basis. The average pass rate during the third quarters 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 forth quarters. One possible explanation would be that during summer season (third quarter) most people are in vacation and might have enough time to prepare their vehicles before inspection<sup>19</sup>.

Finally, the coefficient on a station's age dummy reveal some information about the behavior of new entrants<sup>20</sup> compared to incumbents<sup>21</sup>. We included a station's age dummy predicting that new entrants could use particularly leniency as a strategy to develop their customer base. The point estimate of -0.026 (p = 0.923) on *Stationage* presented in column (4) of Table 4 suggests that the average pass rate by new entrants is not significantly different from the pass rate by the incumbents. In a separate specification, we further checked on a potential heterogeneity in being lenient to customers

<sup>&</sup>lt;sup>19</sup>This, however, is not a complete explanation. In our future work, we will present detail analysis using micro-level data that contain information on the characteristics of inspected vehicles.

 $<sup>^{20}</sup>$ Stations that have been conducting inspection for less than one year

<sup>&</sup>lt;sup>21</sup>Stations that have been conducting inspection for more than one year

between new entrants and incumbents to an increase in the number of competitors. To investigate such heterogeneity in responsiveness in terms of pass rate, we interact station age dummy with the measure of competition. The point estimate of 0.02 (p = 0.451) on the interacted term contained in column (5) of Table 4 suggests that there is no a statistically significant difference in responsiveness to increased competition between new entrants and incumbents.

In all the 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 potential correlation between measures of competition and time-varying unobserved factors in the error term.

#### 5.2 Instrumental-Variables Estimates

We use the three instruments proposed above to estimate the regression equation (6). Table 5 presents results from the first-stage regressions of the corresponding 2SLS estimation results in Table 6. The first column presents first stage regression for the linear term of competition, #Stations, from the 2SLS estimation in column (1) of Table 6. Population size has a positive and highly significant effect on #Stations. Columns (2) and (3) present first stage results for the corresponding 2SLS regressions in columns (2) and (3) of Table 6. In all cases, population size has a significant and positive effect on #Stations and the three instruments are jointly statistically significant. The table also reports first stage estimates 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 endogenous variable,  $\#Stations^2$ . All the three instruments are also jointly significant in each first stage regression for  $\#Stations^2$ .

stages
$\operatorname{First}$
ы. 
ole
Tal

	1	2		3	
Variable	#Stations	#Stations	$\#Stations^2$	#Stations	$#Stations^2$
POP	45.48***	47.12***	-7.53e+02	39.12*** / - 3.07.)	-6.75e+02
$POP^2$	(71.61)	(15.20) -5.86***	$(1.000\pm0.2)$ -1.900 $\pm0.2***$	(10.20) -5.42***	$(7.336\pm02)$ -2.15e+02**
$COM^2$		(0.55) 0.0579***	(28.14) 3.68***	(0.63) 0.0581***	(31.82) $4.0448***$
		(0.0064)	(0.5468)	(0.0066	(0.5717)
KP rk stat	11.968		24.554	.,	36.173
F-statistic	11.97	348.74	112.58	455.68	88.94
R-squared	0.2126	0.7436	0.7560	0.7592	0.7841
Observations	17326	17326	17326	17326	17326

Notes: 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 (See subsection 3.3 for more discussion on how the geographic market is defined). #Stations<sup>2</sup>, is the squared value of the measure of competition, #Stations. All the three columns contain fixed effects regressions. 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;  $POP^{Z}$ , 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  $POP^2$  are multiplied by 100,000 for ease of exposition. We report the F-statistics for the joint significance of all the three excluded instruments. Kleibergen-Paap Wald rk F- statistics for weak instrument test are also reported. \*\*\* indicates significance at 1% level.

	Fixed effects	Fixed effects	Fixed effects
	2SLS	2SLS	2SLS
Variable	[1]	[2]	[3]
#Stations	0.428 * * *	0.665 * * *	0.478***
	(0.044)	(0.151)	(0.154)
$#Stations^2$		-0.0071 **	-0.0075 ***
		(0.0033)	(0.0024)
Marginal effect			
(at Median)	0.428	0.622	0.433
Year	NO	NO	YES
Q. Season	NO	NO	YES
Stationage	NO	NO	YES
Station-level			
fixed effects	YES	YES	YES
Sargan-test			
(P-value)		0.9863	0.6198
Observations	17329	17329	17329

Table 6: Fixed Effects Two Stage Least Squares Estimation

Notes: The dependent variable measures the fraction of total inspected cars that pass the inspection at a given station. #Stations measures the number of other competing stations within certain radius around the focal station (See subsection 3.3 for more details about how the appropriate radius is determined for each station). The unit of observation is a station - month pair for the period July, 2010 - August, 2015. All the three columns present fixed effects 2SLS regressions estimated using xtivreg2 stata command (Schaffer, 2010). 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. All regressions include station-level fixed effects. Column (1) contains results without control variables. Column (2) includes the linear and quadratic terms of the measure of competition, without including any control variables. Stationage is a dummy variable which takes a value of one if a station is younger than one year old and a value of zero otherwise. \*\*\* 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. In all the three specifications, the models satisfy weak instruments and over-identification tests<sup>22</sup>. The first column presents the results for a specification with no control variables and using population size as the only instrument. The point estimate suggests that competition has a positive effect on pass rate.

In column (2), where we include the quadratic term of the competition variable and use all the three proposed instruments together, the fixed effects

<sup>&</sup>lt;sup>22</sup>Weak instruments bias 2SLS estimates toward OLS (Bound, Jaeger, and Baker, 1995 and Stock, Wright, and Yogo, 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, 2010).

2SLS estimates suggest a positive but diminishing effect of competition on pass rate. Column (3), our preferred specification, includes all the control variables, year, quarterly seasonal and station age dummies. The point estimates suggest that one additional rival station (at the median) now increases the pass rate by 0.43 percentage points, which is the same magnitude as the estimate from fixed effects. The fact that fixed effects and fixed effects 2SLS yield similar estimates may suggest that the control variables of the model and the station fixed effects reasonably account for major potential omitted variables bias<sup>23</sup>.

In a regression not reported here, we checked the consequences of not controlling for station fixed effects on 2SLS estimates. The Pooled 2SLS estimates are now identified using cross-station variation. The coefficient of #Stations drops dramatically and make the estimates highly insignificant. Given that the first stage regression still indicates a strong correlation between instruments and the endogenous variables, a potential correlation<sup>24</sup> between the instruments and uncontrolled time-invariant unobserved heterogeneity might be responsible for the biased and insignificant result<sup>25</sup>. The result further confirms that not controlling for unobserved heterogeneity causes a downward bias on the estimate of the effect of competition on pas rate. The direction of this bias is similar to the bias we observed between Pooled OLS and fixed effects results in Table 4.

The control variables in our preferred specification, column (3), demonstrate similar results as observed in the fixed effects estimation. we checked the consequence of not including the year fixed effects in the model and we find that not controlling for aggregate trend imparts an upward bias on the

 $<sup>^{23}</sup>$ The statistical test, reported by the xtivreg2 command for Stata, can not reject the null that our measure of competition can be treated as exogenous, after controlling the full set of control variables.

<sup>&</sup>lt;sup>24</sup>One major advantage of fixed effects 2SLS over Pooled 2SLS is that the former allows for instruments to be correlated to time-invariant unobserved heterogeneity (Wooldridge, 2010).

<sup>&</sup>lt;sup>25</sup>The Sargan test of over-identifying restriction without controlling for unobserved heterogeneity rejects the null that the instruments are valid instruments (at the p-value of 0.0652). Note that, in Column (3) where we controlled for unobserved heterogeneity, the null of the Sargan test is comfortably accepted at the p-value of 0.6198. This suggests that failure of tests of overidentifying restriction may be driven by unobserved heterogeneity.

estimate of the impact of competition on pass rate. We also observed a variation in average pass rates based on a seasonal basis where the average pass rate in the third quarter (July, August and September) is higher than the average pass rate in any of the other quarters. The average pass rate in third quarter is 2.8 percentage points higher than the pass rate in the first quarter and 1.8 percentage points higher than both the second the fourth quarter. We also checked that the coefficients of the main variables remain unchanged when we substitute monthly seasonal dummies for quarterly seasonal dummies. Finally, the results once again confirm that there is no significant differences in pass rates between the new entrants and the incumbents.

Overall, all the estimation strategies give a consistent result that competition has a statically significant and positive effect on pass rate. The results support the predictions of our simple theoretical model that stations tend to be lenient to their customers when facing more competitive environment

# 6 Robustness checks and alternative approach to geographic market delineation

In this section, we report a range of sensitivity analyses and provide further results based on an alternative approach to define stations' geographic market areas. Table 7 reports the results of the sensitivity analyses which are based on our preferred specification, where all the control variables are included. For comparison purpose, the first row of the table reports the baseline results from our main analysis. We present 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 our main analysis, we defined the catchment area of a station based on the travel distance of the median customer in the referenced station's municipality. For example, the median car owner 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 an alternative radii. We define each station's catchment area by the distance

Specification	variable	Pooled OLS (1)	Fixed Effects OLS (2)	Fixed Effects 2SLS (3)
	#Stations	0.197***	0.470 * * *	0.478 * * *
Baseline		(0.075)	(0.086)	(0.154)
	$\#Stations^2$	-0.0032*	-0.0073 * * *	-0.0075 * * *
		(0.0018)	(0.0013)	(0.0024)
	#Stations	-0.032	0.340 * * *	0.369 * * *
75% ile catchment area		(0.076)	(0.067)	(0.140)
	$\#Stations^2$	0.0021	-0.0036 * * *	-0.0039 * *
		(0.0014)	(0.0009)	(0.0019)
	#Stations	0.135	0.440 * * *	0.448 * * *
Top 1% trimmed		(0.0877)	(0.098)	(0.169)
	$#Stations^2$	-6.66e - 06	-0.0066 * * *	-0.0067 **
		(0.0024)	(0.0018)	(0.0031)
	#Stations	0.198 * * *	0.478 * * *	0.574 * * *
Excl. Year 2010		(0.076)	(0.089)	(0.188)
	$#Stations^2$	-0.0033*	-0.0075 * * *	-0.0092 * * *
		(0.0018)	(0.0013)	(0.0028)
	#Stations	0.195 * * *	0.455 * * *	0.434 * * *
Linear time trend		(0.075)	(0.089)	(0.156)
	$\#Stations^2$	-0.0032*	-0.0070 * * *	-0.0062 **
		(0.0018)	(0.0013)	(0.0027)
	#Stations	0.365 * * *	0.388 * * *	0.371 * *
Excl. local monopolies		(0.074)	(0.092)	(0.163)
	$\#Stations^2$	-0.0068 * * *	-0.0063 * * *	-0.0062 * * *
		(0.0016)	(0.0013)	(0.0024)

Table 7: Sensitivity analysis of the impact of competition on pass rate

Notes: Each entry in the table represents separate regression and presents the coefficients on the linear and quadratic terms of competition. All regressions control for year, quarterly seasonal and station age dummies. With the exception of column (1), all regressions also include station-level fixed effects. The baseline results in the first row of the table correspond to our specification in columns (3) and (4) 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. Column (1) contains the Pooled OLS regression, Column (2) contains fixed effects OLS and Column (3) contains fixed effects 2SLS. 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.

the 75th percentile customer travels in their respective municipalities. For example, in Stockholm 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 of geographic market, 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 pass rate with little reduction in the magnitude of the coefficients.

We also checked the sensitivity of the results to the extreme values of the

distribution of the measure of competition. We trim the top 1 percent of the data based on the distribution of the number of competitors. The fixed effects and fixed effects 2SLS point estimates are significant and almost the same in magnitude as the main results.

After the market deregulated in July 2010, private firms start to enter the market actively in the year 2011. We re-estimate the model by excluding the observations from the early periods of the deregulation. Excluding the data for the year 2010, the fixed effects estimates are almost similar to the results based on the full sample. The coefficients of fixed effects 2SLS are a little larger than the estimates from the whole sample. In our main analysis, we control for aggregate trend in the pass rate through year fixed effects. We re-estimate 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 market competition.

Another potential concern that may affect the results relates to the theory of supplier - induced demand. Inspection technicians may use their information advantage over car owners to induce owners to demand more 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. If local monopolies practice such behavior, our estimates of the effect of competition 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 has still a positive and significant effect on pass rate. The fixed effects and fixed effects 2SLS give coefficient estimates a little smaller than the main result. This rules out the possibility that our results are only driven by the differences between stations with local monopoly power and stations with at least one competitor.

Variable	Pooled OLS (1)	Fixed Effects OLS (2)	Fixed Effects 2SLS (3)
#Stations	0.029	0.385***	0.322**
	(0.074)	(0.095)	(0.142)
$#Stations^2$	0.0028	-0.0055 * * *	-0.0041
	(0.0019)	(0.0016)	(0.0026)
Marginal effect (at Median)		0.363	0.306
Year	YES	YES	YES
Q. Season	YES	YES	YES
Stationage	YES	YES	YES
Station-level			
ficed effects	NO	YES	YES
Adjusted $R^2$	0.091	0.663	
Observations	17329	17329	17326

Table 8: Results with fixed - radius approach to measure competition

Notes: 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 28km radius around the focal station ( based on a catchment area of 14km radius for each station). The unit of observation is station - month pair for the period July, 2010 - August, 2015. The first column contains the Pooled OLS regression. The second contains fixed effects OLS regression and the third column contains fixed effects 2SLS. 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 control for year, quarterly seasonal and station age dummies. With the exception of column (1), all regressions also include station-level fixed effects. *Stationage*, is a variable which takes the value of one if a station is younger than one year old and a value of zero otherwise. \*\*\* indicates significance at 1% level and \*\* significance at 5% level.

#### 6.1 Alternative approach to geographic market delineation

In all 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 stations in Arjeplog municipality have catchment area of 41 km. We now repeat our analyses based on fixed size catchment area for all stations. We define each station's catchment area as 14 km<sup>26</sup> and therefore measure the strength of competition by the number of other competing stations within a circular market of 28 km radius from the focal station.

Table 8 presents results based on the specification of our main model where all the control variables are included. We re-estimate the model using 28 km radius circular geographic market area for all stations. The fixed

 $<sup>^{26}</sup>$ 14 km is the median of the distribution of the measured travel distances between the addresses of 458,405 car owners and the corresponding stations they visited.

effects estimates show that competition has a significant positive impact on inspection results. One additional rival station at the median now increases the pass rate by 0.363 percentage points, which was 0.426 percentage points with variable-radius definition. The fixed effects 2SLS estimates of #Stations and #Stations<sup>2</sup> are jointly significant (*P*-value <0.02). The estimates suggest that one additional rival station (at the median) now increases the pass rate by 0.306 percentage points. This result can be compared with the 0.433 percentage points we obtained in the main result where we use variable-radius definition. Overall, the results with fixed-radius definition of catchment area once again support our hypothesis that competition increases the probability for a given car to pass the mandatory inspection.

### 7 Conclusion

In this article, we have examined whether increased competition within markets 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 fixed effects and fixed effects 2SLS estimation methods to identify the causal impact of competition on car inspection results. To account for potential bias from omitted variables that might not be captured by station fixed effects, we use population size at the municipality level as an instrument for the number of competitors in a geographic market. To minimize potential correlation between our instruments and factors in the error term, we use fixed effects 2SLS that allows for correlation between our instruments and time-invariant factors in the error term. Both fixed effects and fixed effects 2SLS estimations indicate that increased competition leads firms to be lenient to their customers.

Our results are robust to alternative approaches we follow to define geographic markets and measure competition. Given limited resources and capacity, the results suggest that the regulator of the market needs to put more effective monitoring in highly competitive markets, where there is a potential for deviations from regulations. The Swedish car inspection market is designed to alleviate distorting incentives (for ex., stations are not allowed to provide repair or car dealership services) that may be caused by competitive pressure and that have been observed in other similar markets. Furthermore, the market is regulated by Swedish Transport Agency and inspection firms need to obtain accreditation from Swedish Board for Accreditation and Conformity Assessment. Given all the precautions taken, competitive pressure still appears to influence inspection results. If we take the results as a lower boundary of the effect of competition on firms' incentive to be lenient to their customers, policies that aim to promote competition need to incorporate such adverse side of competition in the overall analysis.

Finally, although our findings indicate the adverse side of competition on car inspection results, it does not necessarily imply that deregulating the market has not been benefiting consumers on socially desirable way. However, our results suggest that further policies that aim to promote competition (for example, selling currently 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, NJ: Princeton University Press.
- [2] Bennett, V. M., Lamar P., Jason A. S. and Michael W. T. (2013), "Customer-Driven Misconduct: How Competition Corrupts Business Practices", Management Science, 59 (8), 1725-42.
- [3] 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, 457-489.
- [4] Bound, J., David A. J. and Regina, M. B. (1995), "Problems with Instrumental Variables Estimation When the Correlation between the Instruments and the Endogenous Explanatory Variables Is Weak", Journal of the American Statistical Association, 90 (June): 443-50.
- [5] Bolton, P., Freixas, X. and Shapiro, J. (2012), "The credit ratings game", Journal of Finance, 67, 85-112.
- [6] Branco, F. and Villas-Boas, J. M. (2015), "Competitive Vices", Journal of Marketing Research: December 2015, Vol. 52, No. 6, pp. 801-816.
- [7] Bresnahan, T. F. and Reiss, P. C. (1991), "Entry and competition in concentrated markets", Journal of Political Econom, 99(5):9971009
- [8] Cameron, C. A. and Miller, D. L. (2015), "A practitioners guide to cluster-robust inference", Journal of Human Resources, Spring 2015, Vol.50, No. 2, pp.317-373.
- Cragg, J. G. and Donald, S. G. (1993), "Testing Identifiability and Specification in Instrumental Variable Models", Econometric Theory, 9, 222-40.
- [10] Elzinga, K. G. and Hogarty, T. F. (1978), "The Problem of Geographic Market Delineation Revisited", Antitrust Bulletin, XXIII, 1-18.

- [11] 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.
- [12] Kessler, D. P. and McClellan, M. B. (1999), "Is Hospital Competition Socially Wasteful?", NBER working paper no. 7266.
- [13] Murray, M. P. (2006), "Avoiding Invalid Instruments and Coping with Weak Instruments", Journal of Economic Perspectives, 20, 111-132.
- [14] Mazzeo, M. J. (2003), "Competition and service quality in the U.S. airline industry", Review of Industrial Organization, 22(4):275-296.
- [15] 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.
- [16] Salop, S. C. (1979), "Monopolistic Competition with Outside Goods", Bell Journal of Economics, 10, 141-156.
- [17] Schaffer, M. E. (2010), "xtivreg2: Stata module to perform extended IV/2SLS, GMM and AC/HAC, LIML and k-class regression for panel data models", Research Papers in Economics, November 22, 2011. http://ideas.repec.org/c/boc/bocode/s456501.html.
- [18] Snyder, J. (2010), "Gaming the liver transplant market", Journal of Law, Economics, and Organization, 26(3):546-568.
- [19] Staiger, D. and Stock, J. H. (1997), "Instrumental Variables Regression with Weak Instruments", Econometrica, 65, 557-86.
- [20] Stiglitz, J. E. (1986), Economics of the Public Sector, New York: W. W. Norton and Company.
- [21] Stock, J. H., Wright, J. H. and Yogo, M. (2002), "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments", Journal of Business and Economic statistics, 20 (October): 518-39.

- [22] Stock, J. H. and Yogo, M. (2005), Testing for Weak Instruments in Linear IV Regression. In: Andrews DWK Identification and Inference for Econometric Models. New York: Cambridge University Press, pp. 80-108.
- [23] Syverson, C. (2004), "Market structure and productivity: A concrete example", Journal of Political Economy. 112(6):1181-1222.
- [24] Tirole, J. (1988), The Theory of Industrial Organization, Cambridge, MA: MIT Press.
- [25] Wooldridge, J. M. (2010), Econometric Analysis of Cross Section and Panel Data, Second Edition. Cambridge, MA: MIT Press.

# 8 Appendix



# 8.1 Average pass rate versus competition

Figure 4: Pass rate and Competition: Notes: 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 "X".